International Whaling Commission

Biology of the Genus *Cephalorhynchus*

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Preface

This volume, number 9 in our Special Issue series, is in fact the tenth volume to appear in the series, being published after Special Issue 10 due to a number of financial and technical problems. However, I am pleased to say that it has been worth the wait; the volume brings together a considerable amount of new information on a previously little known genus. It is appropriate here to thank Sea World of Florida, the Hubbs Marine Research Center and the Windstar Foundation for their generous financial support for this volume.

G. P. Donovan (*Series Editor*)
Cambridge

Cover photograph: Commerson's dolphins, *Cephalorhynchus commersonii* (courtesy of Stephen Leatherwood).

Introduction

Cephalorhynchus is one of the most widespread coastal delphinid genera in the Southern Hemisphere. It is also the most diverse of the Southern Hemisphere delphinids, with four recognised species. Gray (1846) originally described the genus *Cephalorhynchus* as a subgenus of *Delphinus* for the species *heavisidii*. The four species currently recognised and discussed in this volume are: Commerson's dolphin (*Cephalorhynchus commersonii*), the Chilean dolphin (*C. eutropia*), Hector's dolphin (*C. hectori*) and Heaviside's dolphin (*C. heavisidii*).

In 1984, the International Whaling Commission's Scientific Committee, or, more specifically, its sub-committee on small cetaceans, examined this genus as a special topic at its annual meeting (IWC, 1985). Prior to that meeting, this genus was one of the most poorly known delphinid genera, being found in some of the more remote areas of the Southern Hemisphere where access for study is difficult. At the meeting, the Committee welcomed the significant amount of new information made available, recognised the increasing number of continuing studies and made recommendations for further work regarding (i) the vulnerability of the genus to entanglements in monofilament gillnets, (ii) life-history parameters (especially for the Chilean and Commerson's dolphins) and (iii) population status in areas where captures were taking place. After that meeting, plans were made for the publication of a volume which would include and update the contributions made to the 1984 meeting as well as include the results of new studies, especially those undertaken in response to the above recommendations.

We hope that the seventeen papers included in this volume, ten of which are expanded and reviewed versions of papers originally submitted in 1984, achieve that aim and are representative of the wide diversity of research conducted during the past 20 years on *Cephalorhynchus*. Many interesting biological features of the genus are described: females are larger than males; adult males have relatively large testes for their body size; genital coloration is sexually dimorphic; all may have peculiar serrations along the anterior edge of their flippers. The four species are found disjunct in coastal waters throughout the Southern Hemisphere. All four are exploited (either incidentally and/or directly). Two species have been held in captivity: Commerson's dolphin, which has been held in the USA, Japan and Germany; and Hector's dolphin, which has been kept only in its native New Zealand.

The papers have been grouped by species. Section I presents ten essays on various aspects of the abundance, biology, exploitation and status of Commerson's dolphins. This species has the greatest north-south range within the genus and is the only one with a discontinuous range (western South Atlantic and Kerguelen Islands). The first paper, by Goodall and co-workers,

presents the results of their studies on this species in waters off Tierra del Fuego and also a general review of the species in the South Atlantic. Brown provides sightings records made from vessels of the "Discovery Investigations". He also clearly shows that no definite record of this species exists from the waters around South Georgia Island, contrary to a previously accepted published statement. Lockyer, Goodall and Galeazzi discuss the age and body-length characteristics of dolphins that were incidentally caught off Tierra del Fuego. Details on the genital tract and reproduction of this species from the Kerguelen Islands are presented by Collett and Robineau. Bastida, Lichtschien and Goodall examine the food habits of this dolphin from waters around Tierra del Fuego. Goodall and co-workers present details on the serrations found along the leading edge of the flippers in these dolphins and discuss their possible uses. Two papers by Leatherwood and his colleagues describe observations and population estimates for *C. commersonii* in the northeastern Strait of Magellan. These studies were related to the efforts of Cornell and his co-workers to capture and keep this species in captivity. Evans, Awbrey and Hackbarth report on the high-frequency pulses produced by free-ranging Commerson's dolphins, compare their signals with those made by phocoenids and discuss these results in the context of gillnet entanglements.

In addition to these papers, a number of papers by Robineau and his colleagues on Commerson's dolphins have been published since 1984. These papers are based on dolphins collected in January 1983 from the waters around the Kerguelen Islands. The first paper described the external morphology and colour pattern of these dolphins (Robineau, 1984). Buffrénil and Robineau (1984) described the maturation of the post-cranial skeleton related to dentinal growth layer groups. Robineau and Duhamel (1984) reported on the coastal food habits of these animals. Robineau and Buffrénil (1985) presented details on osteology and osteometrical data. Robineau (1985a and b) described the distribution of the species around the Kerguelen Islands especially in the Gulf of Morbihan and noted that these dolphins are a geographically isolated population that can be identified by their larger size and coloration when compared to South American specimens. Abarnou, Robineau and Michel (1986) reported organochlorine pollutants (DDT, PCB and HCB) in samples from these dolphins but at levels between ten and a hundred times less than those found in similar species from the Northern Hemisphere.

The other published paper on this species is that of Brownell and Praderi (1985) who examined its distribution and reported on the rediscovery of one of the two type specimens of *Lagenorhynchus floweri*, a synonym of *C. commersonii*.

Section II deals with the previously poorly known Chilean dolphin, *C. eutropia*. Goodall and Norris, along with their co-workers, review and focus on certain aspects of the biology and status of these animals and present much new information from specimens they have collected and examined. Goodall *et al.* clarify the status of *Phocaena obtusata*, which they believe is a specimen of *C. eutropia*.

Section III comprises an account by Best on the external appearance of Heaviside's dolphin, *C. heavisidii*, based mainly on observations and material collected since 1970. Photographs of fresh whole animals are presented for the first time. These photographs and measurements of the dolphins are compared

to the previous descriptions of the species, all of which were erroneous in some respect. The only other recent paper on this species, that of Rice and Saayman (1984), provides some details on the movements, coloration and behaviour of these dolphins.

Section IV presents chapters on Hector's dolphin, *C. hectori*, from the coastal waters of New Zealand. Cawthorn reports recent observations of the species and problems with incidental mortality in set gillnets. Dawson and Slooten present results from a boat survey on the distribution and abundance of Hector's dolphin and suggest a total population of only 3,000 to 4,000 individuals. In another paper, Slooten and Dawson provide information on external characteristics, ecology, behaviour and human-dolphin interactions. This paper documents that large numbers of these dolphins are incidentally caught in gillnets, especially around the Banks Peninsula area. The last chapter, by Dawson, describes the high frequency sounds of free-ranging Hector's dolphins and notes that the structure of these sounds has much in common with those described for Commerson's dolphins.

As editors, we have seen our major responsibility as clarity of presentation and have therefore as much as possible left the style and content to the authors, within the peer review system established for IWC publications. The research presented here is the first overall examination of the genus *Cephalorhynchus*; with time it will be, of course, revised and new information will continue to add to our understanding of these four interesting species. With all the new information on *Cephalorhynchus* available in this volume, it may be time to revise the genus, emphasising what is known about the distribution, the relationship to the Antarctic Convergence, the zoogeography of the various prey items and the coloration and osteology of the four species.

Finally, we would like to thank the following people who reviewed the various manuscripts in the volume: D. G. Ainley, A. N. Baker, L. G. Barnes, P. B. Best, M. W. Cawthorn, D. G. Chapman, A. Collet, L. L. Eberhardt, W. E. Evans, D. E. Gaskin, M. Hall, P. S. Hammond, R. J. Harrison, J. E. Heyning, L. Jones, T. Kasuya, V. Lichtschein, C. Lockyer, J. G. Mead, K. S. Norris, W. F. Perrin, M. C. Pinedo, J. H. Prescott, S. B. Reilly, S. H. Ridgway, D. Robineau, G. J. B. Ross, T. D. Smith, S. Spotte, W. A. Watkins and B. G. Würsig. Special thanks are due to Stella Duff, Jacquie Mercer, Susan Wright, Katherine Ralls and Robin Meadows who either typed, re-typed or proof read many of the manuscripts.

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Contents

Preface iii

Introduction iv

Commerson's dolphin, *Cephalorhynchus commersonii*

Goodall, R. N. P., Galeazzi, A. R., Leatherwood, S., Miller, K. W., Cameron, I. S., Kastelein, R. K. and Sobral, A. P. – Studies of Commerson's dolphins, *Cephalorhynchus commersonii*, off Tierra del Fuego, 1976–1984, with a review of information on the species in the South Atlantic (SC/36/SM8) 3

Leatherwood, S., Kastelein, R. A. and Miller, K. W. – Observations of Commerson's dolphin and other cetaceans in southern Chile, January–February 1984 (SC/36/SM8) 71

Brown, S. G. – Records of Commerson's dolphin (*Cephalorhynchus commersonii*) in South American waters and around South Georgia (SC/36/SM16) 85

Leatherwood, S., Kastelein, R. A. and Hammond, P. S. – Estimate of numbers of Commerson's dolphins in a portion of the northeastern Strait of Magellan, January–February 1984 (SC/36/SM7) 93

Lockyer, C., Goodall, R. N. P. and Galeazzi, A. R. – Age and body-length characteristics of *Cephalorhynchus commersonii* from incidentally-caught specimens off Tierra del Fuego (SC/36/SM4) 103

Collet, A. and Robineau, D. – Data on the genital tract and reproduction in Commerson's dolphin, *Cephalorhynchus commersonii* (Lacépède, 1804), from the Kerguelen Islands (SC/36/SM18) 119

Bastida, R., Lichtschein, V. and Goodall, R. N. P. – Food habits of *Cephalorhynchus commersonii* off Tierra del Fuego (SC/36/SM24) .. 143

Goodall, R. N. P., Galeazzi, A. R., Sobral, A. P. and Cameron, I. S. – Flipper serration in *Cephalorhynchus commersonii* 161

Evans, W. E., Awbrey, F. T. and Hackbarth, H. – High frequency pulses produced by free-ranging Commerson's dolphin (*Cephalorhynchus commersonii*) compared to those of phocoenids 173

Cornell, L. H., Antrim, J. E., Asper, E. D. and Pincheira, B. J. – Commerson's dolphins (*Cephalorhynchus commersonii*) live-captured from the Strait of Magellan, Chile (SC/36/SM5) 183

Chilean dolphin, *Cephalorhynchus eutropia*

Goodall, R. N. P., Norris, K. S., Galeazzi, A. R., Oporto, J. A. and Cameron, I. S. – On the Chilean dolphin, *Cephalorhynchus eutropia* (Gray, 1846) (SC/36/SM9) 197

Goodall, R. N. P., Sobral, A. P., de Vinuesa, M. L. and Cameron, I. S. – On *Phocaena obtusata*, with a comparison of certain diagnostic characters in South American phocoenids and the genus *Cephalorhynchus* 259

Heaviside's dolphin, *Cephalorhynchus heavisidii*

Best, P. B. – The external appearance of Heaviside's dolphin, *Cephalorhynchus heavisidii* (Gray, 1828) (SC/36/SM19) 279

Hector's dolphin *Cephalorhynchus hectori*

Cawthorn, M. W. – Recent observations of Hector's dolphin, *Cephalorhynchus hectori*, in New Zealand 303

Dawson, S. M. and Slooten, E. – Hector's dolphin, *Cephalorhynchus hectori*: distribution and abundance 315

Slooten, E. and Dawson, S. M. – Studies on Hector's dolphin, *Cephalorhynchus hectori*: a progress report 325

Dawson, S. M. – The high-frequency sounds of free-ranging Hector's dolphins, *Cephalorhynchus hectori* 339

(Numbers in parentheses indicate IWC meeting document numbers upon which the paper was based, where appropriate.)

Commerson's dolphin
Cephalorhynchus commersonii

Studies of Commerson's Dolphins, *Cephalorhynchus commersonii*, off Tierra del Fuego, 1976–1984, with a Review of Information on the Species in the South Atlantic

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ABSTRACT

Data on Commerson's dolphins were obtained for the South Atlantic from a review of literature and colleagues' unpublished data, a volunteer sightings program (1976–1984) and examination of specimens in museums and other institutions and, for Tierra del Fuego, from a stranded animal salvage program in 1972–1984, interviews, and concentrated surveys by boat, shore, and aircraft (1972–1984). The species was first described from an encounter off Tierra del Fuego in 1767 and named in 1804. It was documented with greatest clarity in 1892 and 1922. Documentation and synonymy are reviewed. Accepted common names are Commerson's dolphin in English and *Tonina overa* in Spanish. Commerson's dolphins have been reliably reported, mostly in shallow nearshore regions, along the eastern coast of South America between about 41°30′S and 55°S, at the Strait of La Maire. Their range includes the eastern Strait of Magellan above Bahía Inútil and Punta Arenas, and around the Falkland (Malvinas) Islands. Peripheral records from farther offshore include reported sightings in Drake Passage and the South Shetland Islands. Previous reports of the species' occurrence at South Georgia cannot be substantiated. Though often postulated, existence of migration cannot be verified. These dolphins inhabit nearshore waters of open coast, sheltered fjords, bays, harbors and river mouths, and occasionally enter rivers. The only available abundance estimates are for the eastern Strait of Magellan, where aerial surveys supported an estimate of 3,211 (SE = 1,168), but the species does not appear rare anywhere within its broad range. It prefers areas with broad tidal flats, broad tidal range, and cool temperatures influenced by the Malvinas current. From 349 specimens (including 272 collected from Tierra del Fuego by the authors, 1972–1984), the appearance and biology of the species can now be described in some detail. Skull, post cranial skeleton, and organs are described. The first two are illustrated. Maximum known sizes are 152cm (female) and 149cm (male) from the Strait of Magellan, and 145.5cm (female) and 138cm (male) from eastern Tierra del Fuego. Females are larger than males at all ages. Males reach sexual maturity at 5–6 years of age and 127–131cm in length, females by 5–6 years and at least 128cm. Calving takes place in austral summer, December–March. Three calves conceived and born in a North American marine

zoological park were also born in this season. Birth length is about 75–80cm. Gestation is believed to be 11–12 months. Fetuses and calves have elements of adult coloration, but as brown or gray on darker gray. Juveniles appear to attain adult coloration within their first year. Adults are strikingly marked in black and white. Genital patches are sexually dimorphic and at least two features, a 'widow's peak' on top of the head and the border of the flank patch, may be sufficient to distinguish individuals. The dorsal fin is rounded or lobate in profile and is not dimorphic. Although Commerson's dolphins often occur in small pods, reported herds have contained from 1 to over 110 ($\bar{x} = 6.85$, SD = 16.5). These dolphins feed at various trophic levels, often in areas disturbed by tidal change. Food items include coastal schooling fishes and bottom-dwelling invertebrates, the latter with surprising frequency. Independent feeding and cooperative feeding are documented. So, also, is play, including harassment of floating gulls, investigation of human divers, riding on large swells and body-surfing on breaking shore waves. High frequency characteristics of the species' sound production make them vulnerable to entanglement in nets. Undetermined but suspected high numbers of deaths have long occurred due to direct killing (mostly for use as bait in crab traps) and accidental entanglement in nets set for crab and various fishes. Some sport sniping is known to occur. Legislation and changes in fishing practices, target species, and fishing areas have likely reduced the frequency of kills in recent years. About 33 have been live-captured and removed to marine zoological parks in Europe and the USA.

INTRODUCTION

The genus *Cephalorhynchus* includes four known species of small (less than about 1.75m long) dolphins, each endemic to a different region of cold temperate to subantarctic and largely coastal waters of the Southern Hemisphere. Commerson's dolphin, *Cephalorhynchus commersonii* (Lacépède, 1804) (Fig. 1), was first described based on an encounter off southeastern South America in 1767 (Lacépède, 1804). It is by far the most widely distributed of the four. It has been reported from the Kerguelen Islands, in the southern Indian Ocean (e.g. Paulian, 1953; Angot, 1954; Pascal, 1901; Robineau, 1984; Robineau and de Buffrénil, 1984), and the Falkland Islands (Islas Malvinas), in the southwest Atlantic (e.g. Bruce, 1915; Hamilton, 1952; Strange, 1972), and off southern and southeastern South America below about 41°30′S, including the central and eastern Strait of Magellan and Drake Passage almost as far south as the Shetland Islands (e.g. Aguayo and Torres, 1967; Brownell, 1974; Aguayo, 1975; Goodall, 1978; Goodall and Cameron, 1980).

Knowledge about this species has accumulated slowly. For the first 115 years or so after the appearance of the original description, writers primarily added anecdotal accounts of their brief observations of living animals or commented on the validity of the putative species or its affinities with other named species. The exception was Moreno (1892) who described the behavior of dolphins he observed in 'the Bay of the Río Santa Cruz' and presented details on external and skeletal appearance of specimens he collected there. Some confusion continued to prevail about the validity and appropriate name of the species and little new substantive data were added until 1922, when Harmer (1922, p. 628) presented a useful summary of his own and previous data and argued convincingly for acceptance of *Cephalorhynchus commersonii* (Lacépède, 1804) as a valid species.

A few of the publications from, approximately, the next 55 years presented data on miscellaneous strandings or sightings (discussed below) but most contained little or nothing new and simply listed or restated previously

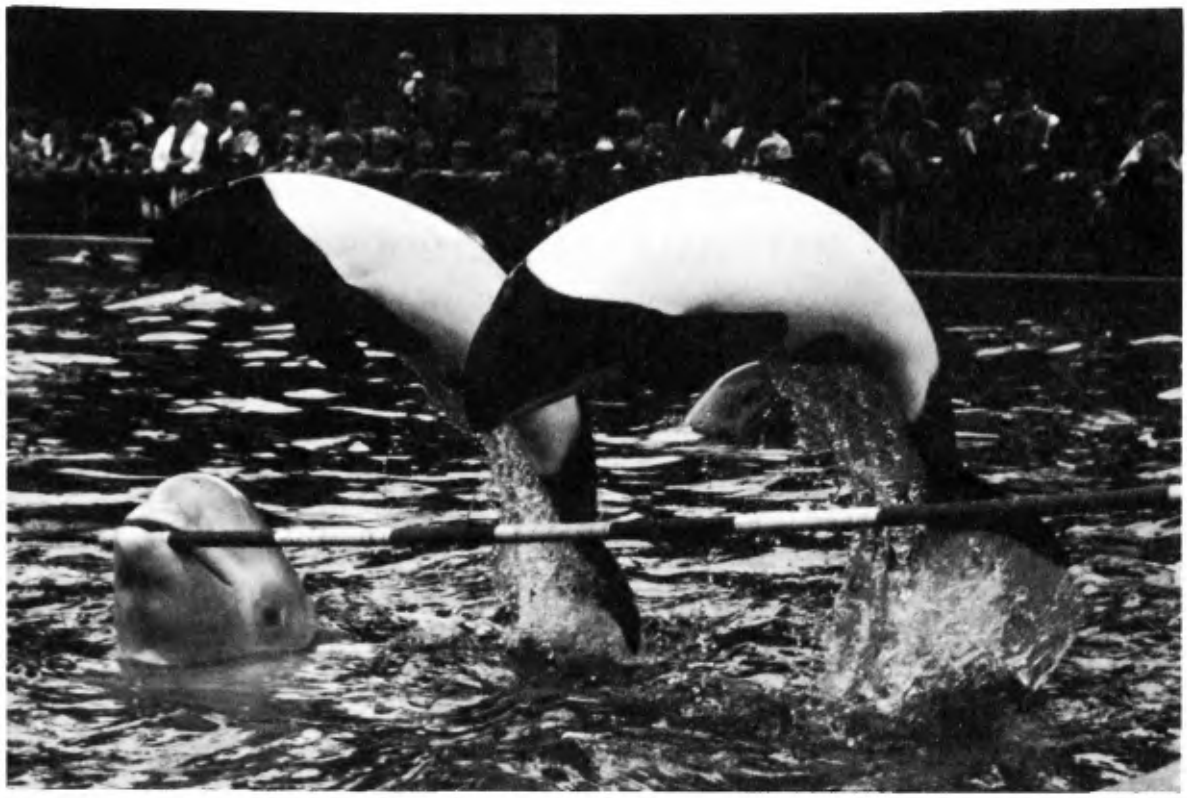


Fig. 1. Commerson's dolphins from southern South America perform at Duisburg Zoo, Duisburg, Germany, on 5 June 1984 (S. Leatherwood).

published information (e.g. Fraser, 1937, p. 318; Kellogg, 1940, p. 89; Yañez, 1948, p. 115; Carcelles, 1948, p. 5; Marelli, 1953, p. 137; Mann Fischer, 1957, p. 103; Cabrera, 1961, p. 64; Walker, 1968, p. 1120; Mörzer Bruyns, 1971, p. 42; Marcuzzi and Pilleri, 1971, p. 129; Nishiwaki, 1972, p. 105; Donoso-Barros, 1975, p. 32; Watson, 1981, p. 248; Ellis, 1982, p. 126).

More recently, there has been a series of investigations involving this species in southern South America. Mermoz (1980) spent portions of three months in 1978 and 1980 studying the behavior of free-ranging Commerson's dolphins at Comodoro Rivadavia. Numerous authors have reported on results of programs to collect stranded specimens, conduct surveys, examine museum specimens and document exploitation – both direct (for fishing bait, food, museum specimens, and captive display and research) and accidental (in various net fisheries) – off Argentina and Chile (e.g. Goodall, 1977, 1978; Goodall and Cameron, 1980; Aguayo, 1975; Atalah, 1978; Sielfeld, 1980; Sielfeld and Venegas, 1978; Sielfeld, Venegas and Atalah, 1977; Venegas and Sielfeld, 1978; Leatherwood, Kastelein and Miller, 1988). Reports of recent live-captures have provided new information on distribution, abundance and behavior (Spotte, Radcliffe and Dunn, 1979; Gewalt, 1979, 1980, 1983, 1984a, b; 1985; Cornell, Antrim, Asper and Pincheira, 1988).

In 1983, noting the general dearth of published information on most aspects of the biology and status of members of the genus *Cephalorhynchus* and concerned about apparent ongoing exploitation of unassessed 'stocks', the IWC Scientific Committee's sub-committee on small cetaceans agreed to review at its 1984 meeting all pertinent data on the genus. This paper is prepared from two contributions to that meeting (Leatherwood, Kastelein and Miller, 1984;

Goodall, Galeazzi, Cameron and Sobral, 1984). It includes a review of information available on the species in the South Atlantic, 1767–1984, with special emphasis on specimens and sightings. It also presents detailed results from studies off Tierra del Fuego, 1976–1984.

MATERIALS AND METHODS

Data were obtained through a background review, a volunteer sighting program in the South Atlantic (begun in 1976), a stranding salvage program off Tierra del Fuego (also begun in 1976), visits to museums and other institutions involved in cetacean research, and personal observations by the authors from shore, vessel and aircraft along the coasts of Patagonia and Tierra del Fuego, 1976–1984.

Literature containing references to Commerson's dolphins was reviewed for information on systematics, distribution, abundance, exploitation and general biology. Institutions and individuals thought to have specimens for which records and data were unpublished were queried for information on where, when and by whom the specimens were collected and on what materials and data were represented. Colleagues were interviewed for summaries of their unpublished observations.

Sightings forms were placed aboard vessels operating off southern South America (principally the R/V *Hero*, ships of the Argentine Navy and oil companies, and US based cruise ships working between southern South America and the Antarctic) and distributed to persons interested in cetaceans. Reliable sightings reported to us were tabulated, plotted and examined, along with published sightings reports, for information on distribution, abundance, patterns of movement and behavior of Commerson's dolphins.

Beginning in 1976, the beaches of Tierra del Fuego were surveyed periodically for stranded or beach-cast material of small cetaceans. Any fresh specimens located were measured (following Norris, 1961) and subjected to the following procedures, when possible: the sex was determined and the condition of the specimen described; appendages were traced; organs were removed, weighed and sampled; stomach contents were collected; and parasites were saved. Skulls and post-cranial skeletons from all specimens, regardless of condition, were cleaned by boiling and stored at the senior author's facilities in Ushuaia.

Various materials were provided to collaborating investigators and appropriate results were used to refine our impressions of age/status based on examination of gross material: C. Lockyer sectioned and read teeth (see Lockyer, Smellie, Goodall and Cameron, 1981; Lockyer, Goodall and Galeazzi, 1988) and examined reproductive materials (see Lockyer *et al.*, 1988); Bastida, Lichtschein and Goodall (1988), with help from M. Clarke on squid beaks, analysed stomach contents; A. Raga and M. Heckman are examining parasites.

On the basis of the amount of fusion of the vertebral epiphyses to the centra, the physical maturity of specimens was classified from skeletal material as:

Class 0 – fetuses or neonates (neural spine still unfused on cervical vertebrae);

Class 1 – juveniles (neural spines fused but no epiphyseal fusion. Class 1a, very small animals; Class 1b, fairly large animals);

Class 2 – subadults (some epiphyses fused to centra, starting at head and tail. Class 2a animals, little fusion; Class 2b animals, fusion in all except one or two vertebrae);

Class 3 – physically mature (all epiphyses fused, either with a line around epiphyses which apparently persists till late in life in this species (3a), or with no such line (3b)).

At least one of us examined all specimens of *Cephalorhynchus commersonii* in the British Museum of Natural History (BMNH), the US National Museum (USNM), the Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia' (MACN-BA), the Museo de La Plata, Argentina (MLP), and the Instituto de la Patagonia in Punta Arenas, Chile (IPPA). In addition, we obtained data on other specimens, as follows: two (USNM 395352 and 395353) taken by K.S. Norris in the Strait of Magellan on 10 December, 1968; three of four confiscated by US Government authorities in 1978, when they were brought into the country illegally from Argentina *en route* to Japan (USNM 550154, 550155 and 550156 – courtesy of J.G. Mead and C. Potter); and one harpooned off the province of Santa Cruz by Rayner in 1932 (Brown, 1988). Data from published specimens were considered in analysis as our confidence in their reliability permitted.

In describing this species' biology and behavior we also have drawn on our collective observations from shore, vessel and aircraft along the coasts of southern South America, from 1976 to 1984, and on our discussions with colleagues, fishermen and others familiar with this species.

RESULTS AND DISCUSSION

Systematics and nomenclature

Brief history of documentation

In mid-December 1767, during Bouganville's voyage around the world, Philibert Commerson, a French physician and botanist, observed dolphins playing around the ship 'near Tierra del Fuego and the Strait of Magellan' and described them as follows in a letter to George Louis Leclerc (Compte de Buffon): '*Jacobite ou marsouin jacobite*; *tursio corpore argenteo*, *extremitatibus nigricantibus*'. Leclerc (Buffon) sent the description on to Bernard La Cepede (Compte de Lacépède), who, thirty-seven years later, used Commerson's note as the basis for his brief description: '. . . the black only appears on the extremities and the rest of the body shines as a polished white, that is to say silvery' (Lacépède, 1804, p. 338). In the absence of a specimen, Lacépède's description is taken as the type *Delphinus commersonii*. The description was repeated by Desmarest (1817) and others.

On 10 January 1769, just over a year after Commerson's sighting, Joseph Banks, aboard the HMS *Endeavour*, encountered porpoises a few hours north of the eastern tip of Tierra del Fuego. From his description the animals appear to have been Commerson's dolphins:

'This evening a shoal of Porpoises swam by the ship different from any I have seen, spotted with large dabs of white and white under the belly, in other respects as swimming etc. like common porpoises only they leap rather more nimbly, sometimes lifting their whole bodys out of the water'. (Beaglehole, 1963, p. 214).

Quoy and Gaimard (1824, p. 87) reported seeing dolphins which were 'half white, half black'. They harpooned one at the 'Islas Malouines' [the Falkland Islands] but it 'dove so deeply that we were not able to procure it'. Lesson (Lesson and Garnot, 1826, p. 181) saw the 'white and black dolphin of Quoy and Gaimard' at Soledad Bay in the 'Malouines', and considered it to be *delphinus Commersonii*, Commerson's jacobite.

During the next several decades, at least two workers resisted recognition of a new species, citing inadequate evidence. Cuvier (1836, p. 217) wrote: 'we do not think that, from the little the voyager (Commerson) said, the characteristics of a new species can be established'. Gay (1847, p. 176) considered Lacépède's description of a silvery white animal with black extremities as dubious and argued that science should not recognize a new species based solely on a description of specimens seen at a distance.

Cunningham (1868, p. 185; 1871, pp. 128, 261), who spent several summers aboard the HMS *Nassau* during that ship's surveys of the Strait of Magellan, saw what he called 'bridled dolphins' on several occasions, but was unable to examine a specimen. He called them *Delphinus bivittatus*.

When Flower (1883, p. 473) reviewed the genus *Cephalorhynchus*, he apparently knew nothing of this species. Because it was named only from a description based on a sighting, it was the last of the four species in the genus for which identity was accepted.

Moreno (1892) reported on his detailed observations of behavior of dolphins in 'the Bay of the Río Santa Cruz'. From six specimens he eventually obtained, Moreno presented the first detailed description (along with illustrations of the pigmentation pattern) and external and cranial measurements. He named his new species *Lagenorhynchus floweri*, though later in the same publication he lapsed into use of *L. burmeisteri*, apparently his earlier choice. At least four authors followed Moreno and included *L. floweri* in their list of species (Trouessart, 1897, p. 1,038; 1904, p. 768; Beddard, 1900, p. 267; Dabbene, 1902, p. 350; Lahille, 1905, p. 62). This last author gave two localities where the dolphin occurred, Islas de los Estados and Pavon, but it is not clear whether he saw them during his trip to Tierra del Fuego in 1898 or was referring to someone else's observations.

Bruce (1915, p. 501) described and illustrated a specimen of 'piebald porpoise' caught in a net at Port Stanley (Falkland Islands) in 1893. The specimen was sent to the museum of the University College, Dundee, but had been lost by the time Bruce wrote. He mistakenly called the specimen *Lagenorhynchus cruciger*; his illustration clearly shows a Commerson's dolphin and not the *L. cruciger* of Quoy and Gaimard (1824).

Harmer (1922, p. 628) clarified the situation when he published data (including external and skull measurements and photographs) on two new specimens and reviewed arguments concerning appropriate scientific names. He wrote:

'It is unfortunate that Moreno's specific name, which was based on a good and well-illustrated account of external and cranial characters, cannot be accepted. It must be regarded, I think, as a synonym of *Delphinus commersonii*, which, although described inadequately and without illustrations, appears to be perfectly recognizable in the light of the evidence now available'.

SYNONYMY

Cephalorhynchus commersonii (Lacépède 1804)

Delphinus Commersonii	Lacépède, 1804, p. 338. Sonnini, 1812, p. 436. Desmarest, 1817, p. 166; 1820, p. 517; 1822, p. 517 (not seen). Desmarest and Dumeril, 1833, p. 309. Cuvier, 1836, p. 217. Gay, 1847, p. 176. Gray, 1846, p. 44. Murray, 1866, p. 340.
delphinus Commersonii	Lesson and Garnot 1826, p. 181.
Phocoena commersonii	Lesson, 1827, p. 414 (not seen).
Delphinus bivittatus	Cunningham, 1868, p. 185; 1871, p. 128. (non *D. bivattus* Lesson, 1827 = *L. cruciger*)
Lagenorhynchus floweri	Moreno, 1892, p. 383. Lahille, 1899, p. 201; 1905, p. 62. Trouessart, 1897, p. 1,038. Dabbene, 1902, p. 350.
Lagenorhynchus floweri	Moreno: Beddard, 1900, p. 267. Trouessart, 1904, p. 767.
Lagenorhynchus Burmeisteri	Moreno, 1892, p. 390. (*Nomen lapsus* for *L. floweri*)
Lagenorhynchus cruciger?	Bruce, 1915, p. 501. (non *Delphinus cruciger* Quoy and Gaimard, 1824) (non *L. cruciger* d'Orbigny and Gervais,1847)
Cephalorhynchus commersonii	(Lacépède). Harmer, 1922, p. 629.

Common names

The species *Cephalorhynchus commersonii* has been known by various common names (see Table 1). In this paper we use Commerson's dolphin (following IWC, 1977) and *tonina overa* as the preferred names in English and Spanish, respectively.

Materials available for the present study

We can account for 76 published records of sightings of Commerson's dolphins in the South Atlantic between December 1767 and February 1984 (Table 2, Fig. 2) and 138 new sighting records from 1943 to May 1984 (Table 3, Fig. 3). The significant increase in sightings in recent years reflects increased interest in cetaceans and increased use of waters of southern South America by persons interested in cetaceans and not necessarily an increase in population size. In

Table 1
Common names for *Cephalorhynchus commersonii*

Name	Source/Comments
Le Jacobite	
Le Marsouin Jacobite	Commerson's original name (Lacépède, 1804).
Dauphin de Commerson	Desmarest (1817 p.166); Cuvier (1836 p.217).
Jacobite	Gray (1846).
Bridled dolphins	Cunningham (1871 p.128).
Delfín blanco	Lahille (1905 p.62) quoting the work of Moreno (1892) who did not assign a common name; Marelli (1953 p.137).
Ground porpoise	Bruce (1915), citing name used by crew of the Balaena.
Piebald porpoise	Bruce (1915).
Commerson's dolphin	Harmer (1922 p.627); most widely accepted and widely used (eg. Brownell, 1977 p.483).
Springer	Hart (1935 p.253), referring to whalers' names for dolphins, thought to be this species and Lagenorhynchus cruciger, off South Georgia.
Tonina, tonina overa or delphin de Commerson	Currently in Argentina and Southern Chile; tonina (for dolphin), overa (for black and white, and not egg colored, as sometimes reported).
Tonina blanca y negra and delfín blanco	Marelli (1953 p.137).
Tunina overa	A variation of tonina overa (Mann Fischer, 1957 p.103; Aguayo and Torres, 1967 p.8; Aguayo, 1975 p.1,124).
delphín de Magallanes	Aguayo (1975 p.1,124), from its abundance in the Strait of Magellan.
White belted porpoise	Gilmore (1969 p.307).
Piebald dolphin	Gilmore (1969 p.307); Rice (1977 p.9); Watson (1984 p.248).
Skunk dolphin(s)	Grzimek (1975, quoted in Ellis, 1982 p.127) - suggested for the genus (Goodwin, 1966).

addition, we are aware of 349 specimens of *Cephalorhynchus commersonii*, 77 from various, mostly published, sources from December 1876 to 1984 (Table 4, Fig. 4a) and 272 from collections by the authors from October 1972 to December 1984 (Table 5, Fig. 4b). All but eight of the authors' specimens were collected from Tierra del Fuego; 102 of 272 were fresh specimens from which measurements and soft tissues were obtained for study. During the first few years of the Tierra del Fuego stranding salvage program, spectacled porpoises, *Australophocoena dioptrica*, were found most often (Goodall, 1977, 1978), but as of 1 January 1985, after eight years, the collection included more specimens of Commerson's dolphin than of any other of the 20 species of small cetaceans known to date from subantarctic waters of South America.

[*Figs 2–4 and Tables 2–5 appear on the following 19 pages. Text begins again on p. 29.*]

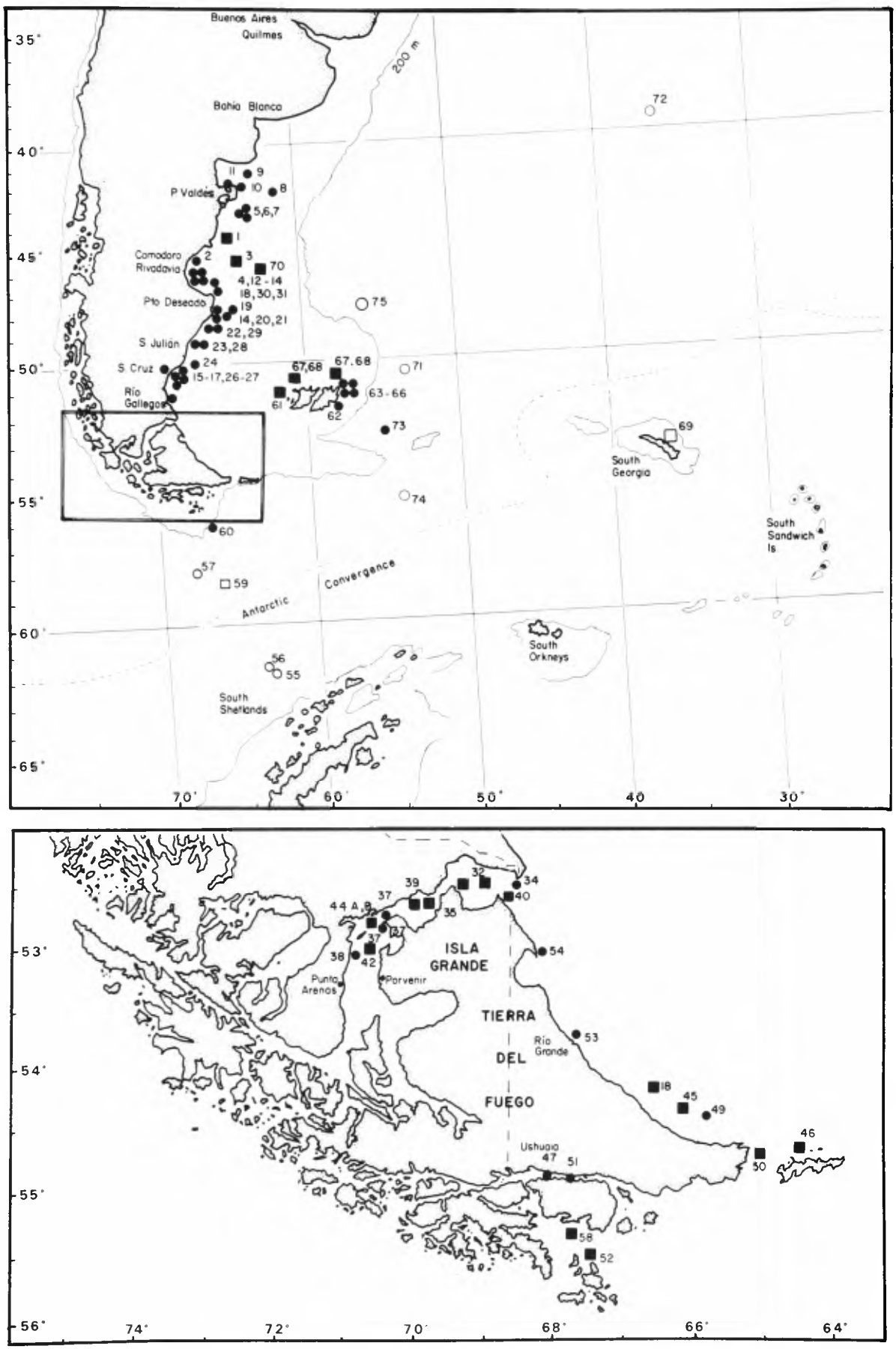


Fig. 2. Published sightings of Commerson's dolphins off South America, December 1867 through February 1984 (reported as exact localities ● or general areas ■; ○ = doubtful sightings of 'piebald porpoises' reported by Bruce, 1915, discussed in text). For details see Table 2.

Fig. 3. Unpublished sightings of Commerson's dolphins off South America, 1943 through May 1984 (reported as exact localities ● or general areas ■). The dotted line in the upper right inset indicates the major shipping lanes in the northeastern Strait of Magellan, along which there are frequent sightings. The gridded area shows where sightings were made during surveys from aircraft, vessel, and shore, January–February 1984. For details see Table 3.

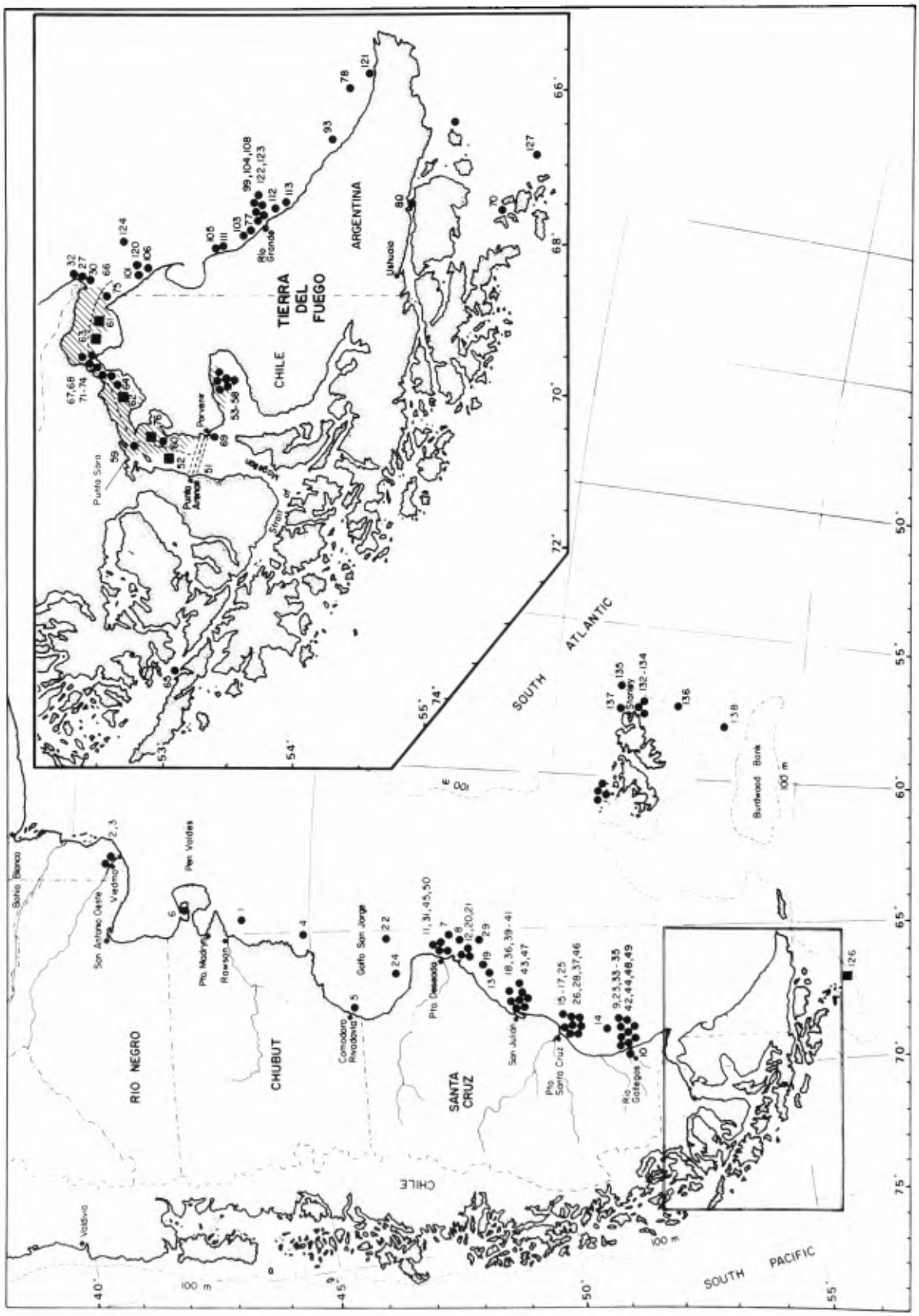


Table 2

Published sightings of Commerson's dolphins, off South America by region, arranged in chronological order (see Fig. 2)

B = bahía, bay; R = río, river; P = punta; G = golfo; I = ísla, island; C = cabo, cape; T = Tierra; pc = personal communication. All dates are twentieth century, except [1] nineteenth century; [2] eighteenth century.

No.	Date	Locality	Comments	Platform	Source
Rio Negro and Chubut, Argentina					
1)	— 12 76[1]	'off Chubut'	Group seen & specimen harpooned by Piedrabuena (lost later)	Santa Cruz	A
2)	— 03 31	Puerto Vissar, N of Comodoro Rivadavia	2 sighted, 'porpoises common here'	Shore	B
3)	29 03 44	2 days N of Puerto Deseado	Accompanied ship all day; seen many times	Transporte Patagonia	C
4)	pre-1960	Comodoro Rivadavia	'Chasing fish at base of pier'	Shore?	D
5)	16 07 69	E of Rawson 43°18S, 64°53W	2 animals, 1010hrs	Hero	E, F
6)	16 07 69	E of Rawson 43°20S, 64°55W	2 animals, 1035hrs	Hero	E, F
7)	16 07 69	E of P. Lobos 43°41S, 64°56W	1 animal, 1040hrs	Hero	E, F
8)	21 06 71	20 mi E P. Norte, Península Valdés, 42°00S 63°30W	3 seen by Cummings 1030hrs	Hero	F
9)	29 06 71	SW of Viedma 41°26S, 63°00W	2 seen by Cummings, 1520hrs	Hero	F
10)	pre-1975	P. Norte, Peninsula Valdes	'in winter' (Payne pc to Mead)	Shore	G
11)	11 02 76	G. San Jose	1 swimming nr 3 P. spinipinnis	Shore	H, I
12)	— 01 77	Comodoro Rivadavia, 45°52S, 67°29W	Studied all January; max harbor census 61 incl. 11 calves; largest group seen = 31	Shore	I
13)	01/02 80	Comodoro Rivadavia harbor	Census on 28 January = 18	Shore	I
14)	01/02 80	Chubut & Santa Cruz	Many observations	Shore, boats	J, pc
Santa Cruz, Argentina					
15)	— 10 74[1]	B. de R. Santa Cruz Mt Entrance	'Hundreds' accompanying the ship day & night, L. floweri	Rosales	K
16)	— 12 76[1]	Santa Cruz	Sightings : one specimen killed by Piedrabuena (lost by crew)	Santa Cruz	K
17)	? 01 96[1]	I. Pavón	L. floweri (observed by Lahille? or earlier observation of Moreno?)		L
18)	Spring 28	S of Co. Rivadavia	Group jumping, 1 harpooned for food	Feuerland	M
19)	19 07 69	Off C. Blanco, 47°25S 65°39W	1 animal, 1254hrs	Hero	E, F
20)	19 07 69	Off C. Blanco, 47°35S 65°45W	1 animal, 1410hrs	Hero	E, F
21)	21 07 69	Mouth of R. Deseado 47°55S 65°40W	2 animals, 0839hrs	Hero	E, F
22)	21 07 69	Off B. Laura, Roca Bellaco 48°35S 66°46W	1 animal, 1615hrs	Hero	E, F
23)	22 07 69	S of San Julián 49°35S 67°39W	1254hrs	Hero	E, F
24)	23 07 69	N of Santa Cruz 50°04S 67°40W	1 animal, 1005hrs	Hero	E, F
25)	24 07 69	S of R. Santa Cruz 51°35S 68°58W	1 animal, 1500hrs	Hero	E, F
26)	26 07 69	Mouth of R. Santa Cruz 51°39S 68°25W	2 animals, 1241hrs	Hero	E, F
27)	26 07 69	Mouth of R. Santa Cruz 51°39S 68°25W	1 animal, 1245hrs	Hero	E, F
28)	13 06 71	B. San Julián 49°20S 67°40W	2 animals, 1200hrs	Hero	F
29)	15 06 71	S Roca Santa Cruz 48°53S 66°15W	3 animals, 1543hrs	Hero	F
30)	11/12 78	B. San Jorge, between Pto Deseado & Co. Rivadavia	Small groups up to 20, 6 captured, taken to Duisburg Zoo	Speed-boat	N
31)	— 12 78	Puerto Deseado?	4 captured for Sunshine Aquarium confiscated in New York, 15 Dec		O

[*continued*]

Table 2 (*continued*)

Strait of Magellan, Chile				
32) — 12 67[2]	Near Tierra del Fuego & Strait of Magellan	Observed by P. Commerson, ms. to Buffón, who sent it to Lacépède	Boudense, Etoile	P
33) — 01 67[1]	Strait of Magellan	Sightings recorded as Delphinus bivittatus	Nassau	Q
34) 16 01 67[1]	W side of P. Dungeness	'bridled dolphins (Delphinus bivittatus)' seen around ship & on 'several subsequent occasions'	Nassau	R
35) Pre-1922	Strait of Magellan	Photo of 2 by Lionel Adams. 'Hundreds .. played around ship'		S
36) Pre-1946	Channels & Atlantic coast	'Frequently seen'		T
37) 10 12 68	NE of B. Gente Grande & in Second Narrows 52°57S 70°12W	'hoards ... all day long'. 2 specimens captured. Photos in Barrett, Aguayo. Sounds recorded.	Hero	U, V, W, X
38) 12 08 69	P. Arenas 53°07S 70°50W	2 animals	Hero	E, F
39) 15 05 -06 07 70	Strait of Magellan	'seen only in central Strait of Magellan'	Hero	E
40) 11 06 -16 07 71	In open ocean near E entrance of & in Strait of Magellan	'several groups'	Hero	Y
41) Pre-1973	No locality (probably Strait of Magellan)	Photos by F. Erize		Z, AA
42) 21 02 73	Strait of Magellan	4 animals, 0830hrs		X
43) 1973?	No locality	2 groups of a dozen each	Calypso	BB
44) 10 02 78	C. Valentin, I. Dawson 53°33S 70°25W	5 animals, 1445hrs		CC
44a)11/12 83	Near P. Sara, NE Strait of Magellan	Frequent sightings, individuals & herds, by US capture crew	Shore, vessel	DD
44b)— 01 84 - — 02 84	Near P. Sara, NE Strait of Magellan	Frequent sightings by capture crew, Duisburg Zoo	Shore, vessel	EE
Tierra del Fuego, Argentina				
45) 10 01 69[2]	ENE coast, S of R. Grande	Shoal observed by Joseph Banks in evening 'leaping nimbly'	Endeavour	FF
46) ? 03 96[1]	I. de los Estados	Observations by Lahille? 9-16 March in Fuegian waters	Transporte Ushuaia?	L
47) 11/12 48	Canal de Beagle	2 sighted twice in the area	Cutter	GG
48) Pre-1953	Coasts of Tierra del Fuego	Photos of 4 animals by Tte. de Navio Lorenzo Buasso		HH
49) 22 04 71	SE Tierra del Fuego 54°20S 65°20W	1 animal seen (+/- 10°long.)	Hero	II, JJ, KK
50) — 10 71	NE of Strait of La Maire	Photo by Mead Cabot	Hero	JJ
51) 1972	Canal de Beagle	Seen by A.F. Fernandez		JJ
52) 20 02 73	N of Wollaston I.	2 seen by Aguayo & Maturana, 1038hrs		X
53) 29 01 74	4km N of R. Grande	Photo by M. Canevari	Shore	LL
54) 13 04 74	Península Páramo	Swimming near the beach	Shore	LL
Drake Passage				
55) 27 02 66	NW Livingston I. 61°59S 63°05W	1 animal, 1738hrs (photo in Aguayo, 1975)	Yelcho	MM, X
56) 27 02 66	NW Livingston I. 61°50S 63°17W	12 animals, 1900hrs	Yelcho	MM, X
57)28 02 66	S of Hermite I. 58°10S 67°58W	5 animals, 1730hrs	Yelcho	MM
58) 04 12 72	S of Navarino I.	2 seen by Aguayo & Maturana, 2130hrs		X
59) 05 12 72	Drake Passage (no co-ordinates)	3 seen by Aguayo & Maturana. 1900hrs		X
60) — 02 78	40 miles SE of Cape Horn	12 in stern wake. USCG ice-breaker Glacier. Film by J.W. Coste, Jr		NN, OO, pc

Source

A	Moreno, 1892: 383	D	Cabrera & Yepes, 1960: 114	F	Brownell & Praderi, 1985: 157
B	Simpson, 1965: 254	E	Gilmore, 1969: 307 and/or 1971: 10	G	Daciuk, 1974: 31
C	Uriburu, 1945: 25			H	Würsig *et al.* 1977: 73

Table 2 (*continued*)

Falkland (Malvinas) Islands				
61) 1824?	'Iles Malouines'	Specimen killed but sank immediately	Uraine Physicienne	PP
62) 1822-5?	B. de Soledad	Observed 'only once'	La Coquille	QQ
63) 11 12 92[1]	3 miles off Cape Pembroke 51°49S 57°35W	'Piebald porpoises'. Temp 40.7F (Originally cited as Lagenorhynchus cruciger)	Balaena	RR
64) 11 12 92[1]	Port William 51°40S	'Piebald porpoises'. Temp 40.7F (probably same sighting as above)	Balaena	RR
65) 03 03 93[1]	Port Stanley 51°42S 57°51W	Piebald porpoise caught in net, skeleton to University College, Dundee, lost. (Originally cited as Lagenorhynchus cruciger)	Balaena	RR
66) 07-27? 01 03	Port Stanley 51°42S 57°51W	'Piebald' seen several times. Temp. 44.6F (cited as Lagenorhynchus cruciger)	Scotia	RR
67) Post 1922	Falkland Islands	'Well known, commoner on W. side than E.'	Shore	SS
68) 1959 -72	Falkland Islands	'Probably the most common (dolphin)'	Shore	TT
South Georgia				
69) Pre-1935	South Georgia	Many sightings of dolphins around South Georgia; called 'springers' (seen by Rayner?)		UU
SW Atlantic, off shore				
70) 10 11 67[1]	200 miles off Patagonia	'Black and white porpoises tearing through the water'	Nassau	R
71) 06 03 93[1]	NE Islas Malvinas 50°35S 53°53W	'Porpoises (piebald?)' (Originally cited as Lagenorhynchus cruciger)	Balaena	RR
72) 16 03 93[1]	E of Viedma 39°28S 36°48W	'Porpoises (piebald?)' (Originally cited as Lagenorhynchus cruciger)	Balaena	RR
73) 27 01 03	SE Malvinas 52°55S 55°00W	'Several piebald porpoises seen. Temp. 44.6F' (Originally cited as Lagenorhynchus cruciger)	Scotia	RR
74) 11 02 04	SE Islas Malvinas 55°47S 54°19W	'School of porpoises (probably piebald) seen in evening. Temp. 39.8F'. (Originally cited as Lagenorhynchus cruciger)	Scotia	RR
75) 04 01 03	47°37S 57°25W	'Black on the back and white on the belly'	Scotia	RR
76) 14 04 04	S of Gough Island 46°35S 10°10W	'Porpoises (probably piebald)' (Originally cited as Lagenorhynchus cruciger)	Scotia	RR
77) 18 04 04	S of Gough Island 43°21S 08°30W	'White, piebald and black porpoises' (Originally cited as Lagenorhynchus cruciger)	Scotia	RR

Source

I	Mermoz, 1980	V	Watkins and Schevill, 1980: 738	HH	Marelli, 1953
J	Gewalt, 1980: pers. comm.	W	Barrett, 1970: 21	II	Bridge & Angle, 1971
K	Moreno, 1892: 383	X	Aguayo, 1975: 1124 (photo)	JJ	Brownell, 1974
L	Lahille, 1899: 201	Y	Cummings *et al.* 1971: 268	KK	Pine *et al.* 1978: 108
M	Plüshow, 1930: 137	Z	Anonymous, 1973	LL	Castello, 1974: 3
N	Gewalt, 1979: 37	AA	Stephen, 1973	MM	Aguayo & Torres, 1967: 8
O	Anonymous, 1978	BB	Duguy, 1973: 5	NN	Ellis, 1980: 127
P	Lacépède, 1804: 338	CC	Sielfeld & Venegas, 1978: 147	OO	Coste Jr, pers. comm.
Q	Cunningham, 1868: 185	DD	Cornell *et al.* 1987	PP	Quoy & Gaimard, 1824: 87
R	Cunningham, 1871	EE	Thielke, 1984	QQ	Lesson, 1827: 181
S	Harmer, 1922: 629	FF	Beaglehole, 1963: 214	RR	Bruce, 1915
T	De Agostini, 1946: 108	GG	Olrog, 1950: 509	SS	Hamilton, 1952
U	Norris, 1968 (field notes)			TT	Strange, 1972: 215
				UU	Hart, 1935: 253

Table 3

Unpublished sightings of Commerson's dolphins off South America by region, arranged in chronological order (see Fig. 3). The key to 'Observer' is on p. 20

No.	Date	Locality	No. and Comments	Platform	Observer
Rio Negro and Chubut, Argentina					
1)	17 07 78	Punta Quiroga, Golfo de San Matías 43°45S 64°40W	4	Hero	1
2)	— 09 79	Viedma, 30km up river	Seen often	Shore	2
3)	1980–84	Viedma and up Río Negro	Seen in river, especially in Aug–Sept	Shore	3
4)	05 08 82	Off Cabo Dos Bahías 44°57S 65°01W	4: rode bow wave	Hercules	4
5)	12 11 83	Comodoro Rivadavia	2: near shore with swimmers and boats	Shore	5
6)	— 01 84	Península Valdés, mouth of Río San Jose	Large groups (R. Bastida pc)	Various	6
Santa Cruz, Argentina					
7)	20 11 72	S of Cabo Blanco 47°25S 65°25W	5: 2 & 3 individuals 13 miles offshore	Calypso	7
8)	21 11 72	2 miles E Islas Pinguinos 47°55S 65°40W	10: groups of 2–3, 1 isolated	Calypso	7
9)	— 05 75	Mouth of Río Gallegos	4–8: off and on in early AM and evening, photographs	Hero	8
10)	23 12 77	Port of Río Gallegas	All day, several animals	Caribbean, Klif	9
11)	— 01 78	Ría de Puerto Deseado	8: seen for 30 min.	Boat	10
12)	24 04 78	B. de los Nodales	3: seen briefly	Shinkai Maru	11
13)	25 04 78	Cabo Vigía 48°38S 66°13W	2	Shinkai Maru	11
14)	11 07 78	10 miles N of Río Gallegos 51°21S 68°53W	3: seen for 2 hours	Hero	1
15)	12 07 78	Barrancas Santa Cruz 50°12S 68°23W	In surfline, one hour before high tide	Hero	12
16)	13 07 78	Río Coig–Río Santa Cruz 50°22S 68°40W	1: windward side of vessel	Hero	1
17)	13 07 78	4–5 miles off Río Santa Cruz 50°12S 68°13W	2–3: seen within 30 min	Hero	1
18)	14 07 78	12 miles S Cabo Danoso 19 miles ENE C. Curioso Santa Cruz 49°03S 67°10W	1: seen within 1–2 min	Hero	1
19)	14 07 78	C. Danoso–C. Vigía 48°48S 66°51W	2	Hero	1
20)	15 07 78	Caleta Los Lobos, B. de Los Nodales 47°57S 65°52W	1?	Hero	12
21)	16 07 78	2.3 miles SE of Isla Pinguino, B. de Los Nodales 47°57S 65°41W	3	Hero	12
22)	16 07 78	36 miles N Cabo Tres Puntas, Golfo San Jorge 46°37S 65°19W	6–8	Hero	1
23)	12 05 79	Río Gallegos, Cabo Buen Tiempo	12: seen for 15 min	Canal Beagle	13
24)	01 01 80	Coast of Patagonia 46°50S 65°50W	7: three pairs and one single	Bransfield	14
25)	— 05 81	Punta Quilla, near Santa Cruz	Several: mostly at night	Kristen Bravo	15
26)	14–26 06 81	Río Santa Cruz, de Punta Quilla a Pto Santa Cruz	Several: played around zodiacs	Yehuin	16
27)	20 06 81	B. between Cabo Vírgenes & Punta Dungeness	5: just beyond breakers	Shore	17
28)	10 11 81	Río de Santa Cruz 50°20S 68°20W	10: in groups, seen here all year	Canal Beagle	18
29)	06 08 82	S of Río Deseado 48°02S 65°42W	3: rode waist on windward side	Hercules	4
30)	20 03 83	8km S of Cabo Vírgenes	4–5: pairs following zodiacs crossing Strait of Magellan	Zodiac	19

Table 3 (*continued*)

No.	Date	Locality	No. and Comments	Platform	Observer
31)	21 05 83	Río de Puerto Deseado	3: accompanied kayak	Kayak	20
32)	11 11 83	Cabo Vírgenes	2+: near shore	Shore	5, 21 22 23
33)	13 11 83	Río Gallegos	1: in the river	Prefectura launch	21
34)	13 11 83	Río Gallegos	1: in the river	Prefectura launch	21
35)	14 02 84	Punta Loyola, Río Gallegos	3: played at stern of anchored vessel	Aquamarine	24
36)	— 04 84	Bahía San Julián	100+: Playing with sailboats, jumping	Sailboat	10
37)	01 05 84	Río Santa Cruz	2: swimming up river	Shore	25
38)	02–05 05 84	Puerto San Julián	100+: seen all over the area	Shore	26
39)	02–05 05 84	Puerto San Julián	10: several followed the boat	LS 11204 launch	crew
40)	02–05 05 84	Balneario Bco. Justicia, San Julián	Several, in groups accompanied ship	LS 11204 launch	crew
41)	02 05 84	Puerto San Julián	20: several, in groups accompanied ship	LS 11204 launch	crew
42)	02 05 84	Río Gallegos 51°35S 69°04W	10–12: accompanied ship	Vito	27
43)	03 05 84	Baliza Gancho, Puerto San Julián	8–15: accompanied ship	PNA launch	28
44)	04 05 84	Río Gallegos 51°34S 69°04W	40–50 Accompanied ship	Maria del Carmen	29
45)	05 05 84	Ría Puerto Deseado	2: unusual jumps	Kayak	10
46)	08 05 84	Río Santa Cruz	4: lobtailing	Shore	30
47)	09 05 84	Loyola, Puerto San Julián	6: accompanied ship	LS 11202 launch	31
48)	10 05 84	Puerto Río Gallegos	4: jumping, very noisy	Shore	32
49)	13 05 84	Punta Quilla, Puerto Santa Cruz	3: jumping, swimming under pier	Lago Colhue	33
50)	14 05 84	Ría Puerto Deseado	3: accompanied ship	Lago Argentino	crew
Strait of Magellan, Chile					
51)	1943–49	From Punta Arenas to Porvenir and return	100s: seen most of the way across 8–12 hr trips twice a year. Always 20–40.	Porvenir Minerva Tamar, Gaviota	8, 34
52)	04 02 68	N of Punta Arenas	100: or more with C. eutropia? Field painting in diary	Navarino	35
53)	13 12 68	Head of Bahía Inútil 53°29S 69°24W	7: 5 miles offshore		36
54)	13 12 68	Head of Bahía Inútil 53°34S 69°48W	2: photo		36
55)	15 12 68	Head of Bahía Inútil 53°31S 69°32W	3		36
56)	15 12 68	Bahía Inútil 53°30S 69°30W	4		36
57)	15 12 68	Bahía Inútil 53°25S 69°22W	1		36
58)	15 12 68	Bahía Inútil 53°29S 69°23W	6		36
59)	11 10 71	Western entrance to First Narrows	1: sketch by Goodall	Hero	5
60)	17 02 72	10–15km NE of Punta Arenas	1: diary, photo	Hero	37
61)	06 04 72	Atlantic end	2–4: Photos	Hero	38
62)	27 12 73	Primera & Segunda Angostura	75: Groups of 1 to 5, one mother with young		39
63)	06 04 76	Strait of Magellan	Photographs	Hero	37
64)	06–11 04 76	Between First and Second Narrows	Up to 24 animals on & off 10 days, never less than 5–6, photographs	Hero	8 1
65)	19 07 76	Entrance Puerto Churruca Isla Desolación	4–6	Hero	1
66)	11 09–01 10 77	Punta Arenas to Mouth of Strait of Magellan	6–10: every day, seismographic ship	Western Shoal	40 41

[*continued*]

Table 3 (*continued*)

No.	Date	Locality	No. and Comments	Platform	Observer
67)	19 11 77	First Narrows	6–7: seen within 15 min.	Barcaza	42 43
68)	03 05 78	First Narrows	2: seen within 20 min.	Barcaza	44
69)	24 01 79	Punta Chilota, B. Porvenir	3: near dock	Milinka	45
70)	03 03 80	Canal between Bayly and Grevy Islands	2		46
71)	21 11 80	Strait of Magellan	6: first 4 together, 6 later	Barcaza	47
72)	30 11 80	Bahía Azul, First Narrows	12?: photograph	Patagonia ferry	47 48
73)	20 12 80	Punta Delgada, First Narrows	2: photograph	Barcaza	22
74)	07 03 83	Bahía Azul, First Narrows	4: 2,2	Barcaza	49
75)	20 03 83	Mouth of Strait of Magellan, 1400hrs	6: 2,2,2, rode bow of zodiac	Zodiac	20
76)	04 01 84	Strait of Magellan	2: photographs riding bow waves	Lindblad Explorer	50
Tierra del Fuego, Argentina					
77)	01/02 49	Caleta La Misión	Several animals accompanied several hours a day within one week	Ara Madryn	51
78)	12 10 71	Off Punta Noguera	5–6: 2 groups, 3 together, several separate, sketch	Hero	5
79)	13 04 74	Península Páramo, midway Atlantic side	2: riding waves on beach, 10–15 minutes		5, 52
80)	Fall 74	Near Gable Island	2:	Angel B	53
81)	21 12 75	Punta de Arenas, Península Páramo	2: feeding, seen during 20 min.	Shore	5, 54
82)	21 11 77	Near lighthouse, Península Páramo	4: feeding, 2 groups	Shore	5, 55 56
83)	18 01 78	6.5 miles from Isla Nueva	1: going fast, seen for 10 sec	Hero	1
84)	28 01 78	Near lighthouse, Península Páramo	4–2: groups seen for 10 min.	Shore	5, 54 57
85)	29 11 78	B. San Sebastián 53°15S 68°01W	6–8	Fueguino	58
86)	09 12 78	B. San Sebastián 53°17S 68°16W	6–8	Fueguino	58
87)	15 12 78	B. San Sebastián 53°17S 68°15W	6–8	Fueguino	58
88)	07 01 79	Fishing Post, Península Páramo	4: 2,2	Shore	59
89)	08 01 79	Bay to N of lighthouse, Península Páramo	5: 2,2,1	Shore	5, 55
90)	08 01 79	Mussel Bank, W side of Península Páramo	2	Shore	5, 55
91)	11 03 79	Punta de Arenas, B. San Sebastián	3–4	Fueguino	56
92)	14 02 81	Península Páramo	2	Shore	
93)	29 03 81	N of Estancia Fueguina	4: seen from 500ft, 2,2	Helicopter	5, 58 17
94)	14–17 04 81	Península Páramo, near tip	15–20	Shore	
95)	19 04 81	Península Páramo, near tip	5–20: in groups of 2 close to shore	Shore	60, 67
96)	01–15 05 81	2 miles offshore, S side Bahía San Sebastián	Up to 50 at a time, 3–4 groups	Oil rig Rico I	61
97)	— 05 81	Bahía San Sebastián	Played around boats, rig and ropes	Oil rig Rico I	62
98)	— 05 81	Bahía San Sebastián	100: 'Hundreds' all over the bay	Yaktemi	63
99)	— 07 81	Port of Río Grande	4: River mouth	Yaktemi	63
100)	04 08 81	Rancho Tadich, Península Páramo	1+	Shore	5, 17
101)	— 11 81	Off Río Cullen	15: playing with sea gulls	Oil Rig Rico I	64

Table 3 (*continued*)

No.	Date	Locality	No. and Comments	Platform	Observer
102)	18 01 82	B. San Sebastián	5–7 Groups of 2–3	Yaktemi	65
103)	24 01 82	Caleta La Misión 53°41S 67°49W	2 Adult with greyish young	Yaktemi	65
104)	— 02 82	Mouth of Río Grande	Several: went up river after a school of fish	Shore	60
105)	14 02 82	Punta Sinaí, Estancia Sara	1	Shore	66
106)	13 03 82	Río Cullen S.	1: near shore. Respiration rate recorded	Shore	5, 21
107)	14 03 82	Punta de Arenas, Península Páramo	12–15: groups of 3–4, surfing in waves	Shore	5, 21
108)	27 03 82	Río Grande, near mouth	7–12: groups of two, in river channels at low tide	Shore	68
109)	10 10 82	B. San Sebastián 53°16S 68°16W	3–4: 2,2	Yaktemi	65
110)	23–26 11 82	B. San Sebastián 53°17S 68°14W	6–8: groups of 2–3 with Lagenorhynchus australis	Yaktemi	65
111)	18 12 82	Puesto 17, Estancia Sara	2–4: surfing in waves	Shore	5, 69
112)	— 03 82	Cabo Peñas	0–12 In groups of 1,2,3	Shore	70
113)	11 01 84	Punta María	1: seen near shore	Shore	71
114)	13 01 84	Rancho Tadich	2	Shore	21,72 73
115)	14 01 84	Los Chorrillos B. San Sebastián	1: swimming near shore	Shore	73 72
116)	14 01 84	Los Chorrillos, B. San Sebastián	1: swimming near shore	Shore	73 72
117)	14 01 84	Los Chorrillos, B. San Sebastián	1: swimming near shore	Shore	73 72
118)	01 02 84	Río Grande, Estación ACA	4–6: swimming in breakers	Shore	24
119)	14 03 84	E of Península Páramo	1	Shore	24
120)	14 03 84	3km S of Río Cullen	2–3: near shore	Shore	24
121)	30 03 84	Mouth of Río Luz	1: in the breakers	Shore	21
122)	07 04 84	Rada Río Grande	1: approached boat, very curious	Motor boat	74
123)	08 04 84	Río Grande	2: approached boat	Motor boat	74
124)	28 04 84	Offshore of Río Cullen	6: crossed bow toward shore	Hero	75
125)	10 05 84	B. San Sebastián	3: playing around ship	Yaktemi	76
Drake Passage					
126)	— 02 77	Well S of Cape Horn	2: swimming N, fast, ahead & alongside bow	Lindblad Explorer	77, 78
127)	01 01 78	NE Cape Horn 55°56S 66°56W	3	World Discoverer	37
Falkland (Malvinas) Islands					
128)	07 12 77	Carcass Island, 51°30S 47°40W	3–5: several groups followed zodiacs	Lindblad Explorer	79
129)	09 12 77	Carcass Island,	30–40: escorting zodiacs, 6 hours	World Discoverer	80
130)	20 01 78	Carcass Island,	5: escorted boats	World Discoverer	81
131)	30 12 78	Carcass Island	12: escorted zodiacs, 2 hours. Photographs.	Lindblad Explorer	82 77
132)	20 12 79	Port Stanley	1	Shore	14
133)	28 12 79	Port Stanley Harbor	3: 2 animals; later 1 followed launch	Bransfield	14
134)	03 01 80	Port Stanley	2	Bransfield	14
135)	28 01 80	Malvinas 51°30S 57°40W	100: schools of 5–25 over a a period of 4 days	John Biscoe	83
136)	? 01 80	Malvinas, 20 miles E. 52°53S 57°50W	4: swam with ship	John Biscoe	84
137)	12 12 80	Port Stanley	4 Followed zodiacs	John Biscoe	85, 86
South Atlantic Ocean					
138)	11 01 79	N of Burdwood Bank 53°35S 57°20W	3 Seen for 1 min	Hero	87

[*continued*]

Table 3 (*continued*): key to observers

1	Polkinghorn	30	H. C. Aguirre	59	R. Gomez
2	J. P. Frontroth	31	J. R. Zapata	60	S. Blanchard
3	F. Fuentes	32	J. Quintana	61	N. Signori
4	E. C. de Ilzarbe	33	M. A. Mendez	62	J. Meyerrick
5	N. Goodall	34	C. M. B. Goodall	63	Capt. Girardoni
6	J. M. Musmeci	35	P. Scott (diary)	64	W. Boreing
7	R. Duguy	36	W. Lester	65	G. Zimmermann
8	T. D. Goodall	37	F. J. Fell	66	J. M. Ayerza
9	V. R. Gomez	38	J. Fell	67	M. Blanchard
10	M. Oliva Day	39	R. P. Schlatter	68	K. & F. Thompson
11	F Del Giudice	40	S. Dean	69	L. Michelli
12	W. K. Wilson	41	J. Thompson	70	J. D. Flores
13	R. Simian	42	F. García Marcos	71	Fisherman
14	R. Davis	43	I. Ximenez	72	J. Castañon
15	J. H. Henkes	44	A. Scolaro	73	A. Travaini
16	P. M. de Ilzarbe	45	J. Perkins	74	L. A. Gallardo
17	K. Laubscher	46	W. Sielfeld	75	G. D. Jenks
18	A. Messidoro	47	K. Watanabe	76	G. A. Marcos
19	D. E. Ruiz	48	J. Zagun	77	K. Shackleton
20	M. E. Oliva Day	49	A. Luna	78	A. Bachelor
21	A. R. Galeazzi	50	D. Larsen	79	T. Ritchie
22	A. P. Sobral	51	E. Gonzalez Lonzieme	80	J. Green
23	M. A. Arana	52	H. P. Castello	81	R. Straneck
24	J. M. Marcenaro	53	J. McFedyen	82	D. Puleston
25	N. Villamayor	54	A. J. Goodall	83	S. Norris
26	N. D. Lasalvia	55	I. S. Cameron	84	R. Wade
27	J. R. Rogel	56	J. A. C. Armendariz	85	D. Fletcher
28	A. R. Barreyro	57	P. Laura	86	A. Baker
29	G. Garate	58	G. Muriel	87	N. Bernstein

Table 4 (on the following three pages)

Specimens of *Cephalorhynchus commersonii* from South America by region, arranged in chronological order within region.

Data are from various sources (see Fig. 4A). Total lengths (TL) are listed as published. Other notations mean the following: ( ) = measurement taken over the curve; (–)? = measurement probably taken over the curve; 'skull' = cranium with mandibles. Museum codes used: BMNH, British Museum (Natural History); USNM, US National Museum of Natural History; MLP, Museo de la Plata; MACN-BA, Museo Argentino de Ciencias Naturales, Buenos Aires; RNP, Collection of R.N.P. Goodall in Ushuaia; CNP, Centro Nacional Patagonico, Puerto Madryn, Chubut; IPPA, Instituto de la Patagonia, Punta Arenas; PSU, Portland State University, Portland, Oregon; SM-F, Senckenberg Museum, Frankfurt; KM-B, Konig Museum, Bonn. All dates are twentieth century except [1] nineteenth century and [2] eighteenth century. The key to the references is on p. 23.

No.	Specimen no.	Locality	Date	Specimen	Details and notes	Sex	TL (cm)	CBL (mm)	References
Patagonia, Argentina									
1)	_	Puerto Santa Cruz	— 12 76	Drawing	Harpooned by Capt L. Piedrabuena. Specimen thrown away by crew (Moreno specimen A)	F	129 (138)	-	1, 2
2)	_	Off Chubut	— 12 76	-	Harpooned by Piedrabuena, thrown away by crew (Moreno specimen B), drawing is type of Lagenorhynchus floweri	-	-	-	1
3)	-	Santa Cruz or Tierra del Fuego	— — 80? (bought 80)	No specimen	Poorly preserved skin coll. by Tonini del Furia (Moreno specimen C)	M	130	-	1
4)	MLP 1480	Santa Cruz or Tierra del Fuego	— — 80?	Skull	'Incomplete, found along shore'. Cranium with 27+ teeth, (Moreno specimen D). Type skull of L. floweri. Mandible does not belong	-	-	- 287	1 3
5)	MLP -	Santa Cruz or Tierra del Fuego	— — 80?	Cranium	Smaller than above, without teeth (Moreno specimen F)	-	-	-	1
6)	-	Santa Cruz or Tierra del Fuego	— — 80?	Skin	Skin of very young female (Moreno specimen E)	F	77	-	1
7)	BMNH 1952.6.20.4	9nm E Río Gallegos 51°35S 68°44W	10 01 32	Complete skeleton	Harpooned from HMS William Scoresby mature, 50kg, cast in Whale Hall	F	(147.3)	299	4, 5, 6
8)	MACN-BA	Playa La Angelina	20 12 73		Taken incidentally in centolla net, coll. H.P. Castello	-	-	-	3
9)	MACN-BA	Rio Gallegos	27 12 73		Taken incidentally in robalo net, coll. H.P. Castello	-	-	-	3
10)	USNM 487889	Ea. La Angelina N of Río Gallegos	19? 02 73		Taken incidentally in centolla net, coll. J.G. Mead	-	-	-	3, 7
11)	USNM 484890	Ea. La Angelina N of Río Gallegos	19 02 73		Miscellaneous skeletal elements, skull, coll. J.G. Mead	-	-	-	8
12)	USNM 504072	Ea. La Angelina N of Río Gallegos	19 02 73		Miscellaneous skeletal elements, skull, coll. J.G. Mead	-	-	-	8
13)	USNM 504073	Ea. La Angelina N of Río Gallegos	19 02 73		Miscellaneous skeletal elements, skull, coll. J.G. Mead	-	-	-	8
14)	USNM -	Puerto Deseado	12 12 78	Complete skeleton	Japanese spec. confiscated in NY, dead on arrival in US, immature	F	144	-	9
15)	USNM 550154	Puerto Deseado	15 12 78	Complete skeleton	Japanese spec. confiscated in NY, died on same day, sexually immature	F	132	-	9
16)	USNM 550156	Puerto Deseado	26 12 78	Complete skeleton	Japanese spec. confiscated in NY, taken to Mystic Aq., sexually mature, lived 11 days	M	136.3	-	9
17)	USNM 550155	Puerto Deseado	26 07 81	Complete skeleton	Japanese spec. confiscated in NY, taken to Mystic Aq., developed spinal deviation, lived 2.5yrs; TL at capture 142; deformed TL 117+	F	-	-	9
18)	-	Bahía San Jorge	11/12 78	?	2 males, 4 females captured for Duisburg Zoo	-	-	-	10, 12
19)	-	Comodoro Rivadavia	01/02 80	?	4 of 5 animals captured for Duisburg Zoo, 1 animal weighed 20kg	-	-	-	11, 12
20)	CNP 099	Off Río Chubut Golfo Nuevo	— 10 84	Complete	Taken in fishing nets	M	134	-	13

Table 4 (*continued*)

No.	Specimen no.	Locality	Date	Specimen	Details and notes	Sex	TL (cm)	CBL (mm)	References
Tierra del Fuego, Argentina									
21)	MACN-BA 2c	Tierra del Fuego	— — —	Cranium	No data	-	-	295	14, 15
22)	MLP 1535a	Tierra del Fuego	— 03 38	Cranium	Large, old, no teeth; harpooned from ARA Mackinlay; Donated F.G. Lynch	-	-	-	16
23)	MLP 1535b	Tierra del Fuego	— 03 38	L. mandib.	With above cranium, but does not belong to it	-	-	-	17
24)	MACN-BA s/n	4km N Rio Grande	28 01 74	Photo	Photograph of specimen by M. Canevari	-	-	-	14
25)	Museo Misión Salesiana s/n	Río Grande	21 05 76	Skin	Caught in net, mounted	-	-	-	17
26)	CNP -	San Sebastián	— — —	Skull	Beach pick up, young animal	-	-	-	13
Strait of Magellan, Chile									
27)	USNM 395352	2nm N Pta San Isidro	10 12 68	Complete skeleton	Harpooned from RV Hero, standard measurements, photos KSN68-86SA	F	140.1	304	18, 19, 5
28)	USNM 395353	4.5nm NE C. San Vicente	10 12 68	Complete skeleton	Harpooned from RV Hero, standard measurements, photos KSN68-87SA	M	134.1	294	18, 19, 5
29)	IPPA CE-13	Punta Dungeness	— — —	Cranium	(formerly CE-6)	-	-	287	20
30)	IPPA CE-20	Seno Otway (Isla Riesco)	— — —	Cranium	(formerly CE-7) Formerly listed as Seno Skyring	-	-	238	20
31)	IPPA CE-15	Punta Dungeness	— — —	Skull & skeleton	(formerly CE-9)	-	-	293	20
32)	IPPA CE-17	Punta Espora	— — —	Skull	(formerly CE-14)	-	-	-	20
33)	IPPA CE-18	Bahia Posesion	— — —	Cranium	(formerly CE-15)	-	-	287	20
34)	IPPA CE-33	Punta Catalina	— — —	Cranium	(formerly CE-32)	-	-	-	20
35)	IPPA CE-34	Punta Catalina	— — —	Cranium	(formerly CE-33)	-	-	-	20
36)	IPPA CE-41	Puerto Espora	— — —	Cranium		-	-	291	21
37)		Punta Sara	11/12 83		12 captured by Sea World, inc. specimens				22
38)		Punta Sara	01/02 84		6 captured for Duisburg Zoo				23, 24
Falkland (Malvinas) Islands									
39)	BMNH 1890.2.20.16	Port Lewis	— — —	No data		-	-	291	5
40)	-	Port Stanley	03 03 93	Drawing	Drowned in net; drawing by W.G. Burn Murdoch; sent to Univ. College, Dundee; specimen lost.	F?	(132.2)	-	25
41)	BMNH 1922.1.27.1	Port Stanley	Pre-1922	Skull	Eviscerated, in salt. Coll. by J.E. Hamilton. Vert. epiph. free, immature (Harmer sp. A.), first photo of animal and of skull	M	(137)?	298	2, 5

No.	Specimen no.	Locality	Date	Specimen	Details and notes	Sex	TL (cm)	CBL (mm)	References
42)	BMNH 1922.7.5.1	Byron Sound West Falkland	— — —	Skull	Picked up on beach by Rupert Vallentin	-	-	295	2, 5
43)	BMNH	Falkland Islands	Pre-1922	Photos	2 photographs of stranded specimen presented by R. Vallentin	M	-	-	2
44)	BMNH	Falkland Islands	— — —		'Adult ... light area very pale grey'	F	(122)?		26
45)	BMNH 1946.12.21.1	E. Falkland	— — —		No data	-	-	287	5
46)	USNM 252568	S of Stanley	— — —	Skull	From Dr Dean	-	-	287	5, 27
47)	BMNH 1951.8.3.1	Carcass Island, West Falkland	— — —	Skull	No data	-	-	-	5
48)	BMNH 1953.9.3.1	Falkland Islands	— — —	Skeleton	No data	-	-	304	5
49)	-	Falkland Islands	— — —	Skull	One or more specimens in the collection of Ian Strange	-	-	-	28

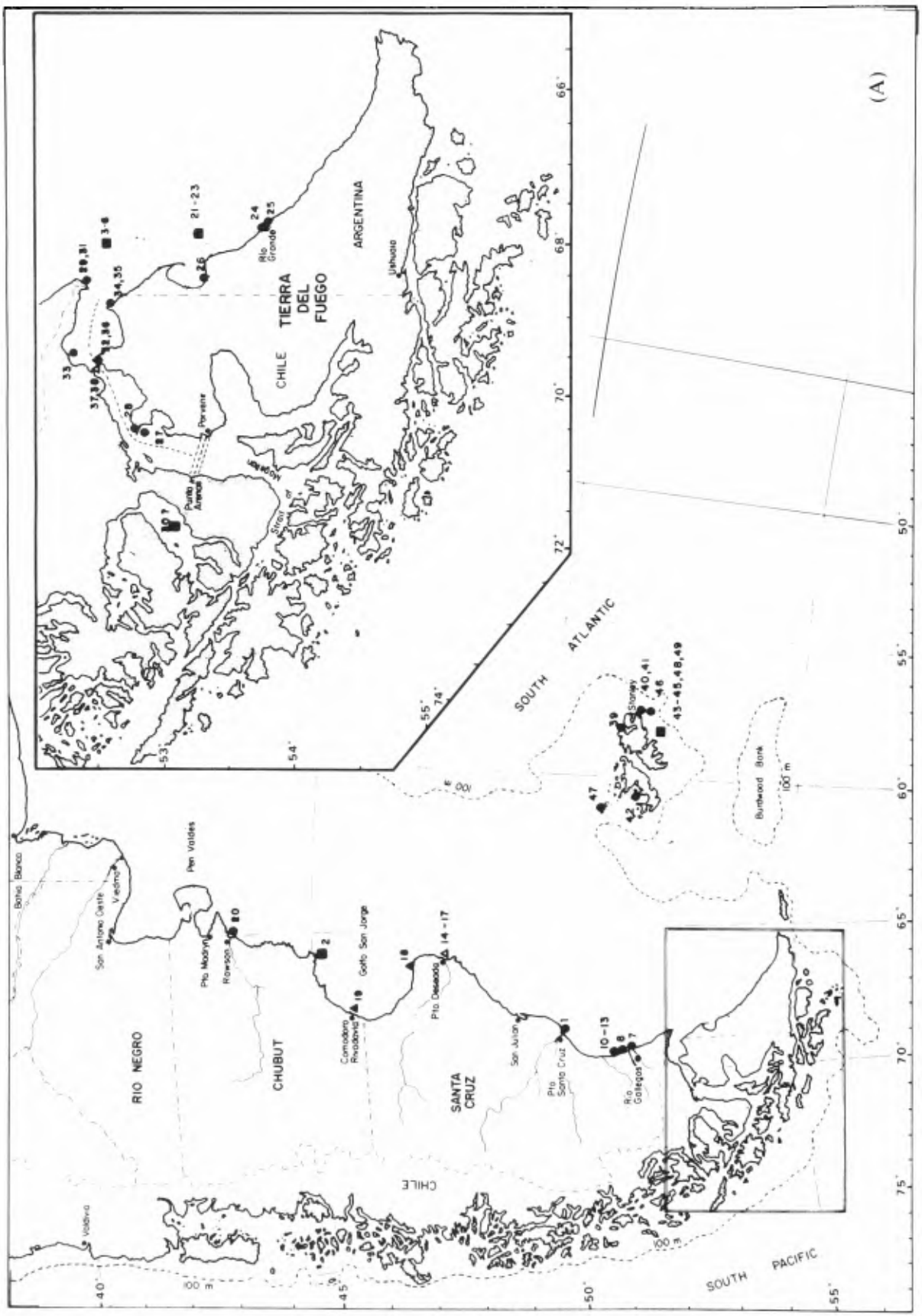
Note: The Museo Damaso Laranaga in Montevideo has a model of C. commersonii sent from the Malvinas by Hamilton.

Uncertain locality									
MACN-BA 4-421		Quilmes, Provincia de Buenos Aires	— — —		Bought from Sr Costa	-	-	303	14, 15
MACN-BA s/n		no data	— — —		No data	-	-	298	
MLP 633		no data	— — —	Skull	With teeth and stylohyal	-	-	302	14, 15
Naturhistoriska Riksmuseet Stockholm			— — —	2 skulls	A. Aguayo and E. Mitchell studied two skulls of C. commersonii and two of C. eutropia in Swedish Museum	-	-	-	29, 30

Key to References

1 Moreno, 1892
2 Harmer, 1922
3 Brownell & Praderi, 1985
4 Rayner, 1932: notes
5 Best, 1977
6 Brown, this volume
7 Mitchell, 1975b: 91
8 USNM master list
9 Spotte *et al.* 1979: 2
10 Gewalt, 1979: 37; undated
11 Mermoz, 1980: 151
12 Gewalt, 1981: pers. comm.
13 A. Scolaro, pers, comm.
14 Brownell *et al.* 1979
15 Brownell & Praderi, 1984
16 MLP catalogue
17 Goodall, pers, obs.
18 Norris, 1968: notes
19 Aguayo, 1975: 1124
20 Sielfeld, 1980: 277
21 Sielfeld, pers, comm.
22 Cornell *et al.* this volume
23 Thielke, 1984
24 W. Gewalt, pers. comm.; 1984
25 Bruce, 1915: 501; pl. 1
26 Hamilton, 1952: 6
27 Kasuya, 1973: pl. 14
28 M. Villanueva, pers. comm.
29 Brownell, 1977: 475
30 A. Aguayo, pers. comm.,

Fig. 4. Sites where specimens of *Cephalorhynchus commersonii* have been collected off South America. (A) From various sources, December 1876 through 1984 (reported as exact localities ● or general areas ■ – see Table 4; △ = areas of live captures). (B) From activities of the authors, October 1972 through December 1984 (● = apparently drowned in *robalo* and *merluza* nets; ○ = cause of death uncertain).



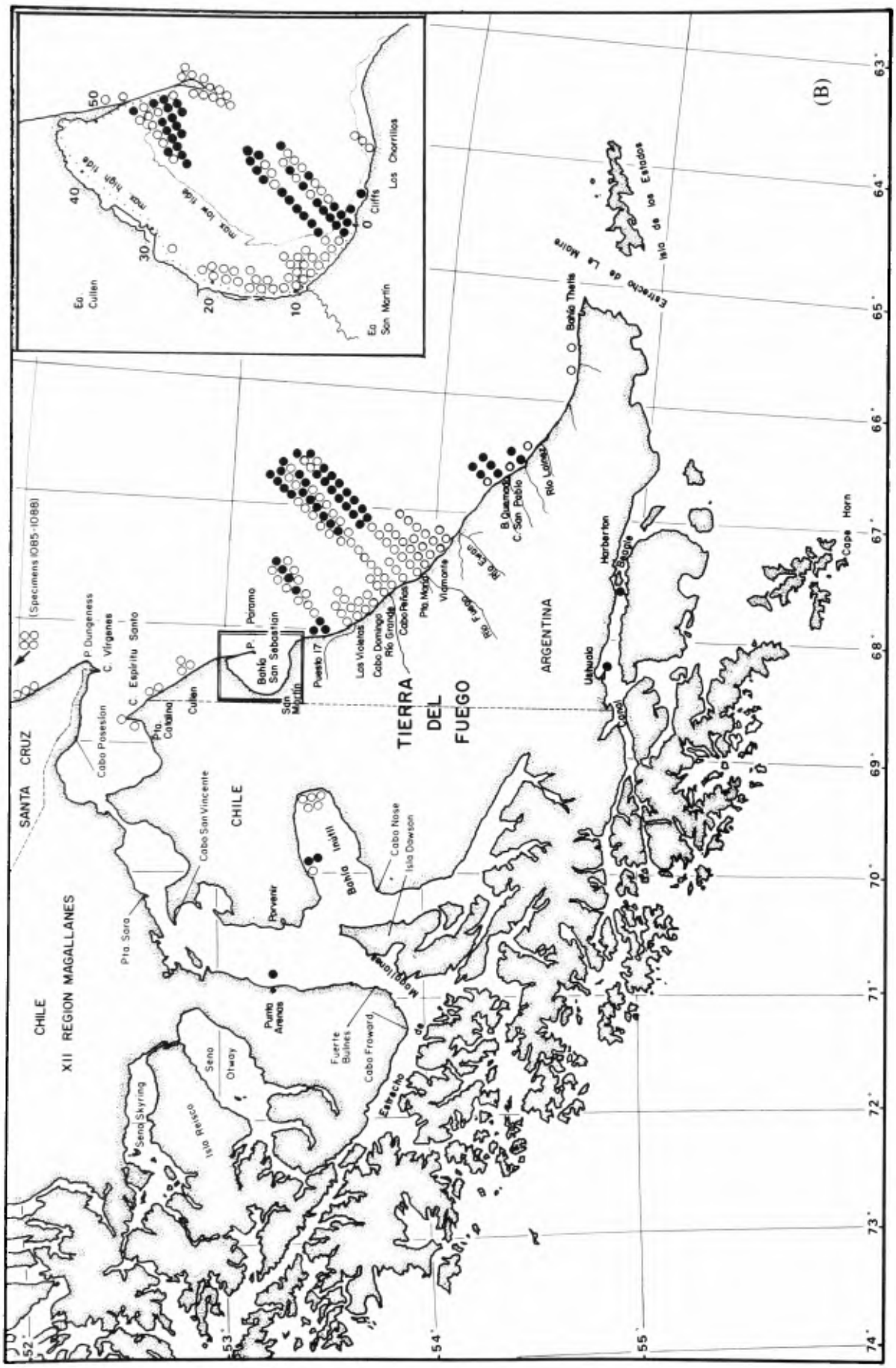

(B)
(Specimens 1085-1088)
P. Dungeness
C. Vírgenes
C. Espíritu Santo
Cabo Posesión
Pta. Catalina
Cullen
Paramo
Bahía San Sebastián
San Martín
Puesto 17
Las Violetas
Cabo Domingo
Río Grande
Cabo Peñas
Pta. Maria
Vicuñaña
Río Espera
Río Chico
B. Guanaco
C. San Pablo
Río Latnas
Bahía Thetis
Estrecho de La Maire
Isla de los Estados
Harberton
Ushuaia
Canal Beagle
Cabo Horn
ARGENTINA
TIERRA DEL FUEGO
CHILE
SANTA CRUZ
CHILE
XII REGION MAGALLANES
Cabo San Vincente
Pta. Sara
Porvenir
Bahía Inútil
Cabo Nose
Isla Dawson
Estrecho de Magallanes
Punta Arenas
Fuerte Bulnes
Cabo Froward
Seno Otway
Isla Reloncaví
Seno Skyring
Cliffs
Los Chorrillos
Ea. Cullen
Ea. San Martín
max. low tide
max. high tide
10
20
30
40
50
52°
53°
54°
55°
63°
64°
65°
66°
67°
68°
69°
70°
71°
72°
73°
74°

Table 5

Specimens of *Cephalorhynchus commersonii* collected by Goodall and associates in Tierra del Fuego, 1971–1984, arranged by specimen number (see Fig. 4B). Notation such as '4 N' indicates location 4 km north of listed site; part of Bahia San Sebastian has been marked with stakes at 0.5 km intervals. Abbreviations: B. = Bahia, bay; R. = Rio, river; C. = Cabo, cape; NE = not exact. Specimen codes: A = nearly complete skeleton; B = skull with incomplete skeleton; Sk. = skull (cranium and mandibles); a,b,c, – good, worn, poor; C. = cranium only (a, b, c); M. = mandible only; E. = postcranial skeleton; D. = teeth only; Cv. = cervical vertebrae only; O. = earbones only; V. = some vertebrae or ribs; P. = pelvic bones. Physical maturity: 0 = fetus or neonate; 1 = juvenile; 2 = sub-adult; 3 = adult. References: A = Goodall, 1978; B = Lockyer *et al.*, 1981; C = Lockyer *et al.*, 1988; D = Goodall and Cameron, 1980.

Field Number	Sex	Age	Locality	Date Collected	Cause	Physical Maturity	TL	Specimen Type	Reference
RNP0000	F	--	Bahia Ushuaia	72.10.16	net	--	112.0	Grey; not kept; sketch	
RNP0007a	?	--	Cabo Domingo S	75.09.27		--	0.0	Sk.c V	A
RNP0014	?	--	Río Fuego N	75.09.30		--	0.0	M	A
RNP0016	?	--	Río Fuego N	75.09.30		3	0.0	V, deformed bones	A
RNP0019	?	--	Río Fuego N	75.09.30		--	0.0	Sk.b	A
RNP0020	?	--	Río Fuego N	75.09.30		--	0.0	Sk.b	A
RNP0022	?	--	Río Fuego N	75.09.30		--	0.0	Sk.c	A
RNP0023	?	--	Río Fuego N	75.09.30		--	0.0	Sk.b	A
RNP0024	?	--	Río Fuego mouth	75.09.30		--	0.0	Sk.c	A
RNP0040	?	--	San Martin N	75.05.12		--	0.0	Sk.c	A
RNP0043	?	--	Ea. Viamonte SE	74.04.12		--	0.0	Sk.c	A
RNP0044	?	--	Ea. Viamonte SE	74.04.12		--	0.0	Sk.c	A
RNP0045	?	--	Ea. Viamonte SE	74.04.12		--	0.0	Sk.c M	A
RNP0049	?	--	Ea. Viamonte SE	74.04.12		--	0.0	Sk.c	A
RNP0052	?	--	Ea. Viamonte SE	74.04.12		--	0.0	Sk.c	A
RNP0053	?	--	Ea. Viamonte SE	74.04.12		--	0.0	Sk.c	
RNP0054	?	--	Páramo	74.04.13		--	0.0	Sk.c	A
RNP0055	?	--	Río Cullen	74.04.13		--	0.0	Sk.c	A
RNP0056c	?	--	Ea. Viamonte	74.04.13		--	0.0	V, deformed bones	
RNP0057	?	--	Ea. Viamonte	71.00.00		--	0.0	Sk.b	A
RNP0063	?	--	Páramo	71.07.04		0	0.0	Sk.b Cv	A
RNP0064	?	--	Páramo	74.07.04		--	0.0	Sk.c	A
RNP0068	?	--	Punta María N	74.07.05		--	0.0	Sk.c	A
RNP0069	?	--	Punta María 4 N	74.07.05		3	0.0	V	A
RNP0072	?	--	Punta María 4 N	74.07.05		--	0.0	Sk.c	A
RNP0075	?	00	B. Inútil NW	75.02.24		1b	0.0	A, grey	A,B,C
RNP0079	?	--	Punta María S	75.07.31		--	0.0	Sk.c	A
RNP0080	?	--	Punta María S	75.07.31		--	0.0	Sk.c	A
RNP0081	?	10	Cabo Penas S	75.07.31		2b	0.0	B	A,B,C
RNP0087a	?	--	Cabo Penas S	75.07.31		--	0.0	Cv	
RNP0115	?	--	Cabo Penas N	75.12.18		3?	0.0	V	
RNP0122	?	--	Ea. Las Violetas S	75.12.18		3?	0.0	Sk.b D	
RNP0134	?	--	Ea. Las Violetas N	75.12.19		1	0.0	Sk.b D	A
RNP0139	?	--	C. Espiritu Santo S	75.12.20		--	0.0	Sk.b	A
RNP0140	?	--	C. Espiritu Santo S	75.12.20		--	0.0	Sk.c	A
RNP0150	?	--	Páramo Km 55	75.12.21		--	0.0	M	A
RNP0151	?	--	Páramo Km 55	75.12.21		1?	0.0	V	
RNP0154	?	--	Páramo, tip	75.12.21		--	0.0	Sk.c	
RNP0155	?	--	Páramo, tip	75.12.21		--	0.0	Sk.c	A
RNP0156	?	--	Páramo, tip	75.12.21		--	0.0	Sk.c	A
RNP0161a	?	--	Páramo, tip	75.12.21		--	0.0	M	A
RNP0162	?	--	Páramo, tip	75.12.21		--	0.0	V	
RNP0165	?	--	Páramo, tip	75.12.21		1?	0.0	V	A
RNP0166	?	--	Páramo, tip	75.12.21		--	0.0	Sk.c	A
RNP0186	?	--	San Sebastian Km 6	76.01.28		--	0.0	Sk.c	A
RNP0192	?	--	San Sebastian Km 9.5	76.01.28		--	0.0	Sk.c	A
RNP0212	?	--	San Sebastian Km 7	76.01.28		--	0.0	Sk.c	A
RNP0213a	?	--	San Sebastián Km 7	76.01.28		--	0.0	Cv	
RNP0217	?	--	San Sebastian Km 7-8	76.01.28		--	0.0	Sk.c	A
RNP0231	?	--	San Sebastian Km 5-6	76.01.28		3?	0.0	V	
RNP0240	?	--	San Sebastian Km 5-6	76.01.28		--	0.0	Sk.c	
RNP0243	?	--	San Sebastián Km 5.5	76.01.28		--	0.0	V	
RNP0250	?	--	San Sebastián Km 8	76.01.28		--	0.0	Sk.c	A
RNP0260	?	--	San Sebastian Km 8.5	76.01.28		--	0.0	Sk.c	A
RNP0294	?	--	San Sebastián Km 13	76.02.13		--	0.0	Sk.c	A
RNP0295	?	--	San Sebastián Km 16.5	76.02.13		--	0.0	Sk.c	A
RNP0296	?	--	San Sebastián Km 13	76.02.13		--	0.0	V	
RNP0300	?	--	San Sebastián Km 10.5	76.02.13		3	0.0	V	A
RNP0321	?	--	San Sebastian Km 14	76.02.13		--	0.0	Sk.c	A
RNP0322	?	--	San Sebastian Km 11	76.02.13		--	0.0	Sk.c	A
RNP0323	?	--	San Sebastian Km 11	76.02.13		--	0.0	Sk.c	A
RNP0341	?	--	Auricosta 2 Km NW	76.11.14		--	0.0	V	
RNP0347	?	--	San Sebastián Km 8-9	76.11.21		--	0.0	V	
RNP0359	?	--	San Sebastian Km 8-9	76.11.21		--	0.0	Sk.c	A
RNP0366	?	--	San Sebastian Km 8	76.11.21		--	0.0	V	
RNP0395	?	03	Cabo Penas S	77.01.16		1	0.0	B D	A,B,C
RNP0396	?	02	Cabo Penas S	77.01.16		--	0.0	M D	A
RNP0397	?	--	Cabo Penas S	77.01.16		3a	0.0	E	A

[*continued*]

Table 5 (*continued*)

Field Number	Sex	Age	Locality	Date Collected	Cause	Physical Maturity	TL	Specimen Type	Reference
RNP0398	?	01	Cabo Penas S	77.01.16		2a	0.0	B	A,B,C
RNP0399	?	03	Cabo Penas S	77.01.16		2	0.0	B	A,B,C
RNP0407	?	--	Cabo Penas S	77.01.16		--	0.0	Sk.c	A
RNP0409	?	--	Sara, Puesto 17 S	77.02.13		--	0.0	V	
RNP0414	?	08	San Sebastián Km 1.5	77.02.13	net	2b	137.0	A; Museo Territorial	A,B,C
RNP0415	M	10	San Sebastián Km 1.5	77.02.13	net	2b	130.0	A	A,B,C
RNP0417	?	--	Páramo Km 55	77.02.15		--	0.0	Sk.c	A
RNP0420	?	--	Páramo Km 55	77.02.15		--	0.0	Sk.c	A
RNP0421	?	--	Páramo Km 55	77.02.15		3?	0.0	V	
RNP0442	?	--	Punta María 7 Km N	77.03.03		--	0.0	Sk.c	A
RNP0447	?	--	Punta María 3-4 Km N	77.03.03		--	0.0	V	
RNP0450a	?	--	Punta María 1 Km N	77.03.03		--	0.0	Sk.c	A
RNP0458	?	--	Punta María 1 Km S	77.03.04		--	0.0	Sk.c	A
RNP0474	?	--	Río Lainez	77.03.05	net	3?	0.0	V	A
RNP0475	?	--	Cabo Irigoyen N	77.03.06		--	0.0	Cv	A
RNP0496	?	--	Punta Maria N	77.03.03		--	0.0	V	A
RNP0497	?	01	Río Lainez mouth	77.03.05	net	1	110.0	B	A,B,C
RNP0506	?	--	Los Chorrillos NW	77.04.08		--	0.0	V	
RNP0508	?	--	San Sebastián Km 7	77.04.08		--	0.0	Sk.c	A
RNP0514	?	--	Cabo Penas N	77.04.09		--	0.0	Sk.c	A
RNP0526	?	--	Los Chorrillos NW	77.05.29		3?	0.0	V	A
RNP0528	?	--	Los Chorrillos NW	77.05.29		--	0.0	Sk.c M	A
RNP0549	?	--	Río Cullen S	77.06.01		--	0.0	V	A
RNP0550	?	--	Río Cullen S	77.06.01		3?	0.0	V	
RNP0560	?	--	B. Inútil E coast	77.07.25		3?	0.0	V, deformed bones Ca.13	A
RNP0562	?	--	B. Inútil E coast	77.07.25		3?	0.0	V	A
RNP0565	?	--	B. Inútil E coast	77.07.25		--	0.0	Sk.c Immature	A
RNP0569	?	00	B. Inútil E coast	77.07.25		--	0.0	Sk.b	A
RNP0570	?	--	B. Inútil E coast	77.07.25		--	0.0	E	A
RNP0574	M	NE	B. Inútil N, Lote 17	77.07.26	net	2a	127.0	A, 0-2 years.	A,B,C
RNP0575	F	00	B. Inútil N, Lote 17	77.07.26	net	1	0.0	A, 104 cm+ grey	A,B,C
RNP0576	M	03	Near Punta Arenas	77.07.29	net	2	130.0	A	A,B,C
RNP0577	F	00	San Sebastián Km 1.5	77.11.30	net	1	99.5	A, grey	A.B.C
RNP0578	?	04	San Sebastián Km 4.5	77.11.05		3b	0.0	B	A,B,C
RNP0591	?	--	San Sebastian Km 5	77.11.21		--	0.0	Sk.c	A
RNP0593	?	--	Páramo, tip E	77.11.21		3?	0.0	V	A
RNP0595	M	09	Páramo Km 55-56	77.11.24	net	3	129.0	A	A,B,C
RNP0596	M	00	San Sebastián Km 0.5	77.11.28	net	1	101.0	A,to Dr. A. Karpenko	A,B,C
RNP0598	?	--	San Sebastián Km 18	77.11.28		--	0.0	M	A
RNP0603	?	--	San Sebastian Km 18	77.11.28		--	0.0	Sk.c	A
RNP0619	M	06	San Sebastián Km 0.5	77.12.11	net	2	128.0	A	A,B,C
RNP0620	M	07	San Sebastián Km 0.5	77.12.11	net	3	127.2	A, deformed bones	A,B,C
RNP0623	M	11	San Sebastian Km 0	77.12.11	net	3	0.0	A	A,B,C
RNP0627	?	--	San Sebastian Km 13	77.12.11		--	0.0	Sk.c	A
RNP0632	M	03	Páramo Km 56	77.12.12		2a	130.0	A	A,B,C
RNP0633	F	00	Páramo Km 56	77.12.12	net	1	108.0	A, grey	A,B,C
RNP0634	F	08	Páramo Km 56	77.12.12	net	3b	145.5	A, With fetus RNP0635.	A,B,C
RNP0635	M	00	Paramo Km 56	77.12.12	net	0	73.4	Fetus in formol, dark grey	A
RNP0636	M	12	San Sebastian Km 1	77.12.20	net	3b	136.0	A	A,B,C
RNP0637	M	15	San Sebastián Km 1	77.12.20	net	3	130.2	A	A,B,C
RNP0645	?	07	Páramo Km 56.5	77.12.12	net	2b	142.0	A	A,C
RNP0646	?	03	Páramo Km 56	78.01.28	net	2	128.0	A	A,B,C
RNP0647	M	09	Páramo Km 56	78.01.28	net	3a	125.8	A	A,B,C
RNP0648	M	09	Páramo Km 56	78.01.28	net	3b	129.0	A	A,B,C
RNP0650	?	04	Páramo Km 56.5	78.01.28	net	2	125.0	A	A,B,C
RNP0651	?	10	Páramo Km 56.5	78.01.28	?	3	139.5	B	A,B,C
RNP0652	F	11	Páramo Km 55	78.01.28	net	2b	130.5	A	A,B,C
RNP0653	F	09	Páramo 56.5	78.01.28	net	3	131.4	A	A,B,C
RNP0655	?	17	Páramo Km 55 N	78.01.28	net	3	0.0	B, TL approx. 127.2+	A,B,C
RNP0675	?	07	San Sebastián Km 0.5	78.04.15		3	0.0	B	C
RNP0678	?	--	San Sebastián Km 16	78.04.15		--	0.0	Sk.c	
RNP0680	F	09	Páramo Km 56	78.04.16	net	2	133.0		A,B,C
RNP0689	?	04	Cabo Penas S	78.05.13		2	0.0	Sk +	C
RNP0691	?	--	Cabo Penas S	78.05.13		1	113.5	B	B,C
RNP0699	?	--	Punta Catalina, tip	78.05.28		--	0.0	Sk.c sent to IPPA	D
RNP0700	?	--	Punta Catalina W	78.05.28		--	0.0	Sk.c sent to IPPA	D
RNP0724	?	01	San Sebastián Km 1	78.11.18	?	1	0.0	B	B,C
RNP0725	?	--	Cabo Penas S	78.11.19	?	2	0.0	B	B,C
RNP0726	?	15	Cabo Penas S	78.11.19		3	127.5	B	C
RNP0730	?	08	San Sebastián Km 1	79.01.05		--	0.0	Sk.b D	C
RNP0731	M	06	San Sebastian Km 1	79.01.04	net	3	129.8	A	B,C
RNP0739	?	04	Cabo Penas 0.5 Km S	79.01.09		2a	0.0	Sk V	C
RNP0740	F	NE	Cabo Penas S	79.02.11	net	1	117.0	A, 0-0.5 years. grey	C
RNP0741	?	03	4 Cabo Penas S	79.02.11	net	2	137.0	A	C
RNP0745	?	--	Cabo Penas S	78.03.27		--	0.0	V	
RNP0746	M	05	Cabo Penas S	79.03.27	net	2b	133.5	A	C
RNP0747	M	02	Cabo Penas S	79.03.27	net	2a	123.0	A	C
RNP0762	?	NE	Punta Maria N	79.12.16		1	0.0	Sk V 1-1.5 years.	C
RNP0763	?	00	San Sebastian Km 3	79.12.17		1	0.0	B	C
RNP0765	?	--	San Sebastián Km 1	79.12.16		--	0.0	R flipper & S.blade	
RNP0766	F	10	San Sebastián Km 1	79.12.31	net	3	132.5	A, deformed bones	C
RNP0767	M	04	Punta Maria N	80.01.14	net	2	127.0	A	C
RNP0768	?	08	San Sebastian Km 0.5	80.01.14		3	128.5	A, deformed bones	C
RNP0769	M	06	San Sebastián Km 3	80.01.14	net	2	119.5	A	C
RNP0773	M	00	Punta Maria N	80.01.30	net	1	103.0	A, grey	C
RNP0774	?	03	Punta Maria N	80.01.30	net	2	128.0	B	C
RNP0775	?	NE	Ea. Las Violetas N	80.02.18		2	0.0	B, 5-6 years.	C
RNP0778	M	11	S. Sebastian cliffs	80.02.19	net	3	129.5	A	C

Table 5 (*continued*)

Field Number	Sex	Age	Locality	Date Collected	Cause	Physical Maturity	TL	Specimen Type	Reference
RNP0779	?	NE	Sara, Puesto 17	80.02.19	net	1	106.0	A, 0-0.5 years.	C
RNP0808	?	--	Punta Maria S	80.02.20		--	0.0	E, deformed bones	
RNP0810	?	NE	Sara, Puesto 17	80.03.30		--	0.0	Sk.b D, 9+ ?? years.	C
RNP0811	?	01	San Sebastián Km 2.5	80.03.31		--	0.0	Sk.b D	C
RNP0812	M	--	Punta Maria N	80.03.29	net	3	133.0	P R L Rest lost	
RNP0835	?	--	Río Fuego S	80.08.17		2a	0.0	B	
RNP0837	M	15	San Sebastián Km 3.5	80.10.25	net	3	128.0	A	C
RNP0840	?	--	San Sebastián Km 15	80.11.08		--	0.0	Sk.c	
RNP0851a	?	--	San Sebastián Km 19	80.11.16		--	0.0	Sk. c	
RNP0851b	M	01	Bahía Quemada	80.11.28		1	108.5	A	C
RNP0853	?	--	San Sebastián Km 15	80.12.21		--	0.0	Sk.a	
RNP0863	?	00	San Sebastián Km 0.5	81.01.23		--	0.0	Sk.c D	C
RNP0864	?	04	San Sebastián Km 0.5	81.01.23		--	0.0	Sk.b D	C
RNP0866	M	02	San Sebastián Km 3	81.01.23	net	1a	117.0	A, grey	C
RNP0871	M	02	Bahía Quemada	81.02.03	net	1	114.0	A, grey	C
RNP0872	M	03	Bahía Quemada	81.02.03	net	1	107.0	A	C
RNP0874	M	11	San Sebastián Km 3	81.02.13	net	3	131.0	A	C
RNP0875	M	08	San Sebastián Km 3	81.02.13	net	2	118.4	A	C
RNP0880	?	--	San Sebastián Km 7	81.03.31		--	0.0	Sk.c	
RNP0883	?	--	Páramo, near tip	81.04.01		--	0.0	Sk.c	
RNP0885	M	09	San Sebastián Km 3	81.04.17	net	3	130.5	B	C
RNP0886	?	--	San Sebastián Km 6	81.04.18		--	0.0	Sk.c	D
RNP0888	?	--	Cabo Domingo S	81.04.25		--	0.0	Sk.c	D
RNP0891	?	08	Ea. Las Violetas	81.04.30		2	0.0	Sk.z	C
RNP0892	?	08	Sara, Puesto 17 N	81.05.01		2	123.0	B	C
RNP0893	?	NE	Sara, Puesto 17 N	81.05.01		1	102.0	A, 2-3 years.	C
RNP0895a	?	01	Ea. Las Violetas N	81.05.12		--	0.0	Sk.a D	C
RNP0895b	?	--	Ea. Las Violetas N	81.05.12		3	0.0	V	
RNP0905	?	--	Ea. Viamonte	81.08.22		--	0.0	Sk.c	
RNP0954	M	10	Cabo Penas S	81.11.20	net	3	129.0	A	C
RNP0956	M	14	Punta María N	82.01.10	net	3	133.0	B	C
RNP0957	F	05	Punta María N	82.01.10	net	2	133.5	A	C
RNP0958	F	04	Punta María N	82.01.10	net	2a	131.5	A	C
RNP0959	F	01	Cabo Penas S	82.01.10	net	1	116.1	B	C
RNP0960	M	01	Cabo Penas S	82.01.10	net	1	111.7	A	C
RNP0961	M	03	Cabo Penas S	82.01.11	net	2a	113.5	A	C
RNP0962	M	01	Cabo Penas S	82.01.11	net	1	102.9	Sk. c	C
RNP0966	M	--	San Sebastian Km 3	82.01.18		1	105.5	TL aprox. Sp. lost	
RNP0967	?	03	San Sebastian Km 3	82.01.18		2a	0.0	B	C
RNP0968	?	01	San Sebastian Km 3	82.01.18		1	0.0	B	C
RNP0985	?	10	Cabo Penas 1 Km S	82.01.29	net	3	0.0	A, TL approx. 127.2+	C
RNP0986	?	06	Cabo Penas 1 Km S	82.01.29		2	123.6	B	C
RNP0987	?	04	Cabo Penas 1 Km S	82.01.29		2	125.0	A	C
RNP0988	M	01	Cabo Penas 1 Km S	82.01.29	net	1	115.3	B	C
RNP1002	?	01	Paramo Km 55	82.03.14		0	0.0	Sk.a D	C
RNP1010	?	02	Cabo Penas S	82.04.06		2a	114.5	A	C
RNP1011	?	08	Cabo Penas S	82.04.06		2	0.0	B	C
RNP1012	?	--	Cabo Penas S	82.04.06		--	0.0	Sk.c	
RNP1015	M	12	Punta Maria N	82.04.06		3	0.0	B, deformed bones	C
RNP1016	?	03	Punta Maria N	82.04.06		--	0.0	Sk.b D	C
RNP1017	?	--	Cabo Penas N	82.04.06		--	0.0	Sk.c	
RNP1029	?	00	Cabo Penas S	82.11.30		1	95.0	B	C
RNP1032	F	NE	San Sebastian Km 3	82.12.03	net	3	136.3	A, 7-9 years.	C
RNP1033	F	03	San Sebastian Km 3	82.12.03	net	2	117.5	B	C
RNP1034	F	04	San Sebastian Km 3	82.12.03	net	2	125.5	A	C
RNP1037	?	10	Sara, Puesto 17	82.12.18		3b	0.0	A	C
RNP1038	?	07	Sara, Puesto 17	82.12.18		3	0.0	A	C
RNP1039	F	18	Sara, Puesto 17	82.12.18	net	3	145.2	A	C
RNP1040	M	06	Sara, Puesto 17	82.12.18	net	2	135.7	A	C
RNP1041	F	09	San Sebastián Km 3	82.12.19	net	3	127.6	A W/Milk.	C
RNP1043	F	06	Sara, Puesto 17	82.12.18	net	2	138.2	A	C
RNP1044	M	14	Sara, Puesto 17	82.12.18	net	3	131.2	A	C
RNP1045	?	01	Sara, Puesto 17	82.12.27		1	0.0	A	C
RNP1048	M	15	Punta María N	83.01.10	net	3	125.2	A	C
CNP1049	F	08	Punta María N	83.01.17	net	2	128.6	A	C
RNP1050	?	02	Sara, Puesto 17	83.01.18		--	0.0	Sk.a	C
RNP1051	?	18	Sara, Puesto 17	83.01.18		--	0.0	Sk	C
RNP1052	M	10	Sara, Puesto 17	83.01.18		3	130.5	A, TL approximate	C
RNP1053	?	12	Sara, Puesto 17	83.01.18		3b	127.0	A, TL aproximate	C
RNP1054	M	05	San Sebastian Km 3	83.01.18	net	2	119.6	A	C
RNP1055	?	12	San Sebastian Km 1.5	83.01.18		3	135.2	A	C
RNP1057	?	07	Páramo Km 54	83.01.27		--	0.0	Sk.a D	C
RNP1059	M	05	4 Km up Río Grande	83.02.23	str	2	131.0	P (A Museo Territorial)	C
RNP1060	?	--	Páramo, near tip E	83.03.06		--	0.0	Sk.c	
RNP1063	?	--	Paramo, near tip W	83.03.17		--	0.0	V	
RNP1064	M	10	Paramo Km 57	83.03.26	net	3	138.0	A	C
RNP1065	M	00	B. Brown, C. Beagle	83.04.17	net	1	111.9	A, grey	C
RNP1068	?	14	San Sebastian Km 0.5	83.05.04	net	--	0.0	Sk.c D	C
RNP1069	?	12	San Sebastian Km 1	83.05.04	net	--	0.0	Sk.a M D	C
RNP1070	?	09	San Sebastian Km 1.2	83.05.04		--	0.0	Sk.b D	C
RNP1072	?	--	Auricosta	83.05.06		--	0.0	Sk.c	
RNP1073	M	10	Punta María N	83.05.06	net	3	129.0	A	C
RNP1074	F	10	Punta María N	83.05.06	net	3b	138.0	A	C
RNP1076	?	03	Punta Loyola S, S.C.	83.11.12		--	0.0	Sk.z	C
RNP1081	?	--	Punta Loyola 13 Km S	83.11.12		--	0.0	Sk.c	

[*continued*]

Table 5 (*continued*)

Field Number	Sex	Age	Locality	Date Collected	Cause	Physical Maturity	TL	Specimen Type	Reference
RNP1082	?	--	Punta Loyola 17 Km S	83.11.12		--	0.0	V	
RNP1085a	?	--	C. Buen Tiempo N	83.11.13		--	0.0	V	
RNP1085b	?	--	C. Buen Tiempo N	83.11.13		--	0.0	V	
RNP1087	?	--	C. Buen Tiempo N	83.11.13		--	0.0	Sk.c	
RNP1088	?	--	C. Buen Tiempo N	83.11.13		--	0.0	Sk.c	
RNP1097	?	16	Arroyo Gama .5 Km S	83.12.15	net	3	0.0	Sk.z	C
RNP1098	?	01	Cabo Penas S	83.12.17		1	0.0		C
RNP1099	M	12	Cabo Penas S	83.12.17		3	0.0	A	C
RNP1100	?	07	Cabo Penas S	83.12.17	net	2	0.0	E	C
RNP1101	?	06	Cabo Penas S	83.12.17	net	1b	0.0	A	C
RNP1102	?	01	Cabo Penas S	83.12.17	net	2	0.0	A	C
RNP1103	?	--	Punta María 2 Km N	83.12.17	net	--	0.0	Sk	
RNP1105	M	06	Punta María N	84.01.11	net	2	117.5	Th not fused. NE TL	C
RNP1106	M	01	Punta María N	84.01.11	net	1	98.6	approx. TL.	C
RNP1107	M	02	Punta María N	84.01.11	net	1	111.5	grey	C
RNP1109	?	06	Páramo Km 57.5	84.01.13	net	3a	132.4	E	C
RNP1110	M	17	Páramo 57.5	84.01.13	net	3b	137.6	E	C
RNP1120	?	--	Playa Rancho Donata	84.02.05		--	0.0		
RNP1126	?	--	Caleta Falsa	84.02.07		--	0.0	V	
RNP1136	?	13	Punta María N	84.02.19	net	3	0.0	A, TL approx. 120.4+	C
RNP1136n	?	00	Punta María N	84.02.19		0	0.0	Neonate, dark grey. Sk v	
RNP1140	?	--	Río San Pablo SE	84.03.25	net	--	0.0	Sk.c	
RNP1141	M	--	Río San Pablo SE	84.03.25	net	3b	0.0	A, TL approx 123.2	
RNP1142	M	--	Río San Pablo SE	84.03.25	net	1b	113.7	A	
RNP1150	?	--	Paso de las Cholgas	84.05.30		--	0.0	A	
RNP1152	?	--	Río Grande N	84.11.13		--	0.0	E, not kept	
RNP1158	M	00	San Sebastián Km 26	84.11.15	str	0	64.3	A, Neonate, TL approx.	
RNP1160	?	--	Paso de las Cholgas	84.11.15		--	0.0	A	
RNP1162	?	--	Cabo Penas 4 Km S	84.11.16		--	0.0	Sk D	
RNP1165	?	--	Río Lainez 5 Km S	84.12.27		--	0.0	Sk.c	

Distribution

Brownell (1974: Plate 8) mapped the records of Commerson's dolphins known to him through 1973. We have updated that exercise with plots of all available sightings from 1767 to 1984 (Figs 2 and 3) and of all known collections – i.e. strandings, harpoonings, live-captures, etc. – from December 1876 to 1984 (Fig. 4). The distribution, migration and habitat preference of this species can be surmised from data in those accounts, supplemented by our own observations.

Sightings of live Commerson's dolphins have been made at widespread, mostly coastal, localities along the eastern coast of South America south of about 41°30′S, including the central and eastern Strait of Magellan, waters around the Falkland (Malvinas) Islands, southeastern Tierra del Fuego, and Drake Passage. The several apparent concentrations within that broad area may be artifacts of ship traffic and related survey effort rather than centers of abundance. The species' overall range has not been systematically surveyed, especially with the goals of quantifying distribution patterns or estimating population size or density.

The northern limit of the species' occurrence is not clear. A single specimen (MACN-BA) labeled as having been collected at Quilmes (about 34°48′S, in the mouth of Río de la Plata) (Brownell and Praderi, 1985) cannot be used with any confidence as it is an old specimen not accompanied by any other information which may be incorrectly labelled. In any event, dead cetaceans can drift many miles beyond their 'normal' range before stranding. No Commerson's dolphins have been seen along the coast of the Province of Buenos Aires, including Mar del Plata, during recent extensive surveys there (R. Bastida, pers. comm.).

The northernmost record of living Commerson's dolphins has sometimes been given as 39°28′S, 36°48′W, from Bruce (1915; table, p. 401). However, we reject this record. The sighting it represents was made over 500 n.miles offshore,

in an area atypical for this species, and the entry in the published table reads 'Porpoises (piebald?)'. Bruce labelled his sketch of a Commerson's dolphin 'piebald porpoise' and some entries in the table noted above refer simply to 'piebald porpoise' with no query. We have accepted from Bruce's table only the records so labelled.

Later published accounts confirm the presence of Commerson's dolphins off Viedma (41°26′S, 63°00′W) in June 1971 and in Golfo San José in February 1976 (Fig. 2, Table 2), and recent anecdotal reports to us suggest that Commerson's dolphins enter the Río Negro, continuing as far upstream as Viedma, in August and September (Fig. 3, Table 3).

Commerson's dolphins are more or less continuously distributed along the east coasts of Patagonia and Tierra del Fuego between about 41°31′S and 55°S, at the Strait of La Maire. Lahille (1905, p. 62) mentioned their occurrence at Isla de los Estados but did not report his source; we have not found them there on two recent expeditions by ship.

Within the Strait of Magellan these dolphins are found mainly east and north of Punta Arenas, in Bahía Inútil, along the northeast coast of Isla Dawson, and on the eastern shore of the Strait north of Porvenir. [Although frequently seen between Punta Arenas and Porvenir in the 1940's (T.D. Goodall, C.M. Bridges, pers. comm.) they are no longer reported from this area.] The density is greatest north and east of Isla Marta and Commerson's dolphins are most plentiful in and near the First and Second Narrows (Leatherwood *et al.*, 1988b; Leatherwood, Kastelein and Hammond, 1988a). There are only a handful of records from the Beagle Channel and islands near Cape Horn (Olrog, 1950; Aguayo, 1975; and specimens and sightings in Tables 2–5). There is a single exceptional record from the western Strait of Magellan, a sighting at Isla Desolación by J.T. Polkinghorn (Table 3).

The presence of Commerson's dolphins at the Falkland (Malvinas) Islands is well documented (Bruce, 1915; Harmer, 1922; Hamilton, 1952; and newer sightings in Table 3). Most sightings have been made near Stanley and the northwestern islands, but the species probably occurs throughout the islands (Strange, 1972).

The southernmost records are those of two isolated encounters northwest of Livingston Island, south of the Antarctic Convergence, in February 1966 (Aguayo and Torres, 1967; Aguayo, 1975) and two sightings in the northern Drake Passage, near Cape Horn, in 1972 and 1978 (Table 3). Despite numerous scientific expeditions between the southern tip of South America and the Antarctic Peninsula since the late 1960s, there are no further records from waters very far south of the South American mainland and none from the Antarctic.

In the single published reference to the occurrence of Commerson's dolphins at South Georgia, Hart (1935, p. 253) wrote 'the dolphins *Lagenorhynchus cruciger* and *Cephalorhynchus commersonii* are common around South Georgia, where they are known to the whalers as 'springers' (at unspecified localities) riding on the pressure waves of great whales'. Hart's second-hand report has not been verified by direct observations at the island. For example, the species was not reported by Murphy (1965) during his stay at South Georgia, 23 November 1912 through 16 March 1913, has never been reported to the British

Antarctic Survey's Sea Mammal Research Unit by its numerous researchers and collaborators visiting the island (R. Laws, pers. comm. and see Brown, 1988) and has never been seen by our numerous other colleagues who have visited the area in recent years (e.g. L.H. Matthews, D.F. Parmalee, W. Weller, W.E. Evans, R. Davis, F.S. Todd, N. Bonner, A.E. Bowles, and B.S. Stewart).

There are no confirmed records of Commerson's dolphins from other South Atlantic Islands. Populations of this species at Kerguelen Island, in the southern Indian Ocean, are postulated to have colonized from South America, using the West Wind Drift (Brownell, 1974, p. 16). If so, it should be possible for Commerson's dolphins to have reached other islands nearer to South America, such as Gough, Tristan de Cunha and Crozet. Stahl (1982) wrote that there were rumors of the presence of Commerson's dolphin at Crozet but no sightings during coastal surveys there. Bruce's (1915) reported sightings south of Gough Island are impossible to substantiate and there have been no sightings of Commerson's dolphins on recent expeditions to the area (P. Best, pers. comm.).

Seasonal movements

There have been suggestions but little evidence of seasonal movements by Commerson's dolphins off South America. Gewalt (1979; 1981) observed that along the south central coast of Argentina these dolphins prefer sheltered coastal areas during summer but 'seem to occupy the open sea at other times'. As he studied only during summer the basis for his statements is not clear. Fishermen at Tierra del Fuego claim that dolphins follow fish offshore during cold months. Nevertheless, when sightings records reported in this paper were examined by area and month (Tables 2 and 3) there were no seasonal or area patterns apparent which could not be readily explained as an artifact of sampling effort. There have been sightings off eastern Tierra del Fuego in all months except June and collections in all months except May, June and August. Ferry captains at the First Narrows in the Strait of Magellan say the dolphins are there year round. Seasonality of sightings at Kerguelen Island, on the other hand, might be interpreted as evidence of migration (Robineau, 1985).

Abundance

There is no quantitative information available on abundance of Commerson's dolphins anywhere except in the Strait of Magellan. For other areas the few reports are largely anecdotal. Most sightings have been in bays, straits, estuaries, river mouths, or ships channels, probably reflecting concentration of effort rather than actual differences in abundance among different areas.

Gewalt (1981) reported seeing 'about 100 individuals' in the bay at Comodoro Rivadavia, Argentina, in November/December 1978 but could only find 15 there when he returned two years later. Weber (1920) reported 'incredible' numbers in the eastern Strait of Magellan and conducted successful fishing operations in the area near Punta Arenas, Chile. At the peak of his operations he harpooned 100 dolphins in less than three hours and took 4,500kg of blubber in a week. In reconnaissance surveys (by vehicle, vessel and aircraft)

of the eastern Strait in January and February 1984, we found Commerson's dolphins widely distributed, albeit in mostly small groups (n = 147, range 1–110, $\bar{x}$ = 4.22, SD = 9.14), from Bahía Inútil northward and from Islas Isabella and Marta eastward to the entrance (Leatherwood, *et al.*, 1988b). C. Venegas (*in litt.* to W.E. Evans, 1983) surmised that 'it is reasonable to suppose there are several thousand in that region'.

In the only quantitative assessment of numbers, Leatherwood, *et al.*, (1988a) estimated, based on aerial sightings made along randomly selected transects between the First and Second Narrows in January and February 1984, that there may have been 3,211 (SE = 1,168) Commerson's dolphins concentrated at that area and time.

The total population of this species is not known. Impressions of low abundance in many areas may be based on the frequency with which these animals are seen in small isolated groups. Commerson's dolphins do not appear rare or in any immediate danger of extinction although there have been and are still significant pressures on the population(s) in some areas.

Habitat preference

From all accounts, Commerson's dolphins appear to be principally a cold water littoral species (Dudok van Heel, 1981, p. 65). They inhabit nearshore waters of the open coast, sheltered fjords, bays, harbors and river mouths, and occasionally enter rivers. Brownell (1974, p. 14) judged the few pelagic records available up to 1973 (Bruce, 1915; Aguayo and Torres, 1967) as insufficiently documented to confirm that the species routinely uses oceanic waters. We share Brownell's reservations about such published accounts. We regard three recent reports of this species from offshore waters (Fig. 2 item 60 and Fig. 3 items 126 and 138) as being near the normal limits of the species range (*ca* 100m depth). There have been no confirmed sightings from oceanic waters during the dozens of cruises in recent decades between southern South America and subantarctic islands, the Antarctic Peninsula, and other Antarctic locations.

During winter surveys, Gilmore (1969; 1971) found Commerson's dolphins off Argentina only in coastal waters, despite the fact he also searched in adjacent pelagic areas. There have been no sightings very far from shore along ship routes between the Falklands and Montevideo, Uruguay. The vast majority of records from eastern South America, the Falklands and Kerguelen (Studer, 1889; Robineau, 1985) also are from nearshore. Moreno (1892) located and studied these dolphins in open bays near river mouths. Gewalt (1979, 1981) found them in sheltered coastal areas (fjords, harbors and inlets) during summer; Mermoz (1980) studied them in the harbor at Comodoro Rivadavia. Numerous sources verify their presence in such shallow bays as Bahías San Sebastián and Inútil and Golfo San Jorge and document their presence and abundance in the eastern Strait of Magellan.

No plausible explanation has been offered for the concentrations found between the First and Second Narrows (Leatherwood *et al.*, 1988b), where tidal currents are particularly swift, but these little dolphins are quite at home in strong currents, tidal rips and breaking surf (Leatherwood and Cornell, 1985).

Off mainland Argentina (Mermoz, 1980), around the Falklands (Harmer, 1922; Hamilton, 1952) and off Kerguelen (Angot, 1954) Commerson's dolphins are often seen swimming in or along the edges of kelp beds (*Macrocystis* and *Durvillea*). Lahille (1899) reported Commerson's dolphins at Isla Pavon in the Río Santa Cruz. Records detailed in Table 3 confirm the occurrence of these dolphins well upstream in the Ríos Grande (Tierra del Fuego), Gallegos, Deseado, San Julián and Negro. In this latter case, animals apparently have been observed making forays as far as 30km from the sea, beyond the town of Viedma. All the above rivers are bordered by a flat shelf and coast and consequently experience significant tidal effects well upstream. Angot (1954) described an incident at Kerguelen on 16 February, 1952 in which a group of 30 animals beached themselves but returned to sea on the next wave; such behavior has been reported to us by fishermen in Tierra del Fuego. The deaths of dolphins stranded by a receding tide in a narrow tidal estuary southwest of Río Gallegos, 4km from the coast at Río Grande and in the very narrow, meandering Río San Martín, indicate that the animals do not always successfully negotiate tidal exchanges in such areas.

In general, off South America, Commerson's dolphins appear to prefer areas where the continental shelf is wide and flat, the tidal range is great, and temperatures are influenced by the cool Malvinas current. The largely allopatric Chilean dolphin, *C. eutropia*, by contrast, seems to prefer the western side of the continent, an area characterized by a narrow continental shelf and deep convoluted fjords (Goodall, Norris, Galeazzi, Oporto and Cameron, 1988; Leatherwood *et al.*, 1988b). Temperatures within the habitat preferred by Commerson's dolphins are 4–9°C in summer near Cape Horn, annually average 11.5°C near Peńinsula Valdés (Gorden and Goldberg, 1970) and have been measured to be as high as 13–16°C in November in Bahía San Jorge (Gewalt, 1979).

External morphology

Until very recently, descriptions of Commerson's dolphins were based largely on illustrations in Moreno (1892), Bruce (1915) and Harmer (1922) and detailed comments on body form by Harmer (1922). Inevitably, some authors who copied from those sources without first-hand experience with the species presented inaccurate descriptions and illustrations. For example, figures in Nishiwaki (1965) and Bonner (1980) do not show the characteristic rounded fin or flippers, and pigmentation and shape in many other illustrations bear little resemblance to the living animals. With the significant numbers of observations and specimens in the past decade, the species can now be described more accurately and completely (Fig. 5).

Size

Prior to 1984, the largest reliably measured specimens of *C. commersonii* were a 136.3cm male (USNM 550156 – Spotte *et al.*, 1979) and a 147.3cm female (BMNH, 1952.6.20.4 – Brown, 1988). Maximum lengths of the 112 South

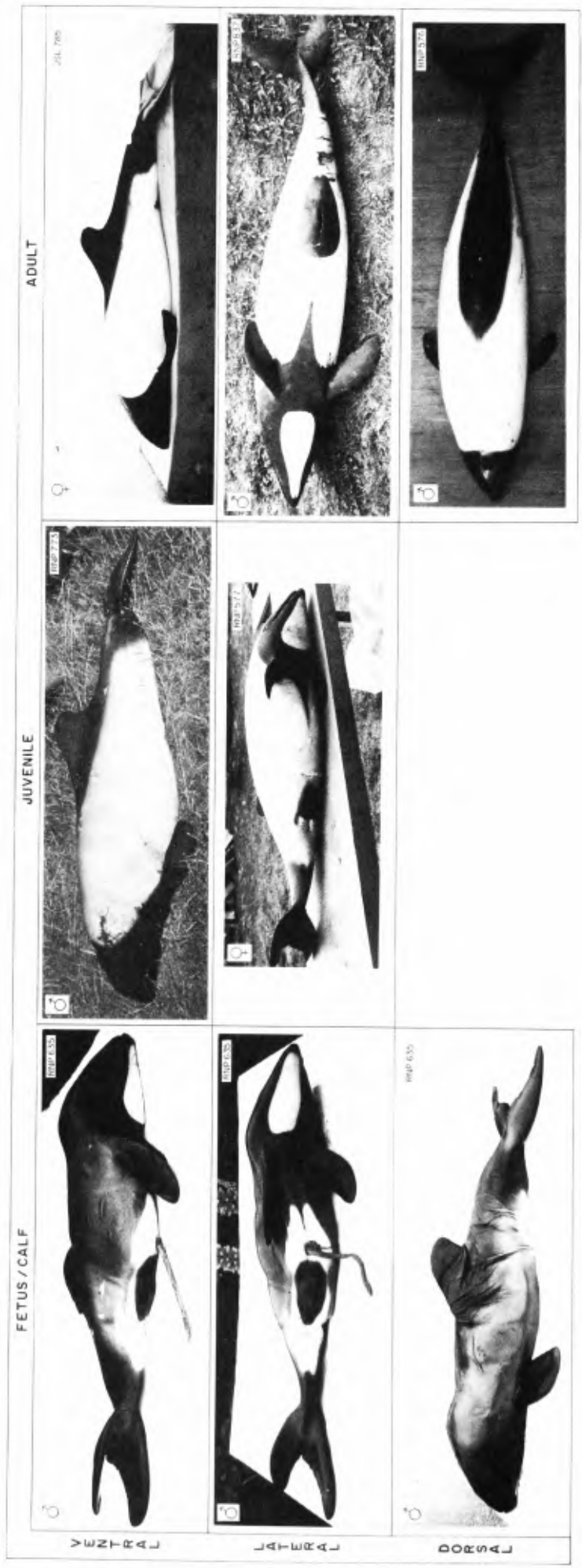


Fig. 5. Coloration and body proportions of fetal (left), juvenile (middle) and adult (right) Commerson's dolphins. The R.N.P. numbers refer to Table 4, where sex and size of the specimens are reported. The adult shown in lateral view is the largest specimen known to date, a 152 cm female live-captured off Punta Sara, Chile in February 1984 (R. N. P. Goodall, A, B, C, D, G; T. D. Goodall, E; S. Leatherwood, F; and I. S. Cameron, H.)

American specimens reported herein (20 published – Table 4; 92 new – Table 5) are 144cm for males and 145.5cm for females. Animals live-captured in the Strait of Magellan were slightly larger than those from elsewhere. In fact, the largest specimens we are aware of from South America are a 149cm male and a 152cm female (Fig. 5, upper right), both captured at Punta Sara in January 1984 by Duisburg Zoo (W. Gewalt, pers. comm. – specimens measured straight line by S. Leatherwood and R. Kastelein). A total length of 158cm reported for a specimen from Comodoro Rivadavia (Mermoz, 1980, p. 151) is inaccurate as it was not taken by standard methods (J. Mermoz, pers. comm.). Other greater lengths reported for specimens from South America (168cm – Fraser, 1948 and Nishiwaki, 1972; 165cm – Watson, 1981) are unsubstantiated. Commerson's dolphins at Kerguelen are substantially larger than those from South America, males reaching at least 166.5cm, females 174cm (Angot, 1954; Robineau, 1984).

Total length and maturity classes of 69 specimens from Tierra del Fuego are presented in Table 5, external measurements of some South American specimens in Table 6. Female Commerson's dolphin are larger than males at all stages of maturation (Lockyer *et al.*, 1981, 1988): Class 1 males averaged 108.7cm, females 110.2cm; Class 2 males averaged 126.5cm, females 129.8cm; Class 3 males averaged 130.5cm, females 136.6cm (Table 7). Age length relationships are discussed more fully by Lockyer *et al.* (1988).

Body proportions

Like other members of the genus *Cephalorhynchus*, Commerson's dolphins are short and stocky. Cornell *et al.* (1988) reported girths to be consistently slightly larger in the five males than in seven females from the Strait of Magellan, but there was no difference apparent in males ($n = 10$, $\bar{x} = 62.1$cm) and females ($n = 6$, $\bar{x} = 62.2$cm) from elsewhere off Tierra del Fuego. The maximum weights of which we are aware for South American specimens are 42kg (males) and 66kg (a female with a near term fetus – see Lockyer *et al.*, 1988), both specimens from eastern Tierra del Fuego. Brown (1988) reported one 50kg female from Río Gallegos. The ratio of length to weight was 3.15–3.68 for 4 males and 3.26–3.74 for 6 females from the wild (Cornell *et al.*, 1988), 4.06–5.4 for 4 captive animals obviously emaciated at the time of death (Spotte *et al.*, 1979). Midway between the anus and fluke notch the tail stock is approximately three times as high as it is thick.

Head

The head of Commerson's dolphin is illustrated in Goodall, Sobral, de Vinuesa and Cameron (1988) and in Fig. 6. It is rounded, not 'broad and flat' as described by Watson (1981). In profile, it slopes smoothly from the blowhole to the tip of the snout. There is no well defined beak, but the lower jaw usually projects about 1cm beyond the upper. The blowhole averages 2.2cm in width, 1.2cm in length ($n = 32$) and is situated slightly to the left of the midline. The external auditory meatus is pinhole-sized and not always visible externally. A

Table 6

External measurements (mm) of all specimens of *Cephalorhynchus commersonii* taken by modern methods (Norris, 1961), including Goodall specimens of physical maturity classes 2 and 3 and the following specimens (measured by or reference): USNM 395352 and 395353 (Norris, 1968); USNM 550154, 550155 and 550156 (Mead, Goodall, 1983) BMNH 1952.6.20.4 (Rayner *in* Brown, 1988); BMNH 1922.1.27.1 (Harmer, 1922); Sea World nos 9, 10, 11 and 12 (Cornell *et al.*, 1987; S. Leatherwood, 1984)

Measurement	N	Range	Mean	SD
Snout to				
deepest part of fluke notch (TL)	58	1,175–1,473	1,317.4	65.7
posterior margin of blowhole	47	140–230	171.9	20.8
angle of mouth	44	105–180	138.1	16.1
center of eye	44	135–195	168.0	14.6
ear	30	165–245	218.6	16.5
ant. insertion of flipper	38	285–380	314.0	19.9
ant. insertion of dorsal fin	40	548–840	620.4	44.8
uppermost part of dorsal fin	42	724–990	816.3	54.1
umbilicus	28	557–670	618.4	30.7
center of genital slit	32	693–1,030	818.0	81.2
center of anus	29	855–1,040	947.5	47.8
Center of eye to				
angle of mouth	37	28–60	37.9	6.7
ear	29	47–61	53.2	3.7
blowhole edge	36	101–150	130.0	10.8
Flipper				
anterior length	43	168–290	212.5	23.4
posterior length	41	122–200	155.1	18.8
maximum width	41	63–95	77.3	7.6
Dorsal fin				
length at base	48	186–370	257.6	42.2
height	48	64–140	90.4	17.3
Flukes				
width, tip to tip	41	215–400	307.7	48.8
ant. margin to fluke notch	50	93–135	113.6	10.5
depth of notch	43	13–26	19.3	3.5
Girth				
at axilla	19	550–950	739.0	84.9
maximum (front of dorsal fin)	21	720–1,120	831.8	86.9
at anus	21	390–570	450.0	38.5
midway anus–fluke notch	28	205–335	249.4	29.8
Height midway anus–fluke notch	30	92–198	119.2	23.2
Thickness, same place	28	31–95	42.8	15.4
Diameter of head between eyes	23	146–240	165.3	25.9
Aperture length				
eye	18	10–21	16.6	2.7
blowhole	37	3–19	12.1	3.3
blowhole width	41	13–30	22.7	3.2
genital slit, females	10	68–130	95.0	19.5
genital slit, males	16	32–110	69.8	18.6

rostral groove (creating the appearance of rounded upper lips) present in one fetus and some neonates fills out early in development. A slight groove was present above the eye of the one fetus examined to date.

Table 7

Total lengths (in cm) of Commerson's dolphins from Tierra del Fuego organized by physical maturity classes, as determined by degree of epiphyseal fusion

Physical maturity	N	Range	Mean	Standard deviation	Coefficient of variation
Females (RNP specimens)					
Class 1	4	99.5–117.0	110.2	8.2	0.07
Class 2	8	117.5–138.2	129.8	6.2	0.05
Class 3	7	127.6–145.5	136.6	6.8	0.05
Total	19				
Males (RNP specimens)					
Class 0	2	64.3–73.4	68.9	6.4	0.09
Class 1	14	98.6–117.0	108.7	5.8	0.05
Class 2	15	113.5–135.5	125.6	6.6	0.05
Class 3	19	125.2–138.0	130.5	3.5	0.03
Total	50				
Total (RNP specimens, both sexes)					
Class 0	2	64.3–73.4	68.9	6.4	0.09
Class 1	18	98.6–117.0	109.0	6.1	0.06
Class 2	23	113.5–142.0	127.0	6.6	0.05
Class 3	26	127.2–145.5	132.2	5.3	0.04
Total	69				

Table 8

Weight of body parts (g) of Commerson's dolphins taken incidentally off Tierra del Fuego

Measurement	N	Range	Mean	Standard deviation	CV
Total weight	13	26,000–66,000	35,249.6	10,412.1	0.30
Blubber skin	7	9,250–24,462	14,389.4	4,787.0	0.33
Muscle	7	7,780–13,590	10,517.4	2,088.7	0.20
Bone	5	2,850–9,060	5,416.4	2,280.3	0.42
Heart (without blood)	21	150–300	219.8	40.3	0.18
Lung, left	24	290–955	453.4	142.5	0.31
Lung, right	23	265–955	479.7	138.3	0.29
Liver	23	750–1,590	1,059.4	209.3	0.20
Spleen	20	5–45	17.7	11.7	0.66
False pancreas	18	40–190	75.5	44.5	0.59
Pancreas	15	65–145	99.9	21.3	0.21
Kidney, left	22	60–235	154.0	40.2	0.26
Kidney, right	22	60–250	156.2	43.1	0.28
Intestines	19	895–1,805	1,367.4	231.3	0.17
Mammary gland, left	4	45–500	198.5	212.0	1.07
Mammary gland, right	5	40–460	176.2	170.0	0.96
Left testes	13	10–470	181.6	146.2	0.80
Right testes	12	10–460	189.9	149.4	0.79

Dorsal fin

The dorsal fin is rounded or lobate, not falcate as in many dolphins. It varies from acutely angled on the leading margin and slightly undercut on the trailing edge to taller and more upright on the leading edge and deeply S-shaped on the trailing edge. Fin and body size appear directly correlated. The largest fin observed was that of the largest specimen in our own collection, an eight year old female 145.5cm long. From measurements and tracings of Tierra del Fuegian specimens the dorsal fins do not appear sexually dimorphic.

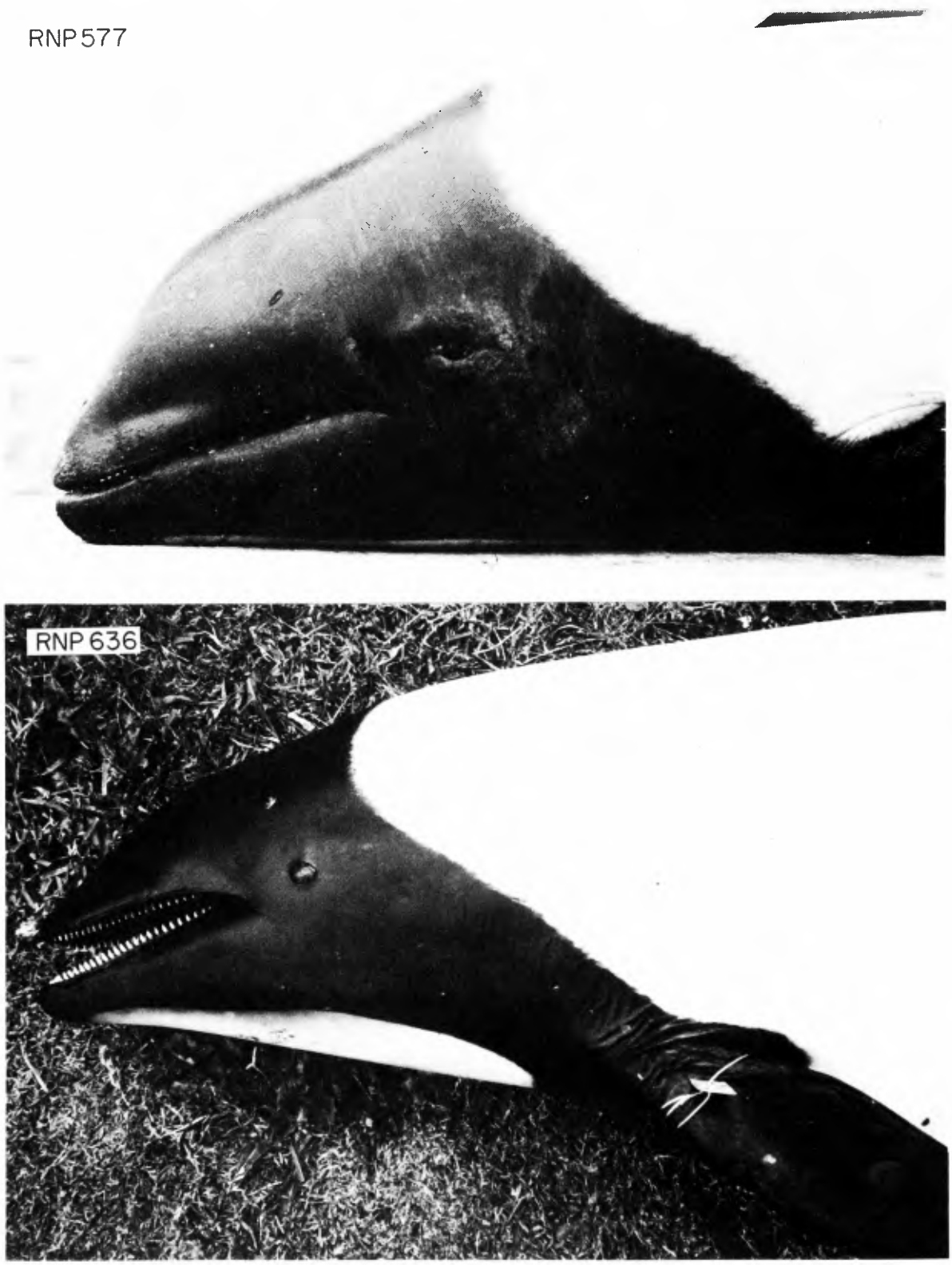


Fig. 6. The head of a young female (top), showing the rostral groove, and that of an adult male (bottom) (R. N. P. Goodall, top, and T. D. Goodall, bottom).

Flippers

The flippers are elliptical and smoothly rounded at the tips. A series of age-related serrations was present on the leading edge of the left flipper of 49 percent of all dolphins from Tierra del Fuego. The right flippers were serrated in the same manner in 80% of the females but only 4% of the males (Goodall,

Galeazzi, Sobral and Cameron, 1988). Subadult specimens of Hector's dolphins, *C. hectori*, had 'rugose nodules' (Baker, 1978) while specimens of *C. heavisidii* from South Africa had extrusions (Best, 1984) on the leading edge of the flippers.

Flukes

The flukes are not exceptional for delphinids. The tips are rounded, the posterior edge is concave and the fluke notch – where the fluke edges sometimes overlap – is 1.3 to 2.6cm deep ($\bar{x}=1.9$cm, $n=37$). The degree of concavity in the posterior edge apparently is less than that of *C. eutropia* (Goodall, Norris *et al.*, 1988) but more than that in *C. heavisidii* (Best, 1984) or *C. commersonii* from Kerguelen (Angot, 1954).

Pigmentation

Published records

In early accounts, *Cephalorhynchus commersonii* is described variously as: black on the extremities, polished white elsewhere (Lacépède, 1804, p. 338); half white, half black (Quoy and Qaimard, 1824, p. 87); 'spotted with large dabs of white' (Banks, *in*: Beaglehole, 1963, p. 214); and black and white (Lesson, 1827, p. 181; Cunningham, 1871, p. 261). Moreno (1892, p. 383) described these dolphins as white 'splashed with black on the head, back and tail' and published the first two illustrations, one of a fairly large and one of a very small female. Although he considered these representative of the range in the species' coloration, Moreno (1892) also noted that there may be tiny dark gray spots at the borders between black and white and described the roof of the mouth as white with black spots. Bruce (1915, p. 503) published the third illustration of a specimen and presented an accurate description, similar to but more detailed than Moreno's. Harmer (1922, p. 630) provided even more detail in the description which accompanied the first published photographs, of two males obtained at the Falklands (Malvinas) by J. E. Hamilton and R. Vallentin. Many subsequent illustrations are curious and inaccurate, representing what Mitchell (1970, p. 719) called 'artwork in the literature'. For example, one erroneous illustration (Cabrera and Yepes, 1960, pl. 76) was copied without correction in numerous subsequent works (e.g. Walker, 1968, p. 1,120; Marcuzzi and Pilleri, 1971, p. 129; Donoso-Barros, 1975, p. 115; Bonner, 1980, p. 47). We provide here detailed descriptions of all components of the color pattern observed to date, arranged by age and sex class (see Fig. 5).

Adults

Adults are strikingly marked in black and white. The head is black with a white throat chevron. The size and shape of the chevron are very consistent among individuals in Tierra del Fuego; in only one of the animals examined (RNP 872) was the forward half of the patch greatly narrowed. The flippers are black on both surfaces. A black band connecting them ventrally extends posteriorly in an

acuminate point. A narrow white finger visible along the midline within this black point in Kerguelen specimens (Robineau, 1984) was seldom seen in specimens from Tierra del Fuego. The dorsal fin is black and surrounded by a black region which extends forward in a more-or-less oval shaped area with a highly feathered leading margin. In the specimen collected by Rayner off Río Gallegos (Brown, 1988) this margin was thinner and more pointed than oval. This black region continues posterior to the dorsal fin as a progressively narrowing strip, then broadens behind the anus to encompass the entire tail stock and flukes. Both surfaces of the tail flukes are black, as is a patch around the genital region (see detailed discussion below). The rest of the body is white (Fig. 5 left).

In adult specimens from Tierra del Fuego the black and white zones are sharply demarcated ventrally, slightly less so laterally. As noted by Moreno (1892) and Harmer (1922), the border between dorsal black and white zones may be slightly streaked or feathered but without a transitional gray zone. The black regions are coal black, not gray or lighter than the dark areas of *C. eutropia*, as alleged by Watson (1981, pp. 249–50). There is no visible eye patch of the kind that can be distinguished in species such as Peale's dolphin, *Lagenorhynchus australis* and *C. eutropia*. There is no visible flipper stripe, although the diagonal border between black and white on the sides of the head might be considered a 'post-blowhole to axilla stripe'. The white axillary patch in the other three species of *Cephalorhynchus* is replaced in *C. commersonii* by a lobe of black.

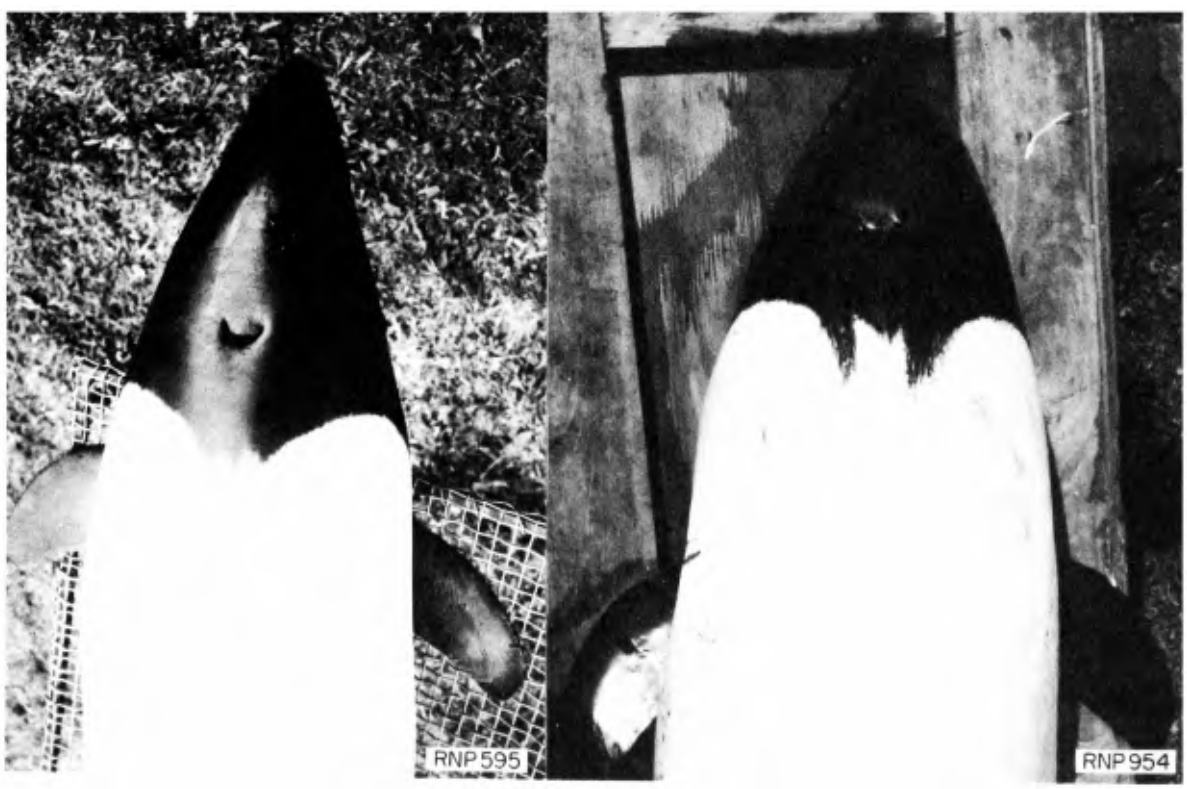


Fig. 7. The 'widow's peak', the fraying along the border between black and white on the back of the head, varies sufficiently that it can be used to distinguish between individuals (T. D. Goodall).

Harmer (1922) observed correctly that the coloration of this species is 'remarkably constant in the position of the areas of black and white'. However, variation does exist in some details of coloration, particularly along borders between dark and light zones. For example, the details on the border behind the blowhole (Fig. 7) are sufficiently variable (e.g. single point, multiple points, feathered, rounded, or indefinite) that they can be used to identify individuals and perhaps to distinguish among stocks. Similarly, the angle at which the black spinal field descends to encompass the tail stock and the shape of the borders between black and white were sufficiently variable in 38 animals we examined (from a gradual posterior slope to an abrupt fall and from smooth to irregular boundaries – see Fig. 8) that they might well be useful in distinguishing individuals, either specimens in hand or live animals in repeated field encounters.

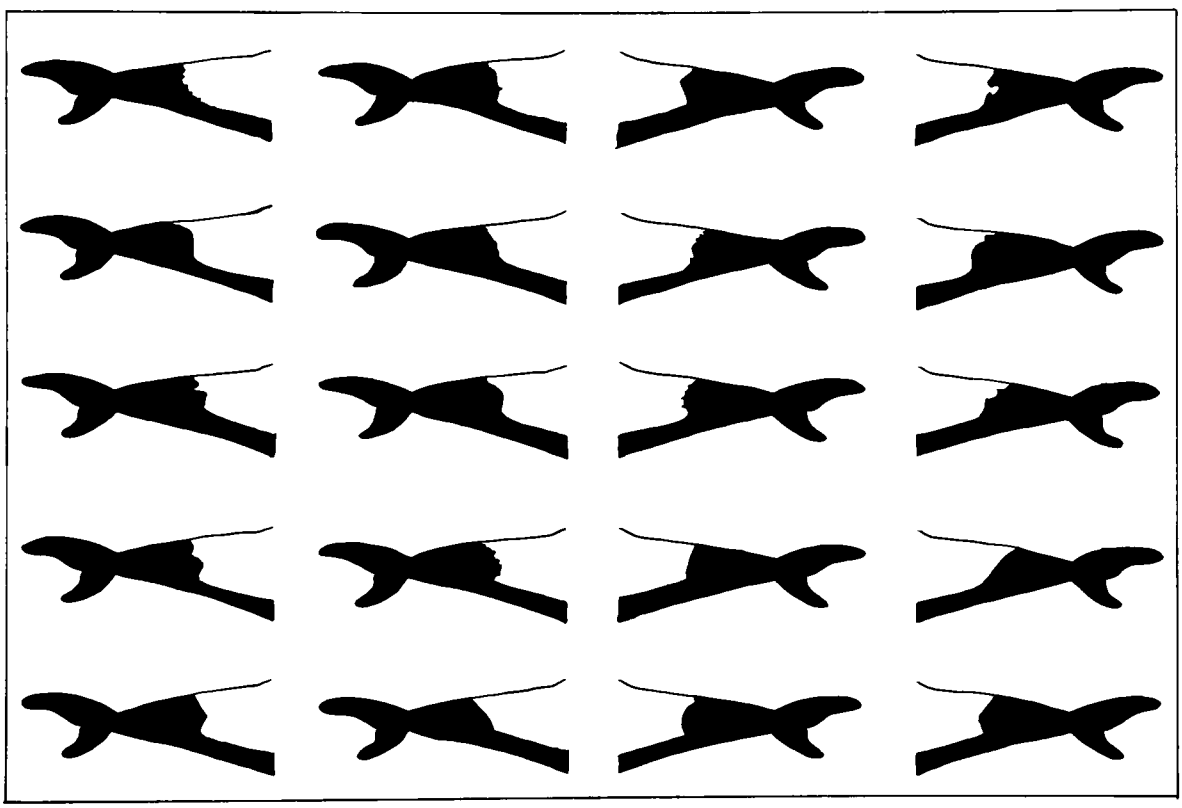


Fig. 8. Variation in pigmentation of the tail stock of specimens from Tierra del Fuego. The angle and details of the margin between black and white can be used to distinguish between individuals.

Genital patches

Moreno (1892, Plate 9, Figs 1–6) and Bruce (1915, Plate 1) illustrated elongated black patches in the genital areas of female specimens of *C. commersonii*. Harmer (1922, p. 630) examined that feature more closely on three males (one reported to him by Hamilton, one Hamilton sent to the British Museum and one from R. Vallentin) and compared them with previous descriptions (all of female specimens). He questioned whether or not the genital patch was sexually

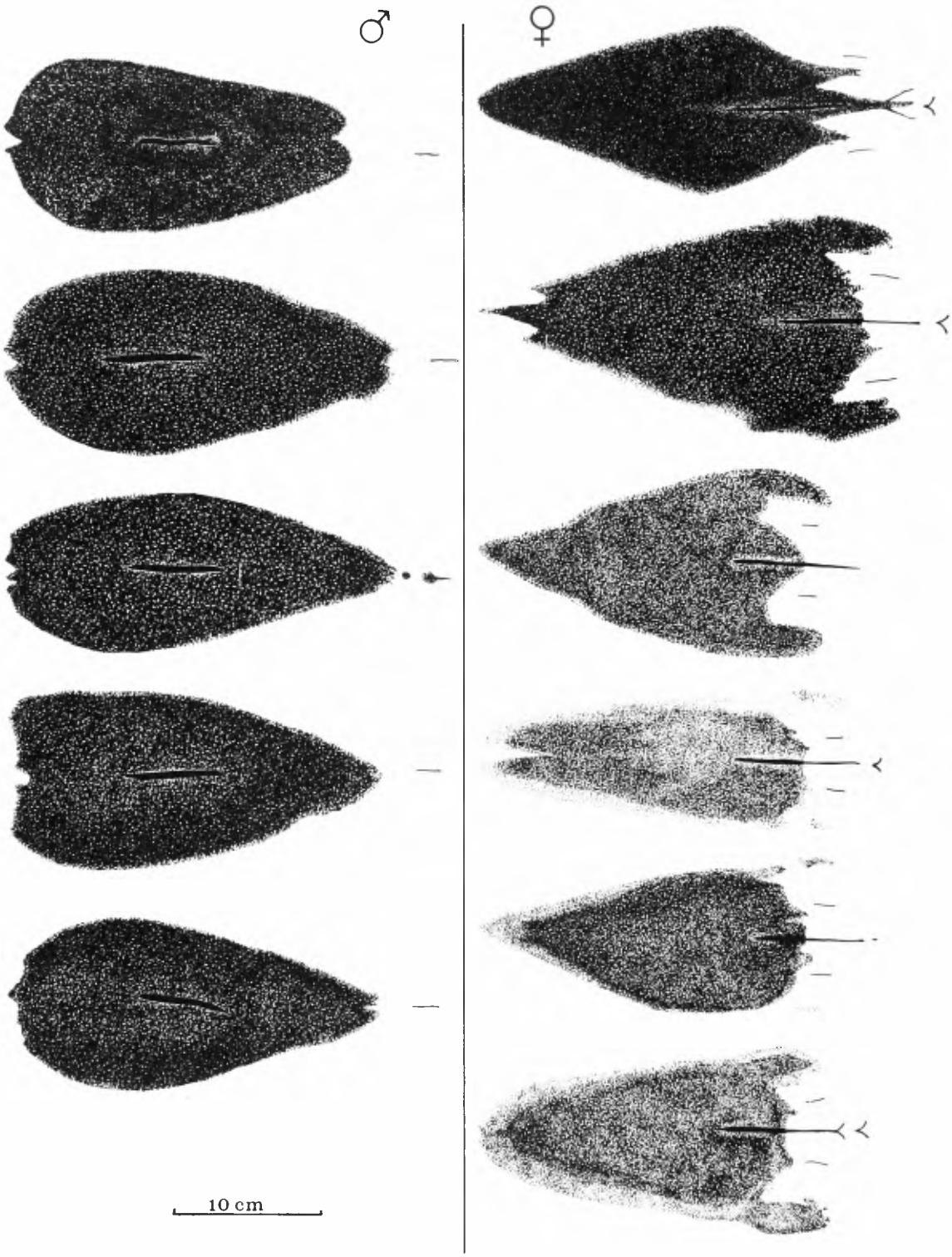


Fig. 9. Comparison of genital patches in males and females, drawn to scale.

dimorphic, males exhibiting a 'large, heart-shaped black area' around the reproductive organs, females a narrower, constricted marking. Goodall and Cameron (1979a, b) first confirmed the existence of such differences. They have since been noted by other investigators (e.g. Gewalt, 1981; Cornell *et al.*, 1988).

Male specimens from Tierra del Fuego (Fig. 9) and Kerguelen (Robineau, 1984) have a heart- or pear-shaped black patch completely enclosing the genital

openings. The patch is oriented parallel to the longitudinal axis of the body with the narrowest portion posterior. This patch approximately mirrors the shape of the larger white throat chevron, which is similarly shaped but points anteriorly. A small proportion of the males examined had one or two small circular black spots near the anus.

Female specimens have an entirely different and more variable genital patch (Fig. 9). Although generally pear-shaped, the patch covers only the anterior half of the genital slit and its orientation is reversed from that of the males, the narrower end pointing anteriorly. Normally, two finger-like projections or lobes, one on each side, extend posteriorly from the patch, partially surrounding the white mammary slits. On the specimen illustrated by Rayner (Brown, 1988) the lobes were medial to the mammary slits rather than lateral of them; some specimens have no lobes at all. Morejohn, Loeb and Baltz (1973, p. 979) speculated that such patches and associated lobes in cetaceans might help in sexual recognition and assist the young in locating the mammaries for nursing. In some younger animals the genital patches and above described lobes were gray. We have found no animals with an elongated stripe of the kind illustrated by Moreno (1892, plate 9, Fig. 1b). It is likely that his illustration was drawn with only cursory attention to fine detail, as the animal he illustrated was killed on the eve of the ship's departure for Buenos Aires, while Moreno stayed behind to explore the Río Santa Cruz. Of the circumstances surrounding the illustration, Moreno wrote 'we barely had the time to take some measurements, prepare the skin and the skeleton and entrust it to ..... transport to Buenos Aires' (Moreno, 1892, p. 386).

Sexual dimorphism in shape and pigmentation of the genital region has been noted for a variety of delphinid species, including other *Cephalorhynchus*, as follows: In the northern right-whale dolphin, *Lissodelphis borealis*, the ventral white band is broader in females than in males (Leatherwood and Walker, 1979: Fig. 14); In Dall's porpoise, *Phocoenoides dalli*, the genital extension of ventral black under the tail stock is short in males (reaching only as far as the anal opening), longer in females (to the front of genital and mammary slits) (Morejohn *et al.*, 1973, p. 979); In *C. hectori* the patches are larger in males than in females (M.W. Cawthorn, pers. comm., 1978); and in *C. eutropia* the patches are larger in males than in females and are shaped differently (Goodall, Norris *et al.*, 1988). As knowledge of sexually dimorphic differences in cetacean coloration increases, it is being used to distinguish between the sexes in observations of some cetaceans. For example, J.T. Polkinghorn was able to determine that a Commerson's dolphin he saw off Patagonia (Table 3; sighting 17) was a male when it rolled on its side while riding the bow wave of his ship.

Pigmentation of apertures

Moreno (1892, p. 388) described the palates of specimens of *C. commersonii* he examined as white with black spots. In specimens we have examined, the palates have been largely whitish, but surrounded by a wide black border with very irregular interior edges. The tongue and lower mouth were purplish white. There were black spots along the tooth row and the outer edge of the tongue

was dark. Some tongues were whitish with scattered black spots. The upper portions of the blowhole and nasal passage were black grading downward in the passage to black with irregular white patches. The penis is white with black markings or black with scattered white spots. The inside of the genital slits of females is often black and white.

Pigmentation of the fetus

Goodall and Cameron (1979a, b) reported that the fetus of *C. commersonii* is dark gray. The observations supporting that statement are as follows: in 1977, fishermen in Tierra del Fuego described two fetuses, one born on the beach and another removed fresh from a mother shortly after her death, as black. Later in the same year we examined a near-term male fetus from a female taken incidentally in fishing nets. The fetus' color pattern consisted of black zones and a white throat patch exactly as in adults. The abdominal field was white but smaller than on adults. Other zones which would have been white on an adult were dark, smokey gray. The posterior margin of the black band between the flippers was bordered by such gray color. The black genital patch occupied the center third of the white abdominal field. The dorsal surfaces abutting the black and both sides were dark gray. The lower posterior boundary of the gray area was reminiscent of an eye-to-anus stripe (Fig. 5, right).

Subsequent to the above observations, in which fine detail could be described, others have confirmed that the fetuses and newborn neonates of *C. commersonii* off southern South America have a largely muted color pattern of gray on darker gray and black. For example, Mermoz (1980, p. 153) wrote that 'the newborn calf is completely brown, as it grows it becomes grayish and then the black and white areas begin to appear, being at first gray instead of white and darker where it will be black'. Gewalt (1981) reported young animals he observed off Argentina as dark brown to gray. During collecting activities near Punta Sara, Chile in November/December 1983 (Cornell *et al.*, 1988), observers frequently encountered 'small, all dark calves'. A decomposing newborn we found entangled beside an adult in a net in January 1984 was black, with few signs of shading. A newborn (determined by fetal folds, awkward swimming motions and close association with an adult) we observed at the First Narrows on 31 January 1984 displayed essentially all elements of adult coloration but as gray on black or dark gray. Three Commerson's dolphins born at Sea World, San Diego, were similarly marked (Cornell *et al.*, 1988; Leatherwood and Cornell, 1985).

Pigmentation of juveniles

There is little quantitative information on the age at which Commerson's dolphin juveniles attain adult coloration. Because stranded animals begin to darken soon after exposure to air and photographs often misrepresent color and tone, all except the best data from studies of strandings and photographs must be interpreted cautiously. Similarly, descriptions of live, free-swimming animals are subjective characterizations based usually on brief glimpses of less than the entire animal; such glimpses rarely reveal subtleties of markings.

A captive-born male at Sea World began to lighten in color at about two months; by five months he was 'difficult to distinguish from adults except by his smaller size' (Leatherwood and Cornell, 1985) although he continued to show slightly darker lines where the 'fetal folds' had been. Medium-sized animals (assumed to be juveniles and subadults) we observed in the Second Narrows in the Strait of Magellan in January 1984 appeared to be marked essentially the same as accompanying larger animals, presumed to be adults. Given the rapid growth rate of dolphins, those observations suggest that at least some Commerson's dolphins develop adult-like coloration early within their first year.

From specimens, Hamilton (1952, p. 6) described males as more starkly black and white and females as having 'had the light area very pale gray, not white'. He also wrote that at a little distance no difference can be detected. During the early years of our study we found all females we examined from Tierra del Fuego to be a clear light gray rather than white on the sides and back and the grayness so soft as to be virtually indistinguishable on free-ranging animals [Mermoz, (1980, p. 153) did distinguish some larger gray animals at Comodoro Rivadavia]. Subsequently, however, we collected white adult females and gray subadult males. Considering length, age and degree of epiphyseal fusion, all gray specimens in our collection subsequently were determined to be Class 0 or 1, i.e. fetuses, neonates or juveniles. The largest specimens in which light gray still replaced white on dorsal and lateral surfaces (five males and five females) were all less than 117cm long and one year old or less. Lockyer *et al.*, (1981 and 1988) found that animals less than one year old were 92–112cm long and animals one year old were 103–117cm long. It is likely, then, that the 122cm female specimen on which Hamilton (1952) based his conclusion that females were gray was an incorrectly measured juvenile and not an adult, as reported. Collectively, these observations support our earlier conclusion that adult coloration is achieved at least by two and most likely by one year of age (Fig. 5, middle).

Anomalous pigmentation

One gray male (RNP 773, total length 103cm) had a small white streak beside each ear, a pattern characteristic of *C. eutropia* (Goodall, Norris *et al.*, 1988). A male resident at Duisburg Zoo since 1978 has white spotting on the undersides of the flippers. We have seen no all black or all white Commerson's dolphins, as have been reported for many species of cetaceans (see Hain and Leatherwood, 1982) and no other anomalously pigmented animals.

Scars and marks

Commerson's dolphins, like other small cetaceans, sometimes bear scars from bites by conspecifics. Mermoz (1980, p. 151) reported tooth-rakes on the sides of a male at Comodoro Rivadavia. We have found tooth-rakes and puncture holes on specimens from Tierra del Fuego. Such rakes usually appear on the

tail, less frequently on the flippers. Puncture holes are often camouflaged by the dark skin but can be detected on close examination by a darkening in the blubber below. One animal, captured for the Duisburg Zoo in 1980, has a series of healed tooth-rakes on the dorsal fin which were present at the time of capture. Bite scars were present on five of 11 specimens of *C. commersonii* from Kerguelen (Robineau, 1984).

Internal anatomy

Hertel (1969, p. 38), repeating a diagram by Kramer (1960), showed a section of skin of a Commerson's dolphin which he described as a soft outer layer of 1.5mm and a stiffer inner skin of 6mm. McFarland (1971) analysed visual pigments of two specimens (USNM355352 and 355353) and found no evidence of cones. Only one retinal pigment, rhodopsin, was evident, leading the author to speculate that the 'blue-shift in the visual pigments of deep-sea fishes and deep diving mammals may represent an adaptation to maximize the detection of bioluminescent organisms'. Pilleri and Gihr (1982) measured brain case volume and calculated brain weight for two specimens. They estimated that the brain of a 50kg female from Patagonia (Brown, 1988) was 770ccm, while that of an emaciated 20kg specimen from Bahía San Jorge (Gewalt, 1981) was 800ccm. From these estimates, the authors asserted that the species has a relatively high brain weight and classed it with those cetaceans (e.g. *Tursiops*, *Lagenorhynchus* and *Grampus*) they regarded as having the highest degree of cephalization.

Organ weights are available for 41 specimens of *C. commersonii* from Tierra del Fuego (Table 8). In three animals examined there were 248–396 lobes in the left kidney, 256–396 in the right. In 20 animals, blubber thicknesses were: mid-ventral (16–30mm, $\bar{x}=21$), mid-lateral (14–25mm, $\bar{x}=20$) and mid dorsal anterior to the dorsal fin (18–35mm, $\bar{x}=25$). Intestines of 13 animals were 7.0 to 10.7m long ($\bar{x}=9.06$), about 5.5 to 9.2 ($\bar{x}=7.1$) times the animals' total length.

Parasites

Lungworms, *Skrjabinalius* sp., were found in specimens from Puerto Deseado confiscated in New York (Spotte *et al.*, 1979) and from Punta Sara, Chile (Cornell *et al.*, 1988). We have found Commerson's dolphins from Tierra del Fuego to be remarkably free of external parasites and to have internal parasites only infrequently. This may, in part, reflect the fact that most of the fresh specimens we examined had died after entangling in nets; so, they were not beach-cast animals which may have stranded because they were ill. We have found worms in stomachs and intestines, lungs, and bronchial tubes, and, in one case, the heart; cysts in lungs, stomach wall and, occasionally, the blubber; and microparasites of the intestinal fluid. Parasites are under study by A. Raga and M. Heckman and staff at Sea World of California.

Diseases

The pathology of wild Commerson's dolphins has not been studied. Post-mortem examination of animals which have died in captivity provide us with the following data: four of the dolphins taken from Bahía San Jorge, Argentina to Duisburg, Germany in 1978 died of 'mycosis of the skin' (*Candida albicans*), lung worms and pneumonia (Gewalt, 1979; pers. comm.); three of four animals confiscated in New York after delays and poor treatment *en route* to Japan died of 'verminous pneumonia caused by lungworm, gastroenteritis, gastric ulcers and pancreatic fibrosis' (Spotte *et al.*, 1979). The fourth animal suffered from an extreme deformity of the spinal column, allegedly precipitated or exacerbated by transport, which worsened until the animal was unable to use her flukes for swimming (Ellis, 1982, p. 129). This specimen was 142cm on arrival (Spotte *et al.*, 1979) but measured only 117cm at death (measured by J.G. Mead and R.N.P. Goodall). Such s-shaped spinal deformities have been noted in pilot whales, *Globicephala* sp. and bottlenose dolphins, *Tursiops* sp. (Cornell *et al.*, 1984; Goodall, pers. observation) but not in other specimens of *Cephalorhynchus*. A variety of other bone deformities noted in Commerson's dolphins in the Tierra del Fuego collection are under study.

Skeletal characteristics

Skull

Moreno (1892, p. 389) first described and illustrated the cranium and mandibles of *Cephalorhynchus commersonii* using two specimens, one male (Museo de la Plata Specimen 1480 – Brownell and Praderi, 1985) and one female. Harmer (1922, p. 633) later compared the skulls of *C. commersonii*, (Fig. 10), *C. eutropia* and *C. heavisidii*. Best (1977 unpublished, *in*: Brownell, 1978) reported that these last two species could be distinguished from each other and from the other two species of *Cephalorhynchus* but that skulls of *C. commersonii* and *C. hectori* are very similar. There was little asymmetry apparent in seven skulls of *C. commersonii* with condylobasal lengths (CBL) of 280–301mm (Ness, 1967, p. 214), but sexual dimorphism does occur in the skulls of this species (Goodall, unpublished).

Measurements (in mm) of the skulls of 26 physically mature (classes 2 and 3) Commerson's dolphins from Tierra del Fuego are shown in Table 9 (see Fig. 10). The condylobasal lengths (CBLs) of 105 specimens in the Tierra del Fuego collection were as follows: Class 0 (n = 1, 194); Class 1 (n = 23, range = 249–285, x = 268.7, S = 9.3, CV = 0.03); Class 2 (n = 40, range = 269–300, $\bar{x}$ = 284.1, S = 7.8, CV = 0.03); and Class 3 (n = 41, range = 264–300, $\bar{x}$ = 285, S = 7.6, CV = 0.03). The anomalously small 264mm skull in class 3 was of a lactating female with all vertebral epiphyses fused. The specimen measured only 127.6cm overall, the cleaned skeleton only 115cm. This is apparently the smallest sexually mature dolphin yet examined (IWC, 1985, p. 133) and must, for the moment, be considered anomalous. For all specimens examined rostral length was 47.1–49.5%, rostrum width at midpoint 15.7–18.5% and zygomatic width 49.6–51.3% of CBL.

Table 9

Ranges and mean values of skull measurements (mm) of 26 physically mature Commerson's dolphins from Tierra del Fuego.

Measurement	N	Range	Mean	Standard deviation	CV
Cranium					
1. Condylobasal length	25	279.6–299.2	286.2	6.5	0.02
2. Rostrum length	25	132.3–146.0	137.6	3.6	0.03
3. Rostrum width at base	26	66.7–82.8	76.7	3.8	0.05
4. Rostrum width at midlength	25	42.2–61.9	48.4	3.6	0.08
5. Premaxillae width at base	26	35.8–41.4	37.9	1.5	0.04
6. Premaxillae width at midlength	25	21.0–27.7	24.0	1.7	0.07
7. Rostrum width 3/4 length	25	32.8–38.4	35.7	1.7	0.05
8. Rostrum tip to external nares	25	167.0–184.0	174.2	5.1	0.03
9. Rostrum tip to internal nares	20	146.0–163.2	152.5	5.2	0.03
10. Preorbital width	25	108.8–128.0	122.2	3.9	0.03
11. Postorbital width	23	134.7–149.8	140.0	3.4	0.02
12. Orbital width	25	118.6–132.0	126.1	3.1	0.02
13. External nares width	26	30.7–37.9	35.6	1.7	0.05
14. Zygomatic width	25	133.0–150.0	141.6	3.7	0.03
15. Greatest width of premaxillaries	26	44.2–53.8	47.6	2.5	0.05
16. Parietal width	24	128.2–141.2	136.5	3.5	0.03
17. Braincase height	25	99.6–117.0	107.5	4.5	0.04
18. Braincase length	25	100.2–109.6	105.2	2.9	0.03
19. Postemporal fossa length L	25	59.0–69.0	63.6	2.6	0.04
20. Postemporal fossa length R	24	58.7–69.2	63.6	3.5	0.05
21. Postemporal fossa width L	25	35.0–45.6	40.2	2.4	0.06
22. Postemporal fossa width R	24	38.4–46.6	42.3	2.1	0.05
23. Orbital length L	25	40.5–48.0	43.4	1.7	0.04
24. Orbital length R	23	40.2–46.6	43.5	1.9	0.04
25. Antorbital process length L	25	3.6–9.7	6.8	1.7	0.25
26. Antorbital process length R	19	4.0–10.0	7.3	1.4	0.19
27. Internal nares width	25	39.5–48.5	43.7	2.4	0.05
28. Pterygoid length L	19	39.8–50.8	44.7	3.0	0.07
29. Pterygoid length R	20	40.3–50.4	44.0	2.7	0.06
30. UL tooth row length	25	115.8–129.4	121.2	3.7	0.03
31. UR tooth row length	25	116.5–129.4	121.5	3.7	0.03
32. LL tooth row length	23	112.7–126.4	116.7	3.9	0.03
33. LR tooth row length	23	109.2–126.0	116.3	4.0	0.03
Mandible					
34. Ramus length L	23	208.0–232.0	218.4	6.1	0.03
35. Ramus length R	23	206.9–231.3	218.6	6.1	0.03
36. Ramus height L	21	49.6–63.4	52.7	2.9	0.06
37. Ramus height R	21	50.5–57.4	52.7	1.7	0.03
38. Mandibular fossa length L	22	79.3–92.9	85.9	3.2	0.04
39. Mandibular fossa length R	20	80.4–92.8	86.2	3.5	0.04
Ear bones					
40. Bulla length L	26	26.4–30.0	28.2	0.8	0.03
41. Bulla length R	25	26.8–29.5	28.1	0.7	0.03
42. Periotic length L	26	25.4–27.6	26.4	0.6	0.02
43. Periotic length R	25	25.5–27.6	26.5	0.6	0.02

The specimens from Tierra del Fuego examined to date (81) have had 25–33/24–32 teeth visible in the fresh state, 28–34/26–34 in the prepared skull and mandibles. Brown (1988) reported that teeth were loose in a specimen from Patagonia. We have found that teeth of live or fresh dead specimens can be wiggled slightly with the fingers and that usually 1–3 very small teeth are hidden in the gums at the tip of the jaws. The sharply pointed, peg-like teeth are less than 3mm in diameter.

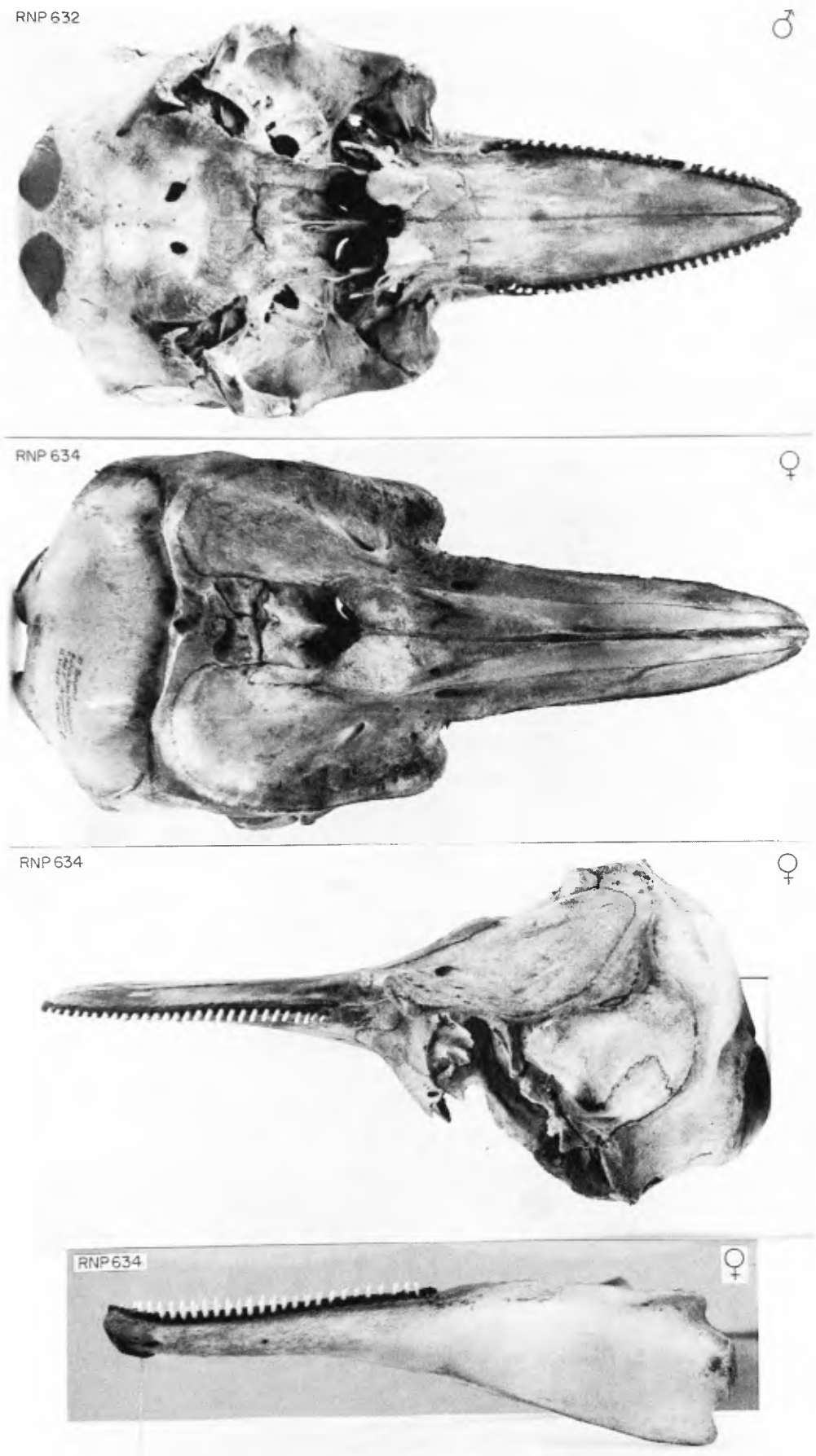


Fig. 10. Dorsal, ventral and lateral views of skulls of Commerson's dolphins. R.N.P. numbers refer to Table 4, where size and level of maturity of the specimens are reported (I. S. Cameron).

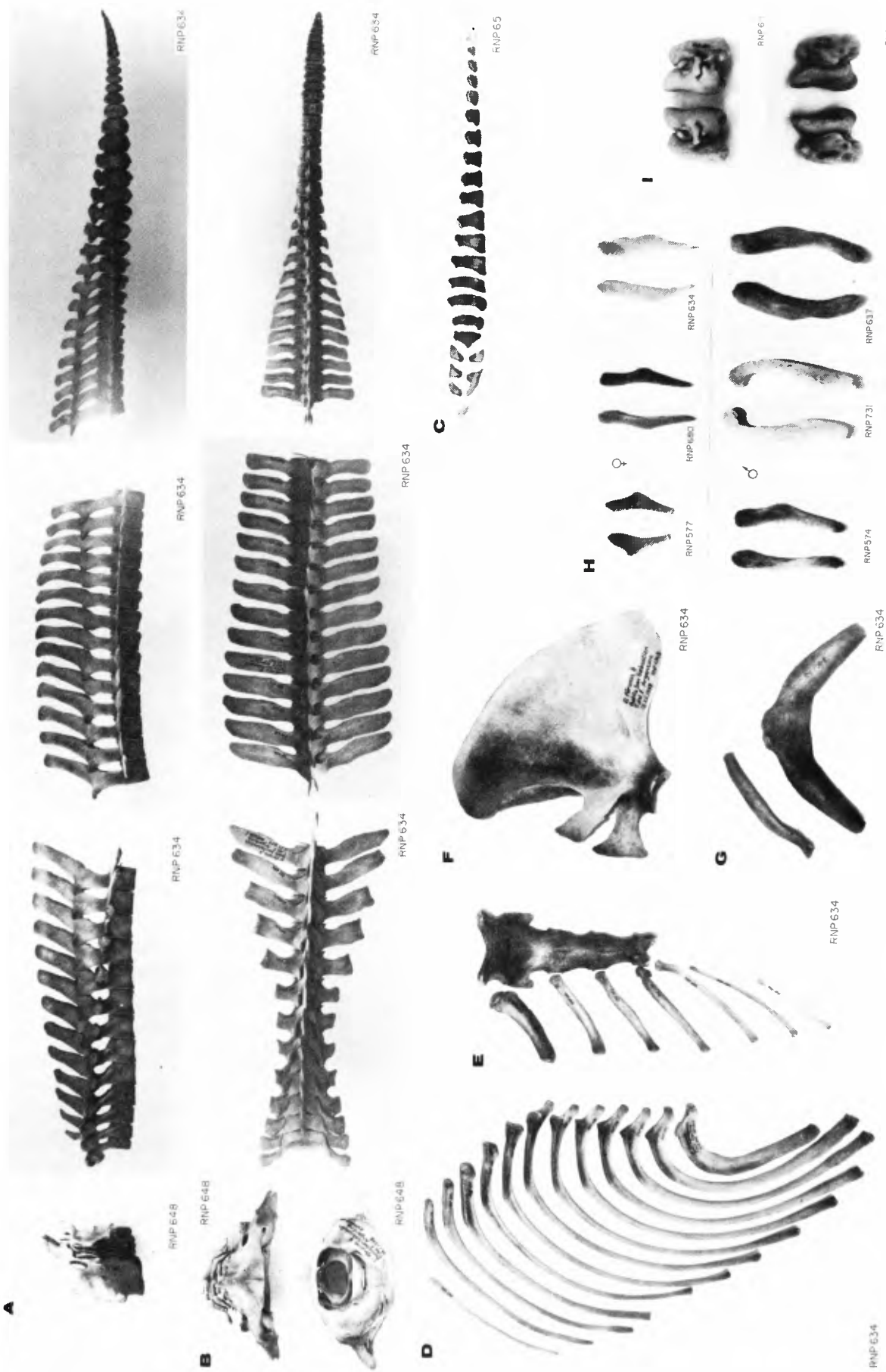


Fig. 11. Features of the skeleton of Commerson's dolphin. Lateral (A) and dorsal (B) views of vertebral column; (C) chevrons; (D) vertebral ribs; (E) sternum and sternal ribs; (F) clavicle; (G) hyoids; (H) pelvic bones and (I) periotics. R.N.P. numbers refer to Table 4, where the size and level of maturity of specimens are reported (I. S. Cameron).

Based on the morphology of tympano-periotic bones of one *C. commersonii* (USNM 252568), which he illustrated in his plate 14, and one *C. eutropia* (USNM 21167), Kasuya (1973) included *Cephalorhynchus* in the subfamily Sotaliinae, along with *Sotalia* and *Sousa*.

The thyrohyals (Fig. 11) were fused with the basihyal such that they separated in only a few Class 2 and no Class 3 animals from Tierra del Fuego. These bones were unfused in all but 2 specimens from Kerguelen (Robineau and Buffrénil, 1985).

Postcranial skeleton

The various elements of the postcranial skeleton of *Cephalorhynchus commersonii* are illustrated in Fig. 11 (A–I). A vertebral formula of 7 cervicals, 12 thoracics, 24 lumbars and 20 caudals, for a total of 63, was reported by Lichter and Hooper (1984, p. 71). The typical vertebral formula of 51 specimens in the present sample was 7 cervicals (the first two always and fourth and fifth occasionally fused), 13 (12–14) thoracics, 14 (13–15) lumbars and 31 (28–32) caudals, for a total of 65 (61–66). The anticlinal vertebra was usually the last lumbar or the first caudal. Rates of epiphyseal fusion were described by Lockyer *et al.* (1981, 1988). There are as many as 22 chevrons; normally all pairs except the first two or three, and sometimes the last, are unfused.

Usually the first seven (rarely six) pairs of ribs have a capitulum and tuburcle. The last rib (sometimes two) on each side may be very small and embedded in muscle some distance from the vertebrae. There are seven pairs of sternal ribs, contrasted with the five pairs present on all eleven specimens of *C. commersonii* from Kerguelen examined to date (Robineau and Buffrénil, 1985).

The pelvic bones (Fig. 11) of juvenile animals do not differ substantially between the sexes. In four males ($\bar{L}=41.6$, $\bar{R}=41.9$) and 10 females ($\bar{L}=32.67$, $\bar{R}=32.95$) examined to date, the right pelvic bone has been slightly longer than the left. The pelvic bones of females point posteriorly and appear to become more pointed with age. In 26 Class 2 and 3 females they ranged in length from 24.6 to 48.2mm ($\bar{x}=34.5\pm5.6$). The pelvic bones of males increase substantially in size with sexual maturity, becoming thicker and developing a slight longitudinal twist and a knob on each end. In 38 physically mature males they ranged in length from 33–58.6mm ($\bar{x}=45.9\pm5.8$).

In 41 flippers (from 22 animals) we examined there were 5 (68.3 %) or 6 (31.7%) carpals. The phalangeal formula, including metacarpals, was usually I: 2; II: 7 (or 8); III: 5 (or 6); IV: 3 (or 4) and V: 0 (or 1–3). This differs slightly from that reported by Robineau and Buffrénil (1985) for specimens of this species from Kerguelen. Sometimes one or two very small spherical bones were present. We agree with the assessment of Buffrénil and Robineau (1984) that phalangeal epiphyses in this species fuse slowly.

Reproduction

Reproductive materials from the present study have been analysed and reported separately (Lockyer *et al.*, 1981, 1988). They indicate that males are sexually mature by 5–6 years of age and 127–131cm, females by 5–6 years and about 130cm. One 9 year old, 127.6cm female in the sample was lactating. In fact, if

she was correctly measured, she was the smallest sexually mature cetacean of any species measured to date (IWC, 1985, p. 133). Other data on reproduction in this species are sparse. Spotte *et al.*, (1979) reported that a 136cm male was sexually mature while two females 132 and 144cm had immature ovaries. From examination of the skeleton, the smaller of these females was determined to be physically mature (C.W. Potter, pers. comm.). It is not clear why its ovaries and that of the even larger female were immature. Collet and Robineau (1988) found that at Kerguelen Island males were sexually mature by eight years and 165cm (n = 4), females by five years and 165cm (n = 7).

Near or full-term fetuses and small neonates have been found in November through February. Specimen RNP 1158, a 64.3cm male collected from the beach on 15 November 1984, was judged to be nearly full-term. A full term fetus in a female collected at Península Parámo on 12 December 1977, (mother RNP 634) was 73.4cm long, (50.5% as long as its mother) and weighed 7.27kg (12.4% as heavy as its mother). The fetus was in the right horn of the uterus, bent to its right such that its snout and tail were side by side and oriented towards the mothers tail. The dorsal fin was bent over to the right, the flippers pressed against the body and the flukes bent downward and forward. The posterior border of the flukes was wavy. Rostral grooves were present on each side of the snout, above and parallel to the mouth. There were five black, curly hairs 19.5–21.2mm long, in a row on each side of the face, just below and anterior to the rostral groove. The hairs began 17mm from the tip of the jaw and were 3-5mm apart. As no vibrissae were seen in any other young animals, they must be lost soon after birth.

Births of captive Commerson's dolphins have occurred in January (Cornell and Leatherwood, 1986), February (Leatherwood and Cornell, 1985) and March (Cornell, pers. comm.). All sightings of free-ranging Commerson's dolphins classed as newborn have been logged in December, January, or February. The birth season appears to be austral summer, even in animals living in a Northern Hemisphere oceanarium. From hormone data and observations of mating and pregnancy, gestation is thought to be approximately 12 months (Leatherwood and Cornell, 1985).

Pascal (1981, p. 328) described and illustrated a vertical, belly-to-belly copulation posture he observed in Commerson's dolphins at Kerguelen Island. We observed similar postures in animals off Península Parámo, in Bahía San Sebastián, on 21 March 1983 and at the First Narrows in January 1984. Cornell *et al.*, (1988) reported that in the breeding colony at Sea World, San Diego, copulations are frequently observed but peak 'in frequency and intensity in January and February'. Females have two mammary slits; no rudimentary mammary slits have been found on any males.

Behavior

Feeding behavior

There are a handful of published records of observations of feeding behavior and prey selection in Commerson's dolphins, but until recently only two stomachs had been examined. Weber (1920) claimed that animals he captured

in the Strait of Magellan spat out sardines which were fresh enough to eat. Cabrera and Yepes (1960) saw Commerson's dolphins pursuing and taking fish, species unnoted, near the pier at Comodoro Rivadavia. In the same area some 20 years later, Gewalt (1979, p. 37) saw Commerson's dolphins following schools of sardines and published a photograph of dolphins and fish together in the breakers. Mermoz (1980, p. 152) watched dolphins in the same area feed near shoals of 'sardines (*Sprattus fueguensis*), ... silversides and southern anchovies'. Stomach contents examined to date suggest Commerson's dolphins feed often on or near the sea bottom (IWC, 1985; Goodall and Galeazzi, 1985; Robineau and Duhamel, 1984).

Despite such frequent circumstantial evidence that they are an important prey, sardines were not positively identified in the few earlier specimens examined. Hamilton (*in*: Harmer, 1922, p. 629) found 'krill ... and the pens of cuttlefish' in one specimen and Rayner found a few cuttlefish[1] beaks and small fish vertebrae in the stomach of a harpooned female (Brown, 1988). Analysis of some 40 stomachs from the present collections indicate that Commerson's dolphins from Tierra del Fuego are opportunistic feeders, eating squid, mysid shrimp, fish of many species (including sardines), isopods and other invertebrates (for details see Bastida *et al.*, 1988). The sample on which these conclusions are based was largely from Bahía San Sebastián, an approximately 60km long beach fronting an almost imperceptibly sloping bay which floods and exposes in tidal ranges of up to 10.6m (Anon., 1978). Tidal ranges in some other areas, such as Río Gallegos, are even greater. In such areas of high tides, Commerson's dolphins appear to feed in the shallows, in or just beyond the breakers of an advancing tide. They are apparently taking fish, such as sardines and anchovies, which are also feeding in the disturbed area, or other organisms which are dislodged or disturbed by the turbulent water.

Elsewhere, Commerson's dolphins remain for protracted periods and presumably feed in kelp beds (Hamilton, 1952, p. 6; Mermoz, 1980) [Kelp has been found in the stomachs of specimens from the kelp-rich rocky shores of eastern Tierra del Fuego (Bastida *et al.*, 1988)], in open waters, around such submarine banks as Burdwood Bank, and near artificial structures, such as piers and oil rigs. The dolphins are sometimes seen feeding independently along boundaries of adjacent currents (Leatherwood *et al.*, 1988b). In many areas, however, they engage in some cooperative feeding, usually consisting of herding fish. In Bahía San Sebastián and at Río Grande, at least, such herding often takes place where fifteen or fewer dolphins form a half circle and drive a school of fish – often *pejerrey*, *Austroantherina* sp. – against the shore. In such feeding activities dolphins sometimes strand. Usually they are able to extricate themselves, but not always – one animal which stranded in this manner in Bahía San Sebastián on 23 March, 1983 was unable to return to the sea until it was assisted by fishermen and another was found stranded dead farther down the same coast (G. Cifuentes, pers. comm.). Angot (1954, p. 8) described instances in which Commerson's dolphins at Kerguelen Island 'advanced so close to the shore that I saw several on the beach, returning to the sea when the waves caught them' – similar to cases where bottlenose dolphins drive fish up a bank and wriggle up to feed on them (Hoese, 1971; Leatherwood, 1975).

[1] Probably the squid, *Loligo sanpaulensis*, see Bastida *et al.* (1988).

Commerson's dolphins engage in other cooperative herding, similar to that described by Leatherwood (1975), Würsig and Würsig (1979) and Norris and Dohl (1980), without use of the shore as a barrier. For example, near the walkways to oil rigs in Comodoro Rivadavia, dolphins have been seen, in groups of 2–6, circling around fish, probably sardines, and taking turns passing through the center of the circle, feeding and then returning to the perimeter of the circle (O. Gallina, pers. comm.).

Associations with other species

Commerson's dolphins have been seen swimming near and interacting with various birds and other marine mammals (Table 10), most often Peale's dolphins, *Lagenorhynchus australis* and southern sea lions, *Otaria flavescens*. Like other dolphins, their presence is often signalled by flocks of birds, usually terns, overhead. Gewalt (1979) depended on the presence of such associated birds to locate the dolphins for capture. The associations of Commerson's dolphins with Peale's dolphins are sometimes close – involving swimming synchronously for prolonged periods, riding the waves of the same vessels, or feeding in the same areas – sometimes more casual, as has been reported for associations of Peale's dolphins with Chilean dolphins, *C. eutropia* (Goodall, Norris *et al.*, 1988).

Dolphins investigated a scuba diver in the estuary at Río Deseado for 25 minutes, diving when he did, rushing at him at high speeds and turning just before collision, remaining at a distance such that the diver could barely touch them with his finger tips (M. Olivia Day, pers. comm.).

Table 10

Reported associations of Commerson's dolphins with other species

Date	Associated species	Comments	Source
Feb. 1968	Cephalorhynchus eutropia	With 100+ Commerson's*	P. Scott diary
Feb. 1976	Phocoena spinipinnis (3)	100m distant, no interactions**	Wursig, 1977
–	Phocoena spinipinnis (3)	100m distant, no interactions	Mermoz, 1980
–	Terns, penguins, shags, sea lions	No interactions	Mermoz, 1980
–	C. eutropia? (3)	100 Commerson's, two larger, darker dolphins, Strait of Magellan	Goodall, Norris et al., 1988
Feb. and Nov. 1982	Lagenorhynchus australis (2 and 3)	Capt. G. Zimmerman aboard M/V Yaktemi*	
Jan. 1983	L. australis (1)	Swimming in close association just outside breakers at Península Páramo for several kms	N. Goodall and P. Laura
–	L. australis	Frequently seen swimming together	N. Goodall
–	Giant fulmars (2 doz)	Birds on water, uninterested	J.T. Polkinghorn
Jan. 1984	L. australis	Frequently together, riding wakes of boats	Leatherwood et al., 1988b
–	Otaria flavescens		Leatherwood et al., 1988b
–	Gulls	Dolphins nudge gulls sitting on water	B. Boreing

* See Table 3. ** See Table 2.

Herd size

Commerson's dolphins have been reported as solitary individuals and in herds of 'hundreds' (Tables 2 and 3) but from all accounts appear to travel most frequently in small groups, containing fewer than ten animals. The distribution of group sizes in all sightings available to us for which there were numerical estimates are shown in Fig. 12. The 'herds' averaged about 6.85 animals (n = 302). Only 75 (25%) of the records reported more than five, 29 (10%) more than ten individuals. The 147 herds seen during intensive surveys in the Strait of Magellan in January/February, 1984 contained an average of 4.22 (SD = 9.14) animals. The large aggregations have occurred at divergent locations and all seasons, so no pattern is evident. One can only speculate whether they are herds which remain together for very long periods or are short term congregations of smaller herds.

The 'schooling behavior' of the species has been likened to that of *C. hectori* in New Zealand waters (Mermoz, 1980, citing Baker, 1978). In its habit of occurring in small groups which may congregate at times *C. commersonii* is similar to *C. heavisidii* (Best, 1984).

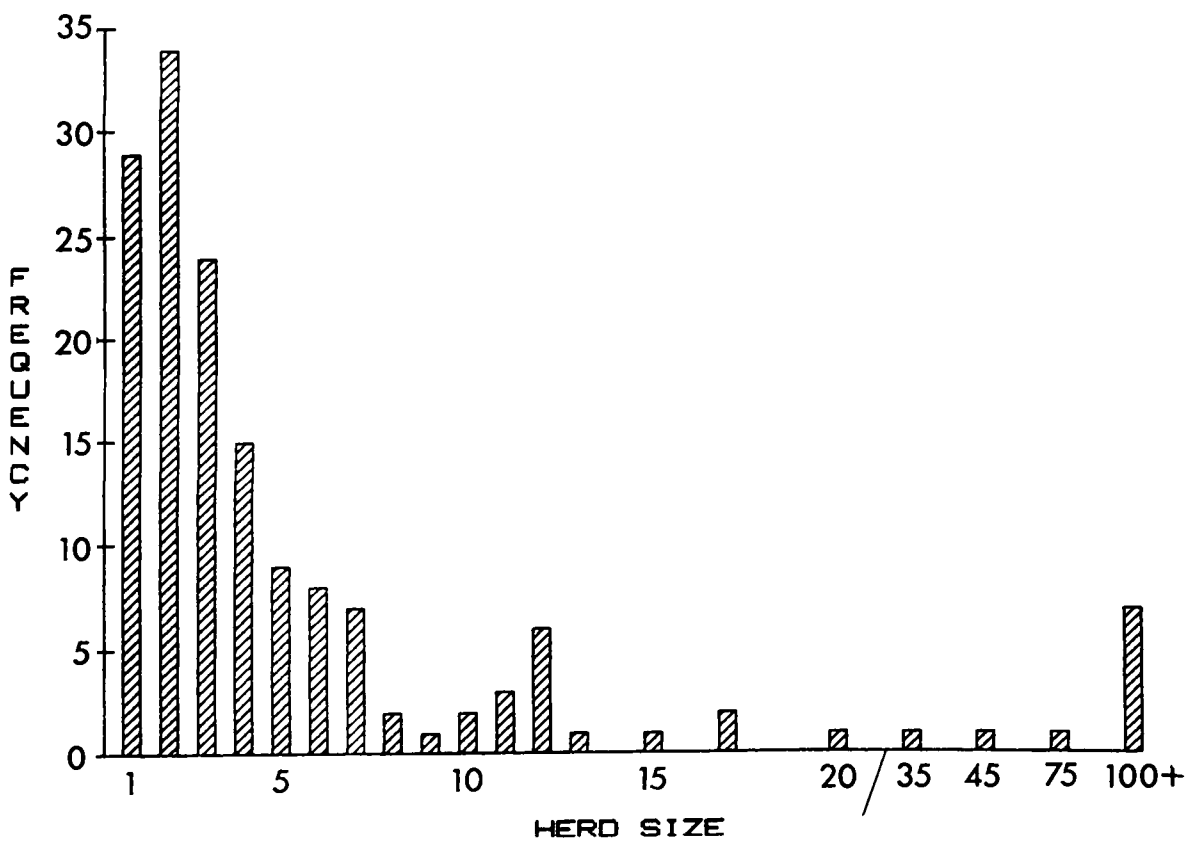


Fig. 12. Distribution of sizes of herds of Commerson's dolphins, from all sources.

Play

We have read, seen, or been told of numerous instances in which Commerson's dolphins were engaged in activities which might be considered play. For

example, in Comodoro Rivadavia they sometimes push objects, such as inflated inner tubes, around the bay and even onto the beach (O. Gallina, pers. comm.). Near the RICO I oil rig off Río Cullen in March 1981, some 15 Commerson's dolphins repeatedly surfaced under and nudged gulls, *Larus dominicanus*, in a flock of some 150, which were resting near the rig after surfeiting with food thrown to them by the rig workers (W. Boreing, pers. comm.). When nudged, the gulls lifted off briefly then returned to the sea surface, only to be nudged again and again over a 30 minute period. Along Península Parámo, a young calf, still dark brown, repeatedly raced ahead of the adult which was swimming with it, then turned abruptly back to the adult and breached on it, landing first on its tail, then on its head. De Agostini (1946, p. 101), Plüschow (1930, p. 137) and others have described vertical leaps made by Commerson's dolphins accompanying ships and most authors recently treating this species have noted its tendency to execute varied and repeated aerial acrobatics (e.g. see Gewalt, 1980).

By far the most interesting and frequently seen 'play' behavior in Commerson's dolphins is wave riding. Hertel (1969, p. 49) described four types of waves which cetaceans might ride: wind waves at sea, breaking shore waves, bow waves of vessels and other waves of vessels, though he did not include stern wakes. We have seen Commerson's dolphins taking advantage of all four waves described by Hertel (1969) and stern wakes to play and/or transport themselves from one location to another. Sometimes they come to a moving vessel from some distance, leaping as they sprint for position. When they do approach vessels, they may ride in the bow wave immediately under the prow (live captures with hoop nets and the hunting of Weber, 1920, and modern harpooners on crab boats have depended on such bow riding), in the stern wake, or in beam waves, alongside.

Pascal (1981) and Robineau (pers. comm.) have reported Commerson's dolphins at Kerguelen spinning underwater on their longitudinal axis as they ride the pressure waves from accompanying vessels. Like the Commerson's dolphins observed in detail in the colony at Sea World (Evans, Cornell and Yoon, 1985), free-ranging dolphins in Kerguelen (Robineau, pers. comm.) and in the Strait of Magellan frequently swim on their backs. This behavior was particularly visible from the perspective of cliffside (Leatherwood and Cornell, 1985; Leatherwood *et al.*, 1988b) or low flying aircraft (Leatherwood *et al.*, 1988a). Commerson's dolphins are quick and agile swimmers, at home in the fast currents and turbulent waters of some of the roughest ocean and inland marine areas in the world. They can maneuver in currents in excess of 12 knots and move freely through areas where waters are rushing and swirling.

Hamilton (1952, p. 6) said of the species that '. . . it has a partiality for playing in the breakers coming in to sandy beaches'. We have seen them riding storm waves in open water and breaking waves to within a few meters of shore. When in the waves, the dolphins sometimes leave the fin and back exposed, but are more often within the wave, except when breathing. The surfing postures of Commerson's dolphins are similar to those described by Caldwell and Fields (1959) for bottlenose dolphins and observed by the authors in many other species.

Reaction to boats and sounds

Commerson's dolphins are sometimes interested in boats and ships. Commerson himself wrote that the dolphins he observed played around the ship at great speed (Lacépède, 1804). Moreno (1892) described how they escorted the *Rosales* 'day and night', coming almost close enough to be touched, but never allowing themselves to be harpooned. De Agostini (1946, p. 108) found them at the keel of his vessel; Cabrera and Yepes (1960, p. 1,214) saw them around anchored ships and under piers; Sir Peter Scott and Dotte Larsen (Table 3, Sightings 52 and 76, respectively) saw them at the bow wave of the *Navarius* and the MS *Lindblad Explorer*. Dolphins were reported playing around the skiffs from the latter ship for over two hours as they landed passengers in the Falkland (Malvinas) Islands (Watson, 1981; J. Green and D. Puleston, pers. comm.). One of the places where one can most consistently see Commerson's dolphins (Table 2) is the ferry crossing in the Strait of Magellan. Although they sometimes ignore the ferries and other vessels, Commerson's dolphins seldom if actively avoid them.

The response of Commerson's dolphins to ship's sonar systems differs with circumstances and type and frequency of the system in use. They have been observed to converge on a vessel when certain 'echosounders' were switched on (Pascal, 1981; author's observations) but avoided the RV *Hero* when the ship's sonar was operating at its sweep beam, 45 degree angle (P.J. Lennie, pers. comm.). Commerson's dolphins appear to have responded to sounds of motors, whistling, or shouting on shore and clacking of stones together underwater. Pascal (1981) found that dolphins converged on his ship when its echo sounder was operating but dispersed when it stopped, a behavior we have observed in the Strait of Magellan.

Acoustics

Workers who recorded underwater sounds in the presence of Commerson's dolphins in the Strait of Magellan in 1968 (Watkins, Schevill and Best, 1977) were uncertain the sounds were produced by this species until they compared them with sounds recorded from *C. heavisidii* from South Africa and with sounds subsequently recorded from Commerson's dolphins at Mystic Marinelife Aquarium (Watkins and Schevill, 1980). Collectively, these recordings indicated that Commerson's dolphins produce sounds to at least 100kHz, probably higher, and that their acoustic repertoire includes some click-like components with high energy suitable for echolocation as well as some stereotyped, pulsed 'cries'. We have heard and been told by others that they have heard cries, often referred to erroneously as 'whistles', being produced by stranded individuals, mothers isolated from their calves, netted animals, live-captured animals just placed in their holding pools and animals that have been isolated in rivers by the receding tide.

Shochi, Zbinden, Kraus, Gihr and Pilleri (1982) and Kamminga and Wiersma (1981, 1982) recorded sounds of Commerson's dolphins housed with beluga whales, *Delphinapterus leucas*, at Duisburg Zoo. The former authors

found 'sonar sounds with a short, narrow-band, high-frequency component around 130kHz and a similar low-frequency signal at 1.2–2kHz' and predicted that the species had a highly directional echolocation signal. The latter authors found similar frequency components to the signals and stated that 'the wave shape of the Commerson's signal indicates a strong similarity with the sonar from the beluga', a species with which the Commerson's dolphins at Duisburg had been held for as long as five years.

The sound production capabilities of captive and free-ranging Commerson's dolphins have recently been the subject of intensive investigations by Evans, Awbrey and Hackbarth (1988). These authors have noted striking similarities between sounds produced by *Cephalorhynchus* and those produced by some phocoenids, most notably Dall's porpoises, and significant differences between the sounds of members of these groups and those of most other dolphins/porpoises. For example, the narrowband, high frequency pulses used by these phocoenids and *Cephalorhynchus* are useful for detecting moving objects in acoustically cluttered places. However, some stationary objects, such as nets, are likely detectable but disregarded as among other 'irrelevant junk signals' that abound in many of the environments where they live (F. Awbrey, pers. comm.). Members of these groups frequently become entangled in gillnets.

Exploitation

Goodall and Cameron (1980) provided a detailed review, based on numerous sources, of exploitation of small cetaceans, including Commerson's dolphins, off southern South America up to 1979. This section updates that account to 1984.

Commerson's dolphins have been taken in direct fisheries (for scientific specimens, bait, oil, sport and formerly food), accidentally/incidentally and in net fisheries and in live-capture fisheries. In general, data on such takes are more complete for Argentinian than for Chilean waters.

Intentional killing

Native canoe indians of the Fuegian and Chilean channels caught and used some cetaceans (Bridges, 1948; Emperaire, 1963). Although Commerson's dolphins are not common in these channels remains of at least one animal were found in 6,000 year old Beagle Channel shell middens (Piana, Orquera, Goodall, Galeazzi and Sobral, 1985).

A few specimens were harpooned for scientific study during nineteenth century expeditions (Quoy and Gaimard, 1824; Moreno, 1892). In the first half of the twentieth century, Spanish, Italian and German sailors took dolphins, probably including this species, for food off Patagonia (Goodall and Cameron, 1980; Plüschow, 1930, p. 137). Weber (1920) hunted them for meat and oil in the Strait of Magellan and lived largely on the meat of these and other dolphins for the duration of his stay in southern South America. Although total numbers were not reported, Weber claimed to have killed 100 dolphins in just three hours in one instance and evidently killed great numbers overall.

More recently, Commerson's dolphins have been harpooned for use as bait in traps for *centolla*, (southern king crab, *Lithodes antarctica*) and *centollón* (false king crab, *Paralomis granulosa*) in both Argentina and Chile, despite the fact the practice is illegal (Goodall, 1978; Goodall and Cameron, 1980; Sielfeld, Venegas and Atalah, 1977a and b; Sielfeld and Venegas, 1978; Venegas and Sielfeld, 1979; and others). Fishermen feel that dolphin meat does not quickly deteriorate in salt water and claim that it attracts crabs; it has been thought to be their preferred bait. However, a recent study (Goodall and Jordan, 1987, also cited in Perrin, 1986) reported that other animals might be more commonly used. For example, interviewed Chilean fishermen used factory-provided bait, penguins, sheep, pinnipeds, seabirds other than penguins, fish and dolphins, in approximately that order of preference.

There are no reliable estimates on numbers of dolphins killed for bait for crab traps in any year. In Argentina this type of crab fishing takes place mainly in the Beagle Channel where few Commerson's dolphins exist. Sielfeld *et al.*, (1977a, b) estimated that 2,350 dolphins (all species, but mainly *C. commersonii* and *L. australis*) would have been necessary to bait the estimated 3,400 traps used during a single season in the Strait of Magellan, Chile. Such captures are difficult to control. Some Chilean fishermen interviewed in the Strait of Magellan near Punta Arenas in January/February 1984 admitted to still harpooning dolphins and we found harpoons, some with blood indicating recent use, on seven of ten crab boats visited. The *centolla* in this region has been overfished and fishing pressure has shifted somewhat to *centollón*, which occur principally farther west in the channels, where Commerson's dolphins are not found. Likewise, little crab fishing takes place in the eastern Strait of Magellan, where these dolphins are abundant (Leatherwood *et al.*, 1988b).

Commerson's dolphins, as other marine mammals, are sometimes targets for indiscriminate snipers, as evidenced by two animals 'killed for sport' in March 1978 (Goodall and Cameron, 1980) and accounts by Chilean fishermen of competition to shoot fast-surfacing dolphins (Leatherwood *et al.*, 1988b).

Accidental/incidental takes

The involvement of Commerson's dolphins in net-fisheries has been described recently by Sielfeld, Venegas and Atalah (1977a, b) and Goodall and Cameron (1980). These consist primarily of:

(1) Incidental entanglement in nets set to catch *centolla* and *centollón*: In Argentina prior to 1976 bottom and mid-water nets set from boats used in the Beagle Channel took some dolphins, including at least one Commerson's dolphin (Goodall, 1978). Since 1976, only traps have been used in this fishery; dolphins cannot enter these traps so are not caught. Near Río Gallegos (Estancia Angelina and others) nets are set from shore for *centolla* during the lowest tide of November. J.G. Mead (*in*: Mitchell, 1975b) estimated that 20 dolphins were caught in these nets annually at Estancia Angelina and that '100 porpoises per year might be a reasonable estimate for the whole coast'.

In Chile, net fishing for *centolla* is also illegal but continues on a small scale at present (Goodall and Cameron, 1980). We learned from fishermen at Isla Isabella, Porvenir and Punta Arenas, some of whom had nets on their crab

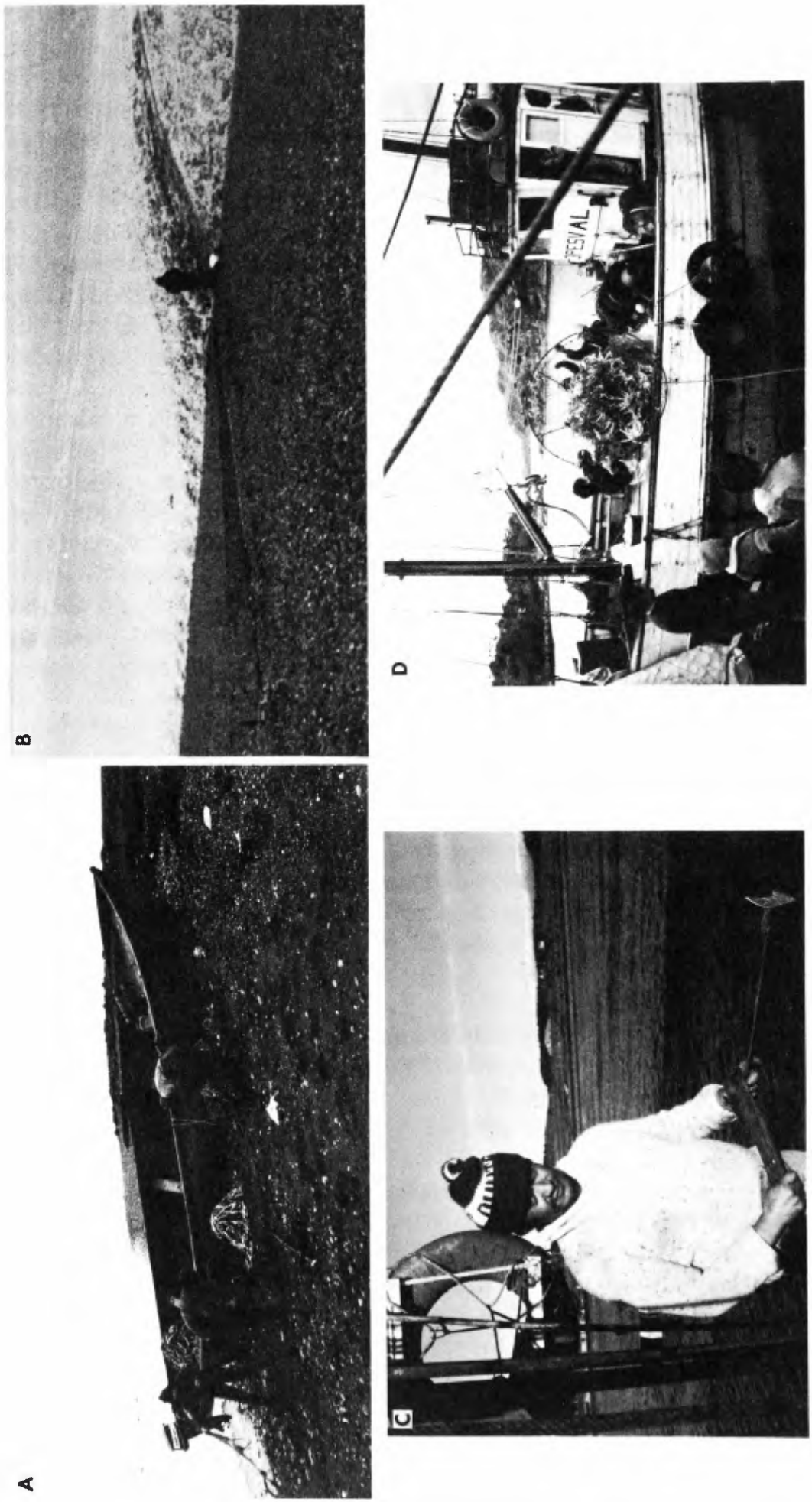


Fig. 13. Some fishing methods which result in deaths of Commerson's dolphins. (A) 'Tanglenets' formerly set for *centolla* and currently set for various fishes, (B) gillnets, for *robalo*, *merluza* and other coastal fishes, set in sand or mud areas with extreme tidal variations, and (C) harpoons used to kill dolphins for use as bait in traps for *centolla* and *centollón* (D) (I. S. Cameron, A; R. N. P. Goodall, B; S. Leatherwood, C; and R. Kastelein, D).

boats at the time of interviews, that such net fishing was still continuing in February 1984, albeit at a low level, and that 'a few' dolphins were killed. We cannot estimate numbers, but fishermen in Bahía Inútil caught an estimated 30 dolphins a year prior to 1980 (Goodall and Cameron, 1980). Apparently they now catch only a few each year. When shown photographs of species occurring in that area, fishermen selected Commerson's and Peale's dolphins. As the taking of dolphins is illegal, we suspect that fishermen's reports of numbers killed are underestimates. The small amount of net fishing for the smaller *centollón* takes place in the western Strait beyond the usual range of Commerson's dolphins.

(2) Incidental entanglement in nets used to catch *róbalo*, *Eleginops maclovinus*: In Argentina, such local fisheries (one to two-man operations) are limited in areas to shallow bays, mud flats and occasionally river mouths with extreme tidal range in northeastern Tierra del Fuego, Santa Cruz and Chubut. They take place between October and March (Goodall, 1978; Goodall and Cameron, 1980). The nets are set perpendicular to the coast from the high tide line seaward in areas where the bottom is mud or sand and imperceptibly sloping. The nets lie exposed on the bottom at low tide (Fig. 13c) but are completely submerged at high tide. Dolphins are taken only when they blunder into these nets. Any entangled dolphins which are still alive when the fishermen find them are left on the flats to swim away on the next tide. A minimum of 69 Commerson's dolphins was known to have been drowned in *róbalo* nets in Argentine Tierra del Fuego between December 1975 and March 1979. Total numbers were probably much higher (Goodall and Cameron, 1980, p. 447, Table 1).

In Chilean waters, especially in Bahía Inútil and along the eastern Strait of Magellan, some Commerson's dolphins are taken in shore-set *róbalo* nets (Goodall and Cameron, 1980). As the fishery continues virtually unchanged since that report, we assume that mortality continues; we could not obtain an estimate of present numbers killed.

(3) Accidental/incidental take in nets set from small boats: In some areas, usually at river mouths, fishing for *róbalo* and other fish takes place with nets deployed from small boats (usually rowboats). This small-scale fishery employs three methods: One person holding one end of the net on shore, another taking the other end around in a circle and returning to shore; the boat circling and setting the net in a circle; and two boats stretching a net between them. These methods are seldom used in Tierra del Fuego but are more common farther north. Commerson's dolphins are sometimes taken, but no numbers are known (Goodall, Galeazzi and Lichter, 1988).

Commercial fishing (usually net fishing) for various types of fish takes place over the continental shelf off eastern Argentina. Commerson's and other dolphins have recently been taken in these nets, but total numbers are unknown (Goodall *et al.*, 1988). Some of these cetacean specimens have been thrown overboard, some have gone to a fish meal plant and a few have been donated to scientific institutions.

Many of the specimens reported in this paper were taken off northeastern Tierra del Fuego in shore set nets for *róbalo* (Table 5). Data from specimens known to have died in the nets were examined for patterns in seasonality, sex composition and dominant age classes in the catch. Although the fishing season

off northeastern Tierra del Fuego extends from October through April, most dolphins were caught in December and January. (The specimens shown in July were taken in *centolla* nets in Bahía Inútil in 1977 or in *róbalo* nets off Argentine Tierra del Fuego). Males were taken more often than females overall and the majority of females were taken in December and January. There were no patterns apparent to the timing of catches of various age classes except that the only Class O (neonate) animals were taken during December and January, the same months when largest numbers of females were taken and the peak of the calving season.

There are numerous popular beliefs among Tierra del Fuegan fishermen about when dolphins are seen and most likely to become entangled in nets. From available sightings information (Tables 2 and 3) it appears that dolphins might be seen at any time of day. When the 53 captures for which exact dates are available were plotted according to the phases of the moon (each phase being defined as the day of the peak event and the three and 1/2 days before and after it) we found that more dolphins were taken at the new and full moons, fewer at the two intermediate periods and the fewest in the third quarter. Within 3 of the 4 phases, more dolphins were taken in the first than in the last half; for the phase of the full moon, however, there were twice as many captures after as before the full moon peak. Samples are too small to warrant rigorous statistical testing.

Dolphins are caught often in nets with large mesh or more than one mesh size (as those set for *róbalo* and *merluza*), infrequently when the net is fine mesh and the net strand is short and set very near shore, as is the case with nets set for *pejerrey*.

Live-captures

We are aware of six episodes of live-capture of Commerson's dolphins for public display, four in Argentina and two in Chile. At least 33 animals have been removed by such operations. Other animals are rumored to have died during one poorly conducted collection attempt at Río Deseado.

In 1978, A.H. Cobreros of Bahía Blanca, Argentina offered Commerson's dolphins for sale, stating in his advertisement that he had captured at least two dolphins, on 26 and 29 February. Reportedly, the dolphins were transported by vehicle six hours from the unspecified capture site to an airport, flown to Bahía Blanca (total transport time 22 hours), and placed in 'ponds', where they were held for 48 days before being released, presumably at Bahía Blanca.

Intrigued by the prospects of displaying this species, three oceanaria (Japanese, German and Dutch) applied to the Argentine government for permits to live-capture. It soon became clear to those investigating the original advertisement, however, that Cobreros 'had neither the intention nor the ability to fulfill his promises' (Gewalt, 1979, p. 37), so, aquaria with permits made alternative arrangements.

In November/December 1978 a German team using a beach seine removed four females and two males from Bahía San Jorge, Argentina (Gewalt, 1979, 1981; Niella, 1979; Goodall and Cameron, 1980; Collet, 1984). Half were

Fig. 14. Collectors from Duisburg Zoo hoopnetting Commerson's dolphins in the Second Narrows on 5 February 1984 (A), releasing one of them into the temporary holding pool at San Gregorio two hours later (B), and observing them on 7 February (C) (S. Leatherwood).

intended for a Dutch aquarium, but the sole survivor of transport, a male, went to Duisburg Zoo.

In December 1978, under an Argentine permit allowing the take of four animals (Goodall and Cameron, 1980), live captures were made for Sunshine City Marine Aquarium, Tokyo. Collectors used a beach seine and a 2km gillnet stretched across Puerto Deseado. The dolphins were allowed to swim up river on an incoming tide, the net was put in place and the dolphins were entrapped on the outgoing tide. Some animals are rumored to have died during capture operations (Gewalt, 1979; pers. comm., 1984). Four animals, one male and three females, were exported, intended for Japan. Instead of reaching Japan, however, they were confiscated on arrival in New York because of improper documentation (Anon., 1978). After an estimated 50 hours in transport, one was dead on arrival; the other three were transferred to Mystic Marinelife Aquarium, where they lived a few hours, eight days (the male), and two and one half years, respectively (Spotte *et al.*, 1979; Reeves and Leatherwood, 1984).

In January/February 1980 a crew from Duisburg returned to Argentina and used a beach seine to capture five more dolphins, this time at Comodoro Rivadavia (Gewalt, 1981; pers. comm., 1984). A single male survived transport and acclimated to captivity (Gewalt, 1981; Collet, 1984).

In 1983, Japanese collectors applied for and were granted a permit to capture 14 more dolphins in Argentina. However, in response to public sentiment

stirred by knowledge about the poor care of the dolphins destined for Sunshine City in 1978 and about Japanese involvement in a business proposal to exploit Patagonian penguins for their skins, the governor of Chubut forbade captures in that province and a subsequent law suit ruled that no further Commerson's dolphins could be captured from Argentina until more was known about the species (Costa, 1983a; Cano, 1984).

In November/December 1983, under a Chilean permit, collectors from Sea World of California used hoop nets to capture bow-riding Commerson's dolphins (four males and eight females) near Punta Sara, in the Strait of Magellan (Eterovic, 1983; Cornell *et al.*, 1988). As of the time of this writing, three of the females have given birth to calves conceived in captivity: a male born 21 February 1985 (Leatherwood and Cornell, 1985; Cornell *et al.*, 1988), a female born 6 January, 1986 (Cornell and Leatherwood, 1986) and a female born 19 April, 1986 (L. Cornell, pers. comm., September 1986).

In January 1984 collectors from Duisburg Zoo used hoop nets to collect 3 males and 3 females from Punta Sara (Anon., 1984; Thielke, 1984; Gewalt, pers. comm., 1984 – Fig. 14). At the time of this writing one male survives.

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Observations of Commerson's Dolphin and Other Cetaceans in Southern Chile, January–February 1984

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ABSTRACT

A field expedition to study cetaceans off southern Chile (involving aerial and vessel surveys, beach surveys by vehicle and foot, interviews and examination of specimens) is described. Commerson's dolphins were found from Bahía Inútil northward, along the eastern shore of the central Estrecho de Magallanes (Strait of Magellan) only, and from Islas Isabel and Marta eastward to the entrance to the Strait. They appeared to be most abundant in and near the narrows, but were encountered with only slightly lower frequencies in the embayment at the eastern entrance to the Strait. They were seen as individuals and in groups containing up to 110+ dolphins ($n = 147$, $\bar{x} = 4.22$, $SD = 9.14$). They visited all available habitats, except the interior of thick kelp beds, and were seen riding vessels' bow and stern waves, ground swells, tidal bores and shore breaks, and swimming in strong tidal currents. Despite legal protection, Commerson's dolphins in Chilean waters die accidentally in nets and are harpooned by fishermen for use as crab bait. No reliable estimate of numbers killed could be made. Individuals of at least five other cetacean species were found; most were Peale's dolphins. Sightings of Chilean dolphins in the western Strait are presented. At present, Chilean and Commerson's dolphins appear largely allopatric. Like Commerson's dolphins, Chilean and Peale's dolphins are killed for crab bait in Chilean waters.

INTRODUCTION

In 1983, Sea World, Inc., San Diego, California, entered agreements with various Chilean government officials and with scientists from the Chilean Ministry of Fisheries, the Veterinary College of the University of Chile, Santiago and the Instituto de la Patagonia, Punta Arenas, to jointly study the biology and status of Commerson's dolphin (*Cephalorhynchus commersonii*) in Chilean waters. As part of that program, specimens were live-captured in the eastern Estrecho de Magallanes (Strait of Magellan) and shipped to San Diego for public display, research and captive breeding (Leatherwood and Cornell, 1985; Cornell, Asper, Antrim and Pincheira, 1988). Hubbs Marine Research Institute was contracted to review all available information on the species (an exercise presented to the IWC Scientific Committee in 1984 as Leatherwood, Kastelein and Miller, 1984 and later combined with another review for

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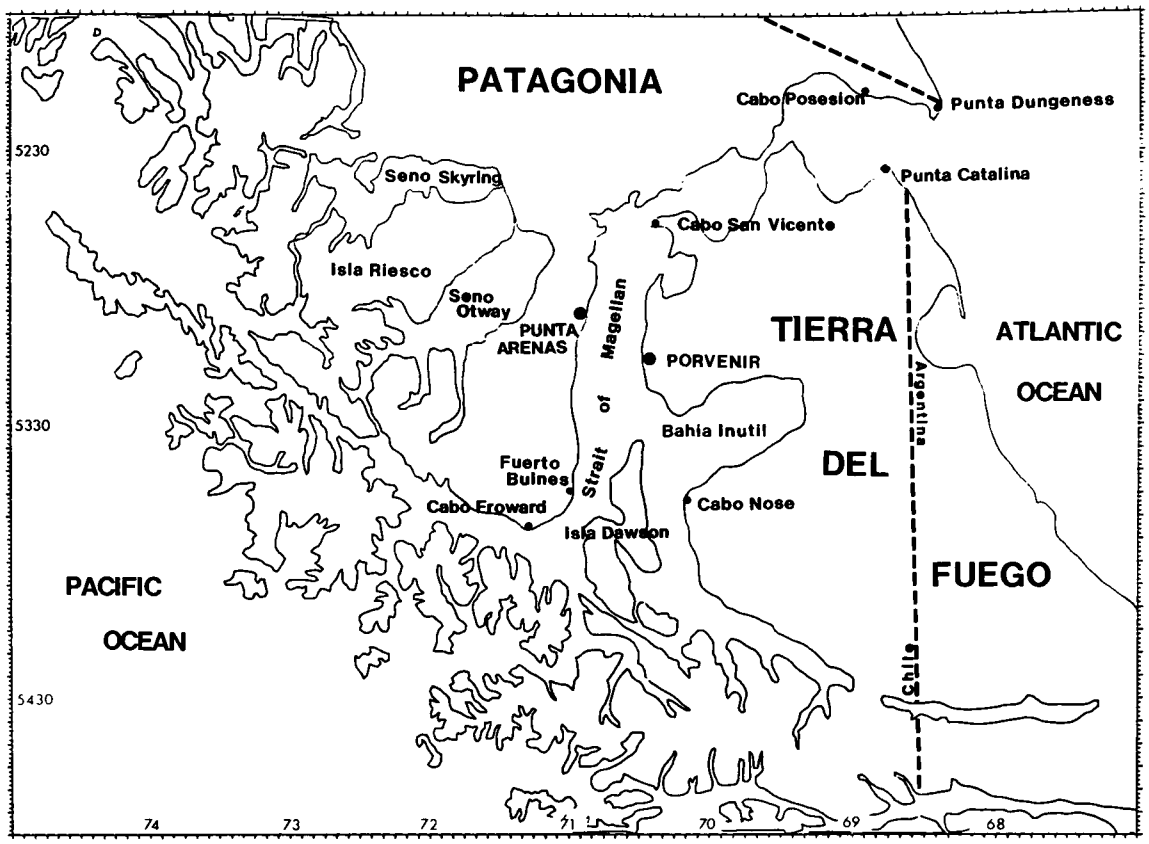

Fig. 1. Map of Chile with place names mentioned in the text.

publication in this volume – see Goodall, Galeazzi, Leatherwood, Miller, Cameron, Kastelein and Sobral, 1988), and to survey in and near the capture site, collecting information on distribution, abundance, habitat preference, behavior and exploitation of Commerson's dolphins and other cetaceans.

MATERIALS AND METHODS

Between 20 January and 19 February 1984 an expedition was made to southern Chile (Fig. 1). Data on Commerson's dolphins were collected by the following means (see Table 1 and Fig. 2): (1) Aerial surveys, at 90 knots and 500ft, in a Piper Dakota, a low-winged, single engine, non-amphibious aircraft with about five hours range. These surveys were used to: (a) estimate size of the population(s) in the segment of the northeastern Strait of Magellan between the First and Second Narrows (study blocks and random transects flown are shown in Fig. 2A – for details and results see Leatherwood, Kastelein and Hammond, 1988); and (b) to search for these dolphins in all areas safely accessible by this aircraft (relative coverage of such reconnaissance surveys is shown in Fig. 2B). (2) Flights aboard twin-engine Dauphin and Bolkow BO–105–C helicopters, operating at 60 to 90 knots at 300 to 1,000ft altitude between Punta Catalina and Cabo Posesión and nearby oil platforms and service vessels in the eastern Strait (Fig. 2C). (3) Trips aboard various 8 to 30m vessels (Fig. 2D): (a) engaged in capture activities for Duisberg Zoo, Duisberg, Germany, mostly near Punta Sara, in the Second Narrows, but once extending along the Patagonian shore as far southwest from the narrows as about 52°55′S, (b) ferrying passengers

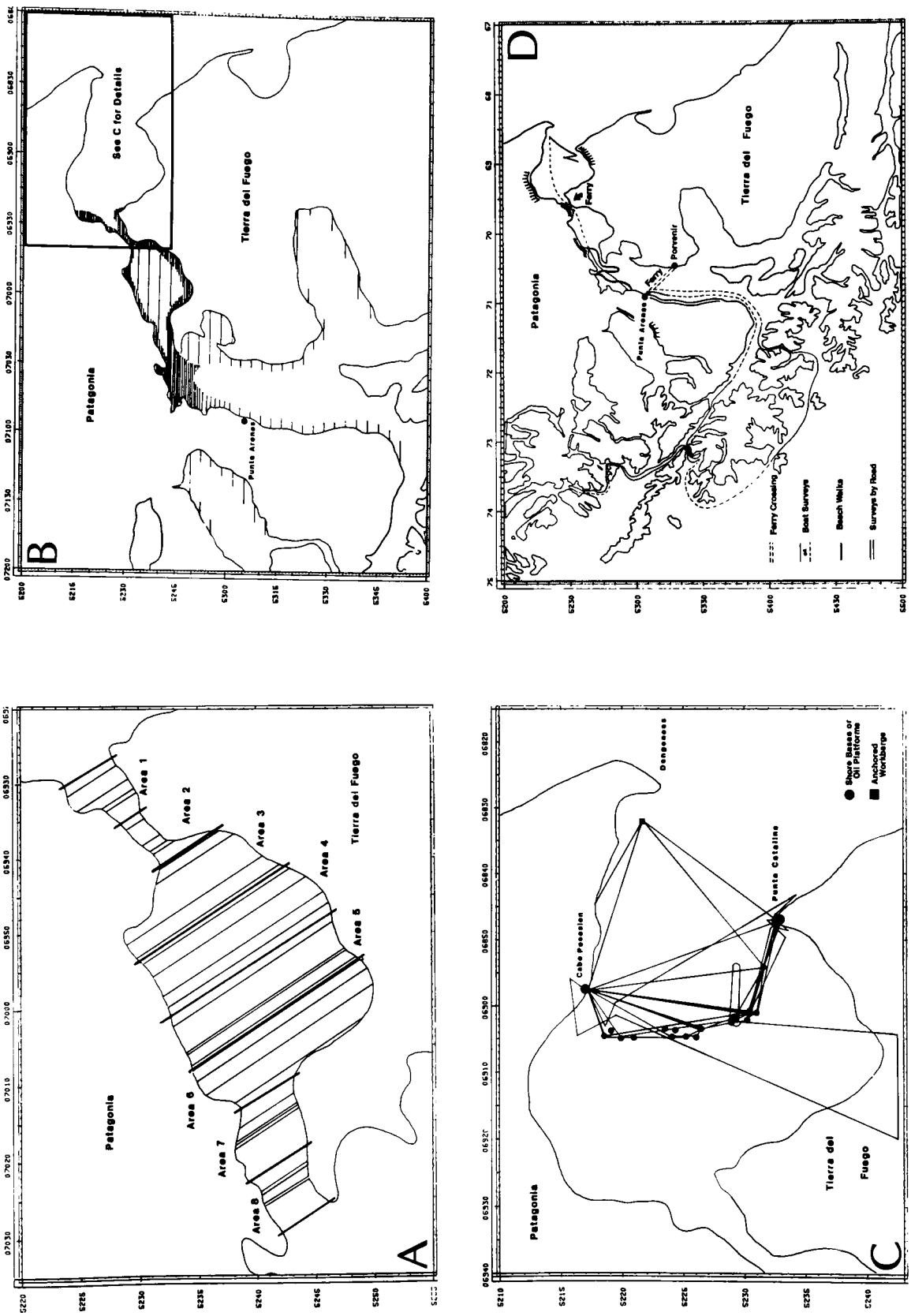

Fig. 2. Summary of survey effort 20 January–15 February. (A) Random transects by fixed-wing aircraft, 21 January–1 February, to estimate population size (see Leatherwood, Kastelein and Hammond, 1988). (B) Reconnaissance searches by fixed-wing aircraft, 20 January–1 February (the relative density of lines indicates relative amount of flying time by area). (C) Helicopter searches, 27–29 January. (D) Boat surveys, 26 January–15 February and miscellaneous shore or vehicle searches.

Table 1
Schedule of activities during expedition to Southern Chile.

Date	Method	Location
20 Jan 1984	Shore (vehicle)	Seno Otway (northeast side)
21 Jan 1984	Aircraft*	Estrecho de Magallanes (Strait of Magellan), between Punta Arenas and Primera Angostura (First Narrows)
22 Jan 1984	Shore (vehicle)	Road from Punta Arenas to Fuerta Bullnez
23 Jan 1984	Ferry	First Narrows (between Punta Delgada and Tierra del Fuego)
24 Jan 1984	Aircraft*	First Narrows to Punta Arenas
25 Jan 1984	Aircraft*	Strait of Magellan (between Punta Arenas and First Narrows)
26 Jan 1984	Boat	Segunda Angostura (Second Narrows) from base at San Gregorio
27 Jan 1984	Shore (vehicle)	Punta Arenas to Cabo Posesion
	Shore (foot)	Posesion
	Helicopter**	Cabo Posesion to Punta Catalina
28 Jan 1984	Helicopter**	Strait of Magellan (east of First Narrows)
29 Jan 1984	Helicopter***	Strait of Magellan (east of First Narrows)
31 Jan 1984	Aircraft*	Strait of Magellan (between Punta Arenas and First Narrows)
31 Jan 1984	Ferry	First Narrows (between Punta Delgoda and Tierra del Fuego)
31 Jan 1984	Shore (foot)	Punta Delgada
1 Feb 1984	Aircraft*	Stait of Magellan (between Punta Arenas and First Narrows)
2 Feb 1984	Ferry	Between Punta Arenas and Porvenir
	Aircraft*	West of Tierra del Fuego (Bahia Inutil to Second Narrows)
3 Feb 1984	Boat	Punta Arenas to San Gregorio (Second Narrows)
	Aircraft*	Strait of Magellan (Punta Arenas to Cabo Froward) and Seno Otway
4 Feb 1984	Boat	Strait of Magellan (east of First Narrows)
5 Feb 1984	Boat	San Gregorio to Isla Marta
9–15 Feb 1984	Boat	Strait of Magellan (west of Punta Arenas)

between Punta Arenas and Porvenir (1 crossing) and across the First Narrows between Patagonia and Tierra del Fuego (10 crossings); (c) servicing oil platforms and facilities in the northeastern Strait of Magellan (2 days); and (d) collecting catches from commercial crab boats in the waters of the western Strait and the adjacent fjords and outer coast (7 days). (4) Observations from shore along coastal roads accessible by vehicle (northeast Seno Otway, Fuerte Bulnes to about 52°45′S and short stretches of the northern shore from the Second Narrows to Cabo Posesión) (Fig. 4D). (5) Surveys by foot of a short segment south of the road on Seno Otway and of Cabo Posesión and Punta Catalina (Fig. 4D). (6) Interviews with fishermen and other coastal residents.

Some of the findings from the above activities are reported in Leatherwood *et al.* (1988) and Goodall *et al.* (1988).

RESULTS AND DISCUSSION

Distribution, habitat and relative abundance

Goodall *et al.* (1988) review all sightings, strandings and collections of Commerson's dolphins in the South Atlantic and conclude that the species is distributed almost exclusively in coastal waters, in the central and eastern Strait of Magellan, off extreme southern and southeastern South America south of about 41°30′S and around the Falkland Islands (Islas Malvinas). Within our area of special interest, the eastern Strait of Magellan, there are confirmed records from the eastern entrance to the Strait (Cunningham, 1871; Cummings, Fish, Thompson and Jehl, 1971), the eastern Strait (Harmer, 1922; Aguayo, 1975), the area between the Narrows (Gilmore, 1971; Watkins and Schevill,

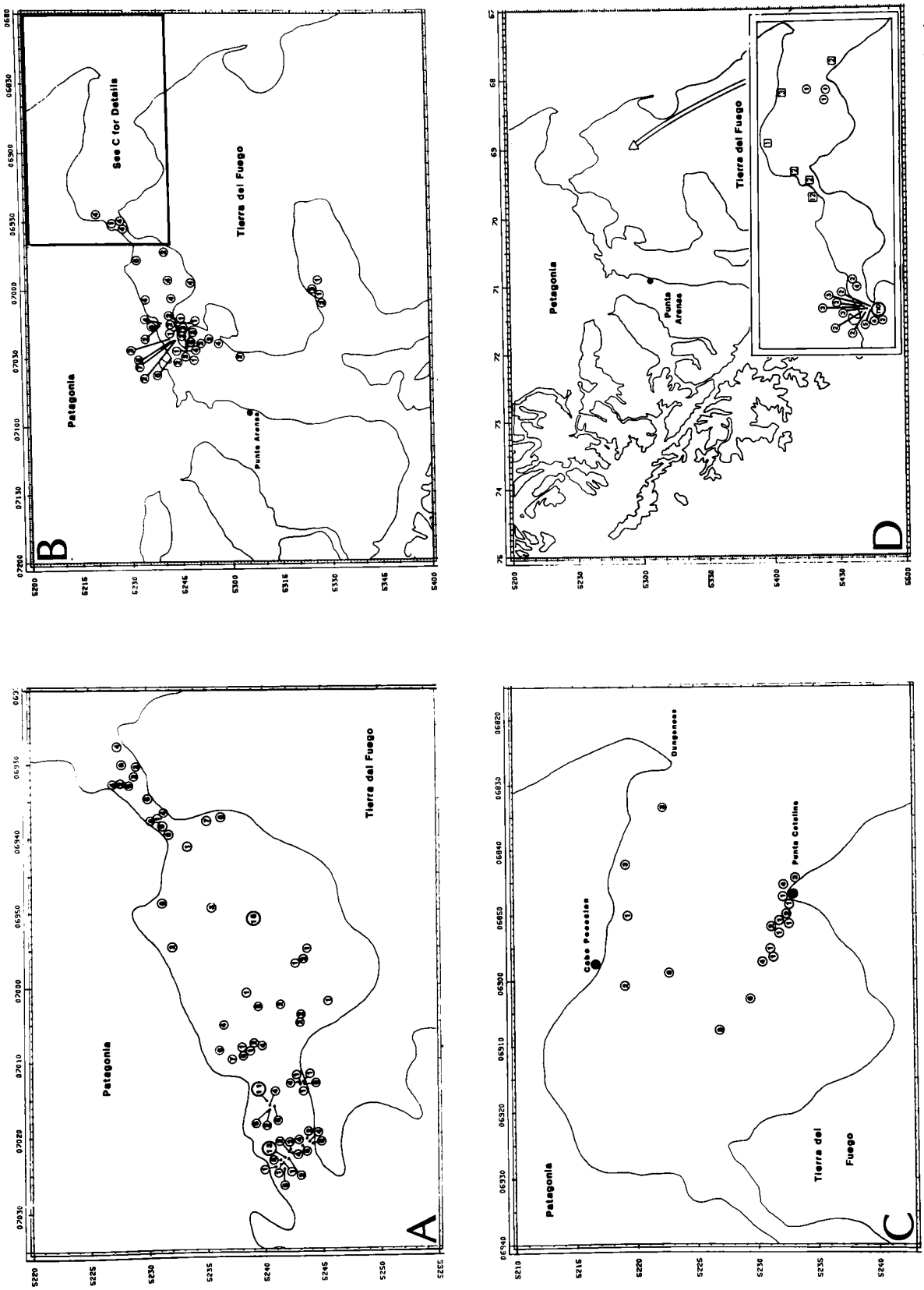

Fig. 3. Summary of sightings of Commerson's dolphins, 20 January–15 February. (A) On-track during random transects by fixed-wing aircraft, 21 January–15 February, to estimate population size. (B) During reconnaissance searches, 20 January–3 February (including those off-transect during random surveys). (C) From helicopter, 27 January–29 January, and from shore, 27 January–2 February. (D) From boats 26 January–15 February and miscellaneous shore or vehicle searches. Not included are multiple sightings from the ferry at First Narrows on 23 and 31 January.

1980) and the north-south oriented region of the Strait between Punta Arenas and the northern tip of Isla Dawson (Sielfeld and Venegas, 1978). Brownell (1974, plate 8 and pp. 18–19), based on sightings credited to numerous sources, indicated continuous distribution of this species from the eastern entrance of the Strait to just west of the Second Narrows, thence along the western shore to Cabo Froward and the central west coast of Isla Dawson.

During all surveys reported in this paper, we saw a total of 147 'herds' of Commerson's dolphins, containing an estimated 621 individuals, as follows: 62 groups (253 individuals) during randomized aerial surveys (Leatherwood *et al.*, 1988; Fig. 3A); 40 (147) during fixed-wing reconnaissance surveys (Fig. 3B); 19 (51) during helicopter reconnaissance surveys (Fig. 3C); 6 (22) from shore or vehicle searches (Fig. 3D); and 16 (148) from boats (Fig. 3D). Not included in these counts are sightings made from the ferry across the First Narrows 23 January (83 dolphins) and 31 January (26 dolphins) 1984, as these were simply logged as total number of animals seen on each crossing.

In most observations the Commerson's dolphins were not accompanied by other marine mammals. However, there are several notable exceptions. In and near the Second Narrows they frequently were seen in the vicinity of Peale's dolphins (*Lagenorhynchus australis*). Near Isla Marta on 5 February a group seen from the boat was milling in an area where southern sea lions, *Otaria flavescens*, were feeding. On two occasions on 23 January, three Commerson's and two Peale's dolphins rode the pressure wave off the ferry M/V *Patagonia* concurrently and departed the vessel in close company. Off Argentina, Commerson's dolphins have previously been reported in the vicinity of southern sea lions and Burmeister's porpoises, *Phocoena spinipinnis*, as well as non-mammalian companions (Mermoz, 1980). Birds of many species were often present in the vicinity of Commerson's dolphins in and near the narrows.

We did not see Commerson's dolphins in several areas where they have been reported previously. For example, we had no encounters around Isla Isabel, an area through which we passed frequently by aircraft and boat, or along the Patagonian shore south of Isabel, where we made roundtrip aerial surveys as far as Cabo Froward and vehicle searches to Fuerte Bulnes. Accounts of fishermen and staff at the Instituto de la Patagonia suggest that at present these dolphins are seen only infrequently near or south of Punta Arenas.

Neither were there any encounters with Commerson's dolphins in the western Strait or adjacent waters during the 7-day boat excursion there (Fig. 4D). Aguayo (1975, p. 1,125, Fig. 3) showed Commerson's dolphins as distributed west and north of the Fuegian Archipélago, but the only reported sighting from west of Cabo Froward is that by Polkinghorn at Isla Desolación (Goodall and Polkinghorn, 1979). During our surveys of the western Straits, watches were maintained almost continuously during daylight hours; marine mammals were seen on 15 occasions. It is unlikely, therefore, that the gregarious Commerson's dolphin, which is wont to ride bow waves, would have been missed altogether had they been present in any appreciable numbers.

We did, however, see Commerson's dolphins along the shore opposite of Punta Arenas. Ricardo Matus and Azize Atalah (pers. comm., 25 January 1984) had informed us these dolphins were common in and near the bay at Porvenir, where they can often be seen riding the stern wave of the ferry. Goodall (1978,

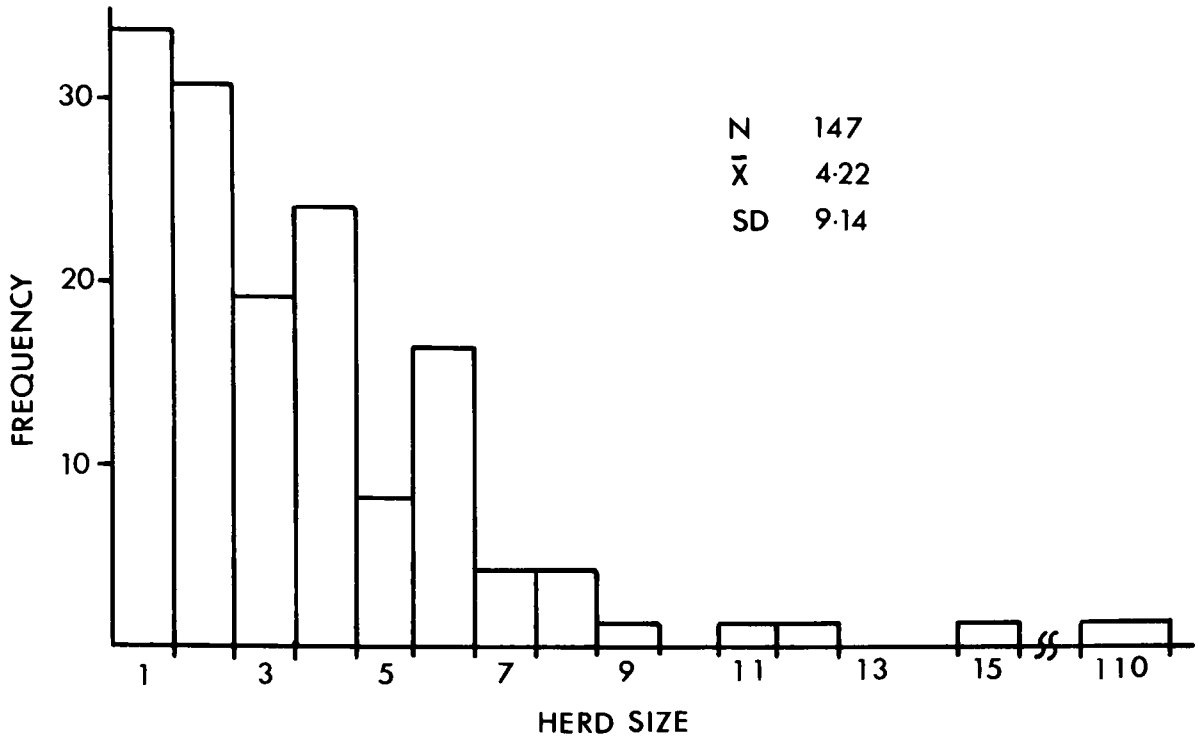

Fig. 4. Distribution of *C. commersonii* herd sizes including all observations from aircraft, helicopter, small boat and shore.

p. 205) collected specimens from Bahía Inútil and reported that fishermen there encounter and take Commerson's dolphins regularly. We failed to see any Commerson's dolphins on our one ferry crossing from Punta Arenas to Porvenir, 2 February, under conditions of Beaufort 1–3. However, during two reconnaissance flights along shore north of Cabo Nose we found herds in the northern end of Bahía Inútil, along shore north of Porvenir, around Isla Contramaastre, near the entrance to Bahía Centro Grande, in Boco Nuevo, and off Cabo San Vicente, at the southwest end of the Second Narrows (Fig. 3B).

Most of our search effort was spent from Isla Marta north and east to the entrance of the Strait (Fig. 2). Within those areas, Commerson's dolphins were seen virtually everywhere we looked, although they were clearly most concentrated in and near the narrows. In the area of our most intensive coverage (Fig. 2A, 2B), i.e. the region between the narrows, dolphins were found in larger herds and higher densities in narrows than in open water. The population in that stretch (Fig. 3A, 3B) was estimated to contain 3,161 animals, SD = 900 (Leatherwood *et al.*, 1988). East of the first narrows we found Commerson's dolphins in all segments of the entrance bay to which we were able to give more than a cursory look (Fig. 2C, 2D, 3C and 3D). Subsequent to our field activities, pilots for the companies servicing the oil rigs maintained sightings logs for March-June in the eastern Strait. They reported seeing Commerson's dolphins on 10 of 43 flights in March, 8 of 35 in April, 14 of 28 in May and 12 of 35 in June. The largest group was estimated to have contained 125 animals. Groups were widely distributed in the area.

We saw Commerson's dolphins only slightly more frequently close to shore

than in or near mid-channel. This observed distribution may simply reflect the facts that more time was spent flying and cruising near shore and that in those areas sea surfaces were calmer and sightings, therefore, more likely than in open water. We did not observe Commerson's dolphins in thick kelp beds, but we did see them near and shoreward of kelp beds. Except when dispersed in small groups and apparently feeding, the dolphins usually approached passing vessels to ride in their bow waves. We also observed them surfing to within a few meters of shore, riding ground swells and tidal bores, and swimming in currents as fast as 15 knots, many of which contained whirlpools and abrupt current-lines.

Group size

The 147 groups (herds) counted or estimated during our surveys ranged from 1 to 110 individuals ($\bar{x} = 4.22$, SD = 9.14). The vast majority, however, contained 9 animals or fewer (Fig. 4). The largest herd seen, an estimated minimum of 110 animals, was northeast of Isla Marta on 5 February.

Exploitation

Goodall and Cameron (1980) and Goodall *et al.* (1988) review exploitation of Commerson's dolphins in Chilean waters. The former authors reported that the setting of gillnets and tangle nets for king crab, *centolla* (*Lithodes antarctica*) and the smaller snow crab or false king crab, *centollón* (*Paralomis granulosa*), 'has gone on for many years and continues at present, in spite of a treaty to eliminate their use. Dolphins, usually *C. commersonii*, are caught.' We learned from fishermen at Isla Isabel, Porvenir and Punta Arenas, some of whom had nets on their crab boats at the time of interviews, that such net-fishing was still going on in February 1984, albeit at a low level, and that 'a few' dolphins are killed. From data available at present, we cannot estimate total numbers. When the fishermen were presented with the published report that two of the many boats fishing in Bahía Inútil caught 30 dolphins a year between them (Goodall and Cameron, 1980, p. 448) they uniformly reiterated that they caught 'only a few each year.' When presented with photographs of species occurring in the areas where they fished, the fishermen selected Commerson's and Peale's dolphins. As the taking of dolphins is illegal in Chile, we suspect that any reports of numbers killed are underestimates. The dolphin meat is used for crab bait, rarely for human consumption. With a decline in *centolla*, presumably from overfishing in the central and western Strait, the crab fishery has switched to the smaller *centollón*. This species is taken principally with traps but there is some net-fishing for it. Much of the activity apparently occurs in the western Strait, beyond the usual range of Commerson's dolphins.

Some dolphins, including Commerson's dolphins, were formerly killed in Chilean gillnet fisheries for *róbalo* (*Eleginops maclovinus*), (Goodall and Cameron, 1980); as the fishery continues virtually unchanged since that report we assume that mortality continues, but could obtain no verification or estimate of present numbers killed.

Goodall and Cameron (1980) report that Commerson's dolphins have been captured extensively for bait for traps belonging to the five large companies and

many private individuals that fish for crab in southern Chile. They present unpublished studies by Sielfeld and Venegas that indicate *centolla* prefer the meat of dolphins to that of seals, fish or terrestrial mammals and restate estimates from Sielfeld, Venegas and Atalah (1977a and 1977b), that 2,350 dolphins would have been necessary to bait the estimated 3,400 traps used in Chilean waters during a single season. Goodall and Jordan (1986) report that about 645 boats, using some 30,000 traps operate in the Chilean Magellanic crab fisheries. Apparently they use the following for bait, in order of decreasing preference: factory provided bait, penguins, sheep, pinnipeds, seabirds other than penguins, fish and dolphins. The fisheries are sufficiently extensive that the takes of dolphins may be significant even if dolphin meat is currently a low priority bait. During our expedition we found harpoons, some with blood indicating recent use, on 7 of 10 crab boats we visited. Further, once they were certain we were not law-enforcement officials, some fishermen admitted to harpooning dolphins, mostly for bait, rarely for food. It was not possible to produce a responsible estimate of numbers killed. As the crab fisheries are shifting more each season from *centolla* to *centollón* and from the central to the western Strait we surmise the pressure on remaining Commerson's dolphin populations in Chile will lessen. However, given that the *centollón* fishery operates essentially year-round and in areas difficult to patrol, there is cause for concern that other species of cetaceans will continue to be exploited.

Other cetaceans seen

In addition to the data on Commerson's dolphins reported above we obtained information on 5 or 6 other species of cetaceans. Locations of our observations are presented in Fig. 5; further information is summarized below, by species.

The dolphins seen most commonly were *Lagenorhynchus* sp., encountered as individuals or in groups of five or fewer in coastal waters throughout the areas surveyed. Only Peale's dolphins (Fig. 6) were positively identified. However, because dusky dolphins (*L. obscurus*), have also been reported from the Strait of Magellan (Brownell, 1974; Sielfeld, 1984 a, b), individuals not positively attributable to either species were reported as unidentified *Lagenorhynchus*.

Peale's dolphins were seen at 16 widespread locations. 'Groups' contained 1 to 6 individuals. All were seen very close to shore, most (11 of 16) within or coastward of kelp beds. They were frequently found in the company of Commerson's dolphins but came to a moving vessel to ride its bow wave less frequently than the Commerson's dolphins. Two newborns, estimated to be less than 1 month old, were noted, one at the mouth of Bahía Porvenir on 2 February and one at Banco Marta on 5 February.

Animals identified by fishermen as Peale's dolphins are killed by rifle or hand-harpoon for use as bait in *centolla* and *centollón* traps. Fishermen interviewed reported seeing and killing Peale's dolphins in Bahía Inútil, in bays near the south end of Canal Beagle, southwest of Isla Santa Inez, near Isla Navco, in Bahía Stokes, near Cabo Philips and in Canal Smythe. In this last area fishermen reportedly took 'hundreds' in 1980 and 1981 and thereafter saw very few.

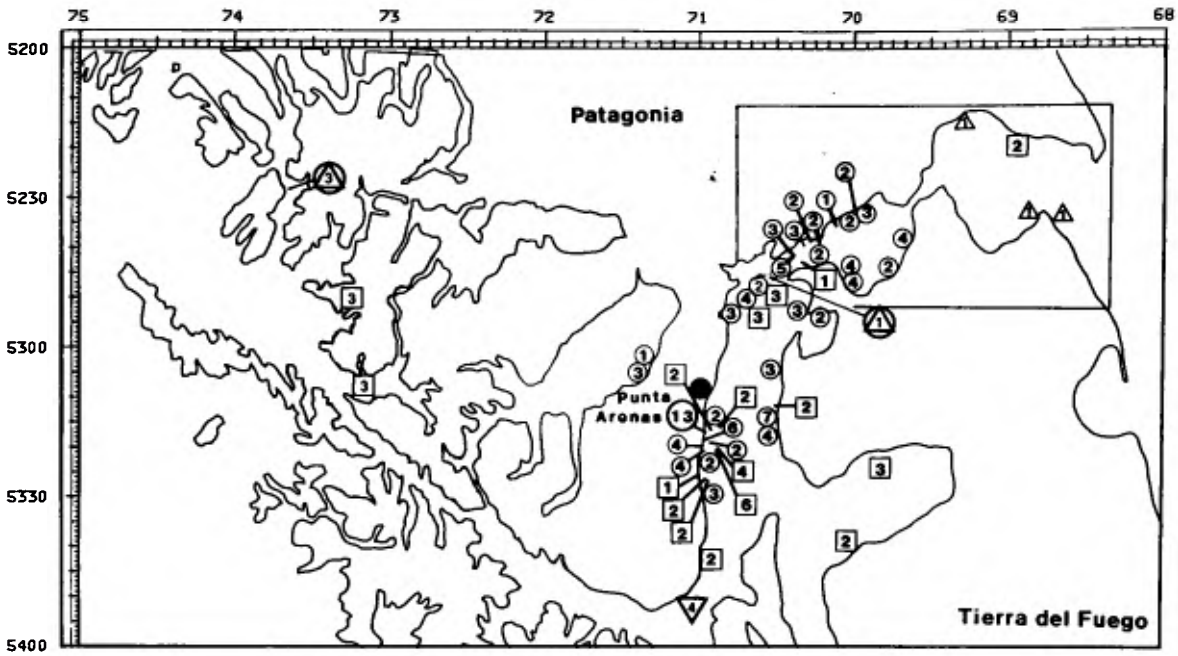

Fig. 5. Locations of sightings of cetaceans other than Commerson's dolphins, 20 January–15 February 1984. The numbers in the symbols indicate the number of individuals seen. Key: *Lagenorhynchus* sp. ○, *L. australis* □, *Orcinus orca* ◎, *Globicephala* sp. △, *Cephalorhyncus eutropia* ▽.

Fig. 6. Peale's dolphin, *Lagenorhynchus australis*, in Second Narrows. (photo: S. Leatherwood).

We had a single observation of what were probably black or Chilean dolphins (*Cephalorhynchus eutropia*). During a 3 February aerial survey, four small (< 2m long) dark dolphins were seen about 400m off Cabo San Isidro, south of Punta Arenas. The plane was at *ca* 165m altitude and the conditions were ideal (wind force < Beaufort 1 and sea surface glare-free); nevertheless the group could not be relocated for positive identification and photography. The animals had a typical *Cephalorhynchus*-like dorsal fin and no white zones visible from a dorsal-oblique view.

At the Instituto de la Patagonia there is a skull (specimen CE–5) identified as a Chilean dolphin. Location, date and collector are unknown. Although fishermen in the western Strait of Magellan, north and west of Isla Reisco, appear very familiar with this species (they identified it in photographs), the 16

Table 2

Sightings of *Cephalorhynchus eutropia* in the western Strait of Magellan.

Date	Location	Number	Source	Remarks
-	Off Isla Riesco	3	W. Sielfeld[1]	-
-	Near Puerto Natales	-	W. Sielfeld[2]	-
2 Jan 1982	Seno Ultima Esperanza	1	R. Matus	Identified by S. Leatherwood from photos at HMRC
3 Feb 1984	Cabo San Ysidro	4	S. Leatherwood	Aerial observation
22 Jul 1984	53°32'S, 70 55'W	3	Eduardo Carlos[1]	Identified by S. Leatherwood from photos at HMRI
26 Jul 1984	52°52'S, 71°00'W	3	Eduardo Carlos[1]	
1 Oct 1984	53°55'S, 71°10'W	2	Eduardo Leal[1]	-
2 Oct 1984	53°25'S, 71°10'W	2	Eduardo Leal[1]	-
4 Oct 1984	53°55'S, 73°25'W	6	Eduardo Leal[1]	-
18 Oct 1984	53°47'S, 73°20'W	9	Eduardo Leal[1]	-
20 Oct 1984	53°52'S, 73°22'W	2;2	Eduardo Leal[1]	-
21 Oct 1984	53°57'S, 77°22'W	2;6;2	Eduardo Leal[1]	-
25 Oct 1984	54°07'S, 73°05'W	6;2	Eduardo Leal[1]	-
26 Oct 1984	54°09'S, 72°49'W	3	Eduardo Leal[1]	-
2 Nov 1984	54°07'S, 72°10'W	7;8	Eduardo Leal[1]	-
4 Nov 1984	53°55'S, 70°55'W	4	Eduardo Leal[1]	-

believable detailed records of this species we assembled during and subsequent to our expedition are summarized in Table 2. In available photographs the Chilean dolphins appear lead colored, with dark head, flippers, flukes and dorsal fin (Eduardo Leal Lavado, photos of 2 April 1984 *et seq.*, examined by the authors). Crab fishermen selling their catches to one cannery with which we worked reported taking 1–2 *C. eutropia* per boat per week. Since 1982, these boats have fished year-round, although the most important season is November–February. Based on these preliminary figures one might fear that hundreds of these dolphins, or perhaps more, are killed annually in this fishery. The problem is now under investigation (Goodall and Jordan, 1986).

A single live pilot whale, *Globicephala* sp., was seen from a helicopter in the shallows just east of Punta Catalina on 29 January. Two stranded long-finned pilot whales, *G. melaena*, were discovered – a 5.07m female found near the mouth of Río Butterfly during a beach walk on 27 January and a 4.57m male seen from helicopter at the northeast tip of Punta Catalina on 29 January and examined and measured the following day. From various sources we learned of a recent mass-stranding of this species in the area. A group of 31 came ashore on 13 August 1982 between Río Duck and Río Butterfly in the western end of Bahía Posesión (La Prensa Austral, 14 August 1982). Some specimens were collected and deposited at the Instituto de la Patagonia.

Killer whales, *Orcinus orca*, were seen twice – a single male, *ca* 7m long, 0.25 n.miles north of the northern spit of Isla Marta on February 5 – and a group of three at 52°29′S, 73°42′W in the northwestern Strait of Magellan on 11 February.

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Records of Commerson's Dolphin (*Cephalorhynchus commersonii*) in South American Waters and Around South Georgia

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ABSTRACT

Fifteen sighting records of Commmerson's dolphin (*Cephalorhynchus commersonii*) in South American coastal waters and off the Falkland Islands made from vessels of the 'Discovery Investigations' in the years 1931–34 are listed, with notes on the numbers of animals seen and their behaviour. External measurements and other information from a captured specimen are recorded. Statements on the occurrence of the species around South Georgia are discussed. There appears to be no definite record of the dolphin there.

INTRODUCTION

The work of the 'Discovery Investigations' in the Southern Hemisphere during the years 1925–39 included a long series of oceanographical and whale marking voyages by the vessels *Discovery* (1925–27), *RRS Discovery II* (1929–39) and *RRS William Scoresby* (1926–38) (Mackintosh, 1950). There were also some whale marking cruises using chartered whale catchers in the waters around South Georgia (1932–37). During these voyages records were kept of all cetaceans sighted. The records of the large whale species have been used in several publications but most of those relating to small cetaceans are unpublished. The present note lists the records of Commerson's dolphin (*Cephalorhynchus commersonii*).

METHODOLOGY

Sightings records

Details of the methods used during 'Discovery Investigations' to record sightings of cetaceans will be described in a paper now in preparation on the sightings of small cetaceans. For this note it is only necessary to state that where possible detailed notes were made of the external appearance, colour, estimated size, numbers and behaviour of the animals. These notes were supported by pencil sketches of the colour pattern and shape of head and dorsal fin, made at the time of the observations. Only those records of Commerson's dolphin which include sufficiently detailed notes to enable a definite identification to be made

or confirmed are reported here. A few additional sightings lacking sufficient details but which either may have been this species, or were recorded as such, have been omitted.

DISTRIBUTION

Fifteen records of Commerson's dolphin seen from *RRS William Scoresby* and *RRS Discovery II* between April 1931 and March 1934 are listed in Table 1. One (observation No. 4) is a record off the Falkland Islands in December 1931. The remaining 14 records were all in South American coastal waters. Seven sightings (Nos 1, 2, 3, 10, 11, 14 and 15) were in the Strait of Magellan and two (Nos 12 and 13) were of animals seen just off the eastern entrance to the Strait. These nine sightings were in March, April, September (two on same day), October (including three on one day) and December.

Five sightings were in Argentinian inshore waters to the north and south of the Strait of Magellan. Three (Nos 5, 6 and 7) in January 1932 were at or just off Puerto Gallegos north of the Strait, and two (Nos 8 and 9) on 2 February 1932 were near San Sebastian Bay, Tierra del Fuego, to the south. All 15 records were in areas well known to be within the distributional range of the species (Brownell, 1974).

Size of schools

Nine of the 15 observations give estimates of the numbers of animals seen but it is clear in two cases (Nos 2 and 5) and possibly in a third (No. 7 when at least 20 animals were at one time accompanying the ship), that the group of animals first seen was later joined by others. In eight cases where apparently a single school was seen either initially or throughout the observation, the mean school size was 4.3 with a range of 1–9 animals.

BEHAVIOUR

Thirteen of the 15 records include information on the behaviour of the dolphins. For 12 records notes are available on their behaviour towards the vessel. On 10 occasions the animals approached or were around the vessel during the observations and on six occasions they accompanied the vessel for a time. Observation No. 2 states that their movements when accompanying the vessel were erratic and that the individual animals seemed to keep to themselves and not to swim in twos and threes as is usually the case. One dolphin swam immediately in front of the vessel's stem for a while and several times made a cork-screw motion displaying its underside.

One of the five or six dolphins encountered on 10 January 1932 (No. 5) was harpooned and secured (see below). While it was in the water harpooned, Rayner notes that:

'its companions failed to show as much interest in the condition of the wounded individual as is usual, nor were they frightened from the ship. After getting under way, they still accompanied the ship and their numbers were augmented, about 15 being around at one time. They frequently jumped clear of the surface'.

Table 1

Sighting records of Commerson's dolphin observed during the 'Discovery Investigations'

WS = *RRS William Scoresby*, D11 = *RRS Discovery II*, NAM = N. A. Mackintosh, GR = G. W. Rayner.

Observation number	Date/time	Position	No. of animals	Notes	Vessel	Observer
1	23 April 1931 (10.40hrs)	52°40'S 69°56'W (Strait of Magellan)	1	Behaviour	WS	-
2	18 September 1931 (09.00hrs)	52°53'S 70°28'W (Approaching Second Narrows, Strait of Magellan)	6–20	Behaviour	WS	GR
3	18 September 1931 (14.10hrs)	Strait of Magellan	3 or 4	Behaviour	WS	-
4	3 December 1931 (13.50hrs)	51°26'S 59°08'W (Off Falkland Is.)	At least 2	Behaviour	WS	GR
5	10 January 1932 (16.30hrs)	51°35'S 68°44'W (Off Puerto Gallegos Argentina)	5–6 later ca. 15	Specimen, Behaviour	WS	GR
6	11 January 1932 (15.30hrs)	51°39'S 68°55'W (Puerto Gallegos)	2	Behaviour	WS	GR
7	12 January 1932 (08.30–09.35hrs)	51°27'S 68°51'W (Off Puerto Gallegos)	At least 20 at one time	Behaviour	WS	GR
8	2 February 1932 (09.55hrs)	53°06'S 68°02.30'W (Off San Sebastian Bay, Tierra del Fuego, Argentina)	Several	Behaviour	WS	GR
9	2 February 1932 (later)	Entering San Sebastian Bay	Several	Behaviour	WS	GR
10	7 October 1932 (08.00–08.45hrs)	52°44.5'S 70°21'W (Strait of Magellan)	-	Behaviour	D11	-
11	7 October 1932 (11.20hrs)	52°23'S 69°17.5'W (Strait of Magellan)	8–10	Behaviour	D11	GR
12	7 October 1932 (16.00–16.15hrs)	52°25.5'S 68°12'W (Off the Strait of Magellan)	5 or 6	Behaviour	D11	GR
13	16 October 1932 (19.20hrs)	52°20'S 68°07.5'W (Off the Strait of Magellan)	-	-	D11	GR
14	23 December 1933	Strait of Magellan (Approaching first Narrows to Dungeness)	A large school	Behaviour	D11	NAM
15	20 March 1934	Strait of Magellan (Approaching first Narrows to Dungeness)	"Much fewer than on 23.12.33"	-	D11	NAM

On 7 October 1932 Rayner notes (No. 11) that eight to ten dolphins were playing around the bows and the ship generally, and later (No. 12) that five or six animals were accompanying the ship. 'They were seen to leap out of the water by means of a depressing action of the flippers'. It was noted in Observation No. 1 that the single dolphin did not keep pace with the vessel travelling at a speed of 10 knots.

Table 2

External measurements of a female Commerson's dolphin captured on 10 January 1932. Weight = 50 kg, no. of teeth = upper left 29, upper right 30, lower left 26, lower right 30. The teeth were remarkably loose and were absent from the extreme anterior tips of both jaws

Measurements*	In cms
1. Tip of snout to notch of flukes (total length) (1)	147
2. Tip of snout to gape (4)	15
3. Tip of snout to eye (2 approx.)	19.4
4. Tip of snout to blowhole (9)	19.7
5. Tip of snout to tip of flipper	58
6. Outer length of flipper (29)	23
7. Axilla to tip of flipper (30)	18
8. Breadth of flipper (31)	8.6
9. Notch of flukes to posterior margin of fin	56
10. Length of fin (33)	33
11. Height of fin (32)	11.7
12. Breadth of flukes (35?)	12
13. Span of flukes (34)	39.4
14. Notch of flukes to anus	42.5
15. Notch of flukes to genital aperture	49
16. Notch of flukes to umbilicus	81.3
17. Girth anterior to dorsal fin	96.5
18. Girth at genital aperture	52
19. Eye to ear (6 approx.)	-
20. Outer edge of flipper around curve	25.4
21. Notch of flukes to tip	20.3
22. Anus to genital aperture	6.5
23. Projection of lower jaw (15)	0.8
24. Girth anterior to flippers	75

* The measurements have been converted to centimetres from the original measurements in inches and fractions of an inch. Except where appropriate to the measurement concerned, the conversion is to the nearest centimetre. Numbers in brackets are the equivalent measurements in Norris (ed. 1961).

NOTES ON A CAPTURED FEMALE SPECIMEN

As noted above, a female dolphin (Observation No. 5) was harpooned and secured on 10 January 1932 from a school of five or six animals around *RRS William Scoresby* at 51°35′S, 68°44′W. The external measurements, weight and numbers of teeth are listed in Table 2. The skull and skeleton (registered number 1952.6.20.4) are in the cetacean collection of the British Museum (Natural History). G.W. Rayner described the animal and his notes are given here.

The animal was not pregnant nor lactating and no vaginal band was present. The left ovary contained many follicles, one corpus luteum and no corpora albicantia; the right ovary had one follicle and six corpora albicantia. The stomach was empty except for nematodes, one or two small cuttlefish[1] beaks and eyes. The gut contents were meagre, only one or two squid beaks and small fish vertebrae in the posterior part of the gut. Four ulcers were present in the duodenum. All other organs appeared to be healthy and in good condition. There were no external parasites. The palate was dusky pink medially with black pigment laterally.

[1] Probably the squid *Loligo sanpaulensis*, see Bastida, Lichtstein and Goodall (1988).

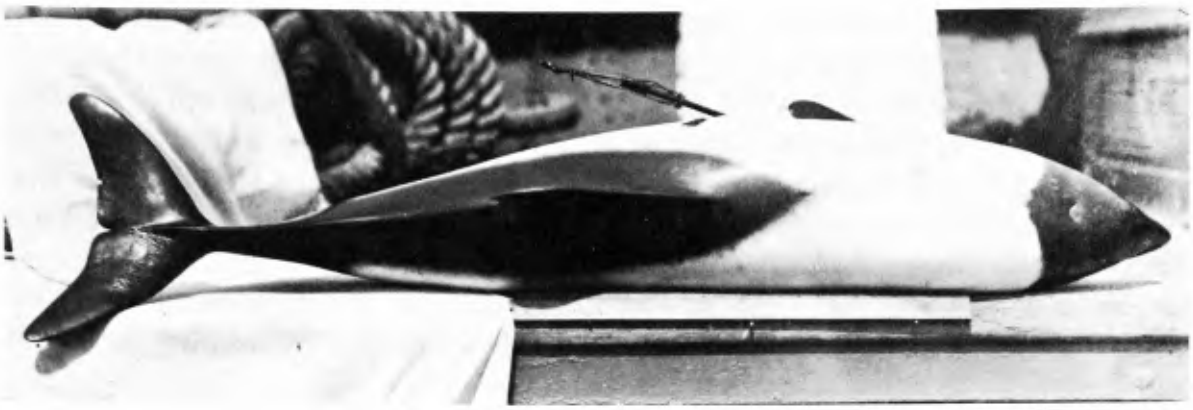

Fig. 1. Dorsal aspect of female specimen.

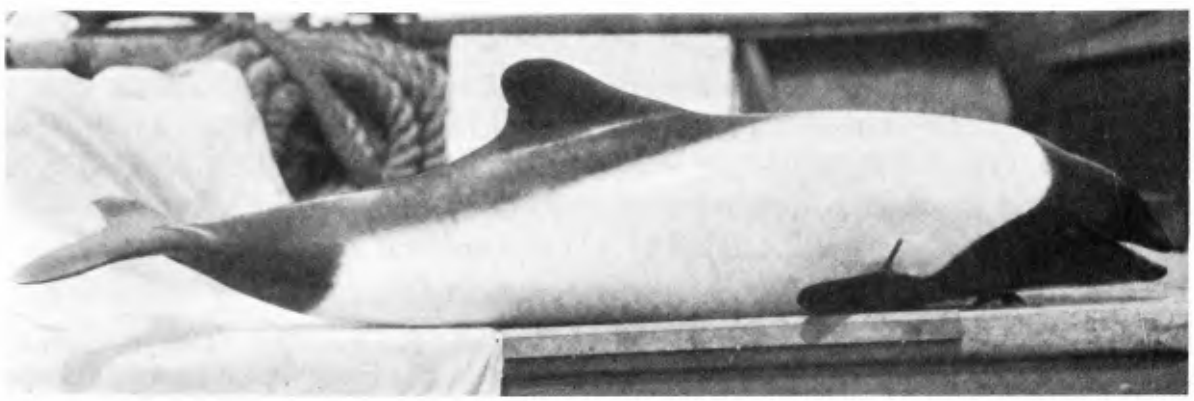

Fig. 2. Lateral aspect of female specimen.

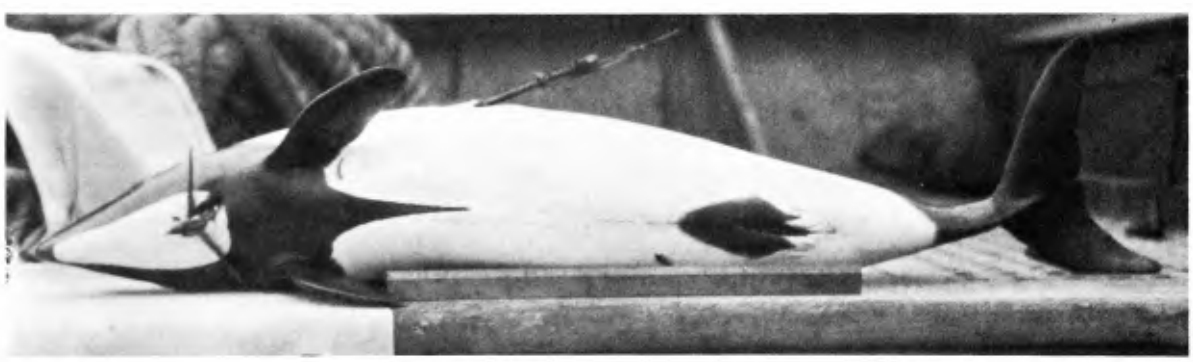

Fig. 3. Ventral aspect of female specimen.

Fig. 4. External genitalia of female specimen.

The specimen was photographed and Figs 1–4 illustrate dorsal, lateral and ventral aspects, and the external genitalia. If Figs 3 and 4 are compared with the photographs of ventral views of the two male specimens in Harmer (1922), it is clear that in this female the black area surrounding the genital opening was smaller and of a different shape to the corresponding black area in the two males. While more information on the shape and extent of this ventral marking on females is necessary for confirmation, the present specimen supports Harmer's suggestion that females may normally have a ventral black marking narrower and of a different shape to that of the male, and the findings of Collet and Robineau (1988).

OCCURRENCE AROUND SOUTH GEORGIA

Brownell (1974) records Commerson's dolphin around South Georgia, giving Hart (1935) as the source of the at-sea observation plotted on plate 8. Mitchell (1975) and Goodall (1978) record the species there, citing Brownell (1974), and Mitchell and Brownell are probably the source of other recent references to its occurrence there, e.g. Nishiwaki (1977), Leatherwood and Reeves (1983).

Hart (1935, p. 253) states:

> 'The dolphins, *Lagenorhynchus cruciger* and *Cephalorhynchus commersoni* [*sic*], which are common round South Georgia, where they are known to the whalers as 'springers', are thought to become infected at times, and this may well be so, for Mr Rayner has seen them playing round the larger rorquals as they do round the bows of ships.'

A rather similar statement occurs in Matthews (1931, p. 39):

> 'Two beautiful species of dolphin (*Lagenorhynchus cruciger* and *Cephalorhynchus commersoni* [*sic*]), up to six feet long, are also found in the waters surrounding the island. The colour of these is black with white markings on the sides, back and below.'

Plate XVIIb in the book, entitled *Black and White Dolphins Playing under a Whaler's Bow* shows two individuals of *L. cruciger*.

As no records of sightings of Commerson's dolphin around South Georgia occur in the 'Discovery Investigations' cetacean observations records which I have examined, I wrote to Dr Harrison Matthews, who was a member of the staff of the 'Discovery Investigations' working at South Georgia at that time, drawing his attention to this lack of records and asking if he had any personal records of the dolphin at South Georgia, or whether he could recall any such sightings apart from the reference in his book. He replied (pers. comm.) that he had 'no definite record of the occurrence of *C. commersoni* [*sic*] in South Georgia waters'. He included the record in his book on the strength of a verbal statement by Dr J.E. Hamilton (Government Naturalist at the Falkland Islands who also worked for 'Discovery Investigations' around South Georgia at that time). Dr Matthews agreed that Hart appeared to have copied the statement about the occurrence of the species at South Georgia from the reference in his book. He also confirmed that plate XVIIb does show *L. cruciger* and added that the photograph was taken by him from the whaler *Don Ernesto* (Compañia Argentina de Pesca) off South Georgia.

There are no records of Commerson's dolphin around South Georgia in the records of cetaceans observed during the work of the 'Discovery Investigations'.

The statement of the dolphin's occurrence there in Harrison Matthews (1931) is based on an unconfirmed report, and this also apparently applies to the statement in Hart (1935). There appear to be no other definite published records of this species in South Georgia waters. Hoare (1982) published the journal of J.R. Forster, with Cook on HMS *Resolution* (1772–75). Forster notes (p. 714) on passage through Stewart Strait, between Bird Island and Willis Islands, off the northwestern end of South Georgia 'saw several Porpesses [sic], with large white Spots or blotches'. This description hardly fits Commerson's dolphin, although it may refer to *L. cruciger*.

Commerson's dolphin has been recorded and photographed in Drake Passage as far south as 61°59′S, 63°05′W (Aguayo L, A., 1975) and it does occur at Îles Kerguelen (Angot, 1954; Frost and Best, 1976; Pascal, 1981; Collet and Robineau, 1988). It may occur around South Georgia. However, Frost and Best (1976) suggest that the species may have a preference for a well-indented coastline with sheltered bays. If this is so, the relatively less broken and indented coastline of South Georgia, when compared with that of the Falkland Islands and Îles Kerguelen, could indicate its absence there.

ACKNOWLEDGEMENTS

The author of this note has been a compiler using the records of earlier observers. He wishes to acknowledge their efforts in providing observations which have retained their value, even though made some fifty years ago. He is much indebted to Dr L. Matthews FRS, for providing information and comments on his own and Dr Hart's published statements on the occurrence of Commerson's dolphin around South Georgia. He also thanks Martin Sheldrick of the Department of Zoology, British Museum (Natural History), for checking the registration number of the specimen in his care, and Arnold Madgwick of the Institute of Oceanographic Sciences for preparing prints from the original photographs. R.L. Brownell, Jr and G.P. Donovan made useful comments on the original text.

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Estimate of Numbers of Commerson's Dolphins in a Portion of the Northeastern Strait of Magellan, January–February 1984

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ABSTRACT

Low altitude aerial surveys were flown along randomly selected transects in eight survey blocks between the First and Second Narrows, northern Strait of Magellan, Chile, in January and February 1984. Commerson's dolphins were seen as solitary individuals and in groups of 2–15. Effort and sightings under conditions of Beaufort < 4 were analysed in detail. After elimination of sightings within 0.055 n.miles of the transect to account for obstructed downward visibility, and the few distant outliers, the remaining 34 sightings of groups containing 1–13 dolphins ($\bar{x}$ = 3.77, SE = 0.52) were treated with a Fourier series model to estimate population size for two strata, narrows (blocks 3–8 n.miles long × 5 n.miles wide) and open water (blocks 11–16 n.miles long × 5 n.miles wide). Herds were found in higher density in the narrows (6.702 herds/n.miles^2) than in open water (0.658 herds/n.miles^2) and were larger in the former (mean herd size = 4.35) than in the latter (mean herd size = 2.70) areas. In the absence of a reliable estimate of variance for the stratified estimate, the pooled estimate of population size, 3,211 (SE = 1,168), is considered to be the best estimate. Limitations of the estimates are discussed.

INTRODUCTION

The distribution of Commerson's dolphin, *Cephalorhynchus commersonii*, (Fig. 1) is apparently limited to waters of southern and southeastern South America (from Drake Passage, the southern and eastern coasts of Tierra del Fuego, and the central Strait of Magellan, near Cabo Froward, northward on the eastern Argentine coast to about 41°30′S), the Falkland Islands and the Kerguelen Islands. Earlier reports of their occurrence around South Georgia (Hart, 1935) have not been corroborated by recent work (for a review see Goodall, Galeazzi, Leatherwood, Cameron, Miller, Kastelein and Sobral, 1988 and Brown, 1988). Except for infrequent references to reported sightings in pelagic waters of Drake Passage and speculation by Gewalt (1979; 1981) that they occur "in offshore

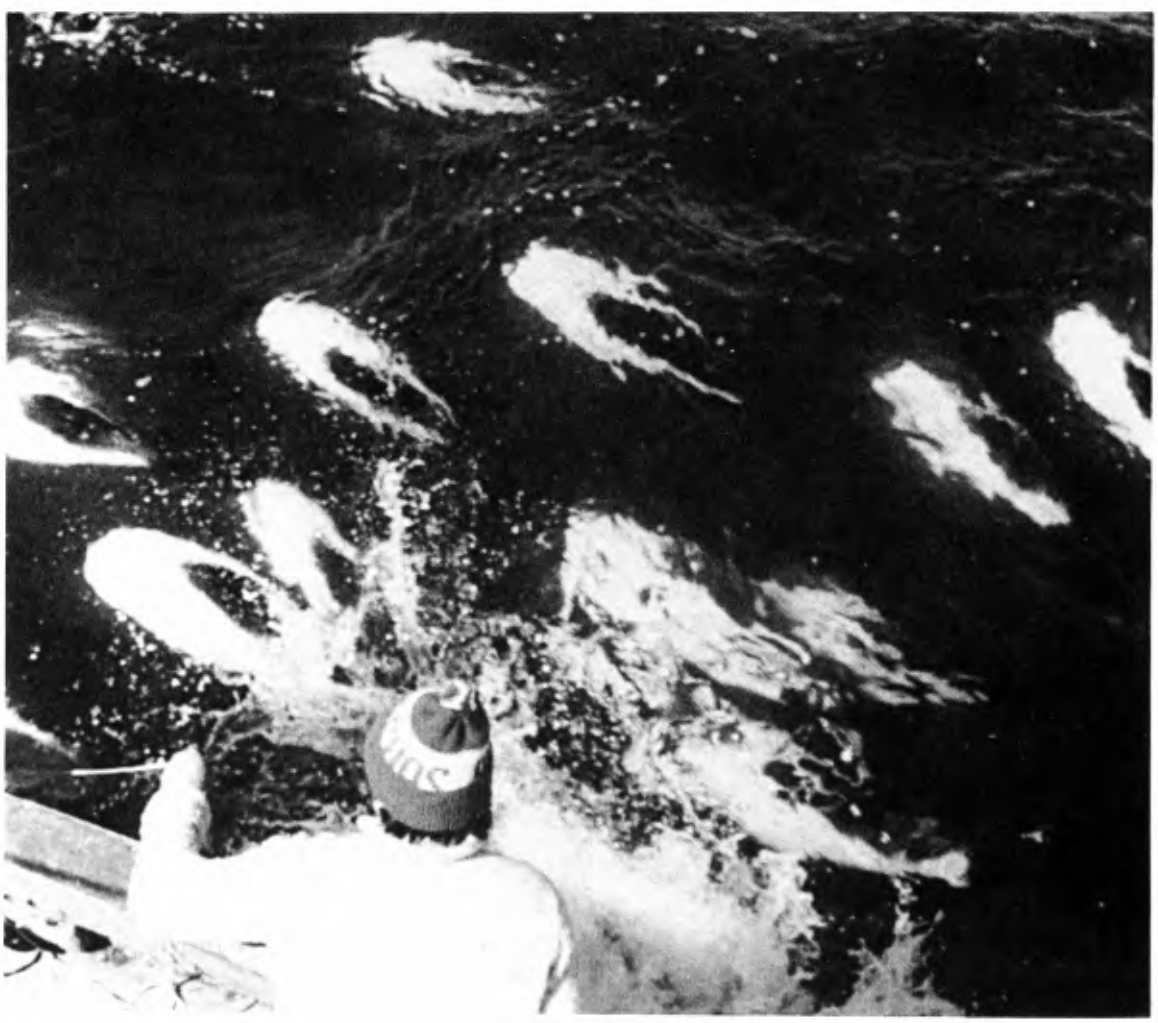

Fig. 1. Aerial view of a Commerson's dolphin on the bow of an oil-platform service vessel in the First Narrows, eastern Strait of Magellan, 21 January 1984 (top) and a portion of a herd of approximately 110 seen from the F/V *Vicky*, over Marta Bank 5 February 1984 (bottom). These gregarious little dolphins are eager bow riders. (Photos by S. Leatherwood).

waters" off north central Argentina during fall through spring, the species is known only from coastal areas (Gilmore, 1969; Brownell, 1974; Gewalt, 1979; 1981).

There are few published figures indicating the abundance of Commerson's dolphins anywhere in their range[1]. Weber (1920) reported seeing "incredible" numbers in the east side of the Strait of Magellan. Fishing there, he was apparently able to harpoon more than 100 individuals from a boat in less than three hours and to continue fishing successfully for a week, returning to Punta Arenas, Chile with 4,500kg of blubber. He reported on one occasion taking 80 dolphins of this species before 1100 hours. Gewalt (1981) reported seeing about 100 individuals in the Bay at Comodoro Rivadavia, Argentina in November/December 1978 but found only 15 there in December 1980.

Reports that significant numbers of Commerson's dolphins are accidently killed in fishing nets or taken deliberately for food or as crab-bait in Argentina and Chile, (Mitchell, 1975; Sielfeld, Venegas and Atalah, 1977a and b; Goodall and Cameron, 1980; Gewalt, 1979, 1981) and the small numbers recently live-captured from both countries for zoos and marine zoological parks (Gewalt, 1979,1981; Spotte, Radcliffe and Dunn, 1979; Thielke, 1984; Cornell, Antrim, Asper and Pinchera, 1988) have prompted concern about the size and status of the population(s) of this species.

This paper reports results of aerial surveys flown in January/February 1984 to estimate size of the population(s) of Commerson's dolphins in the area of the northern Strait of Magellan between the First and Second Narrows (Fig. 2).

SURVEY DESIGN AND DATA COLLECTION

The surveys were designed using a stratified random sampling scheme to balance practical aspects of logistics with the need for a random sample. The area was divided into eight rectangular blocks of equal width (5 n.miles) but varying length because of the shape of the shoreline and of the Strait (Fig. 2A inset). The southeastern boundary of each block was scored at 1/8 n.mile intervals, numbered consecutively. Thirty two transects, four in each block, which were selected at random, represented starting points of four sets of transects. This design assured that if all transects were completed, the data could be pooled among blocks in case there were insufficient data in each block for separate analysis.

Transects were flown northwest/southeast, across the length of the block parallel to block boundaries (Fig. 2A), in a low-winged aircraft (*Piper Dakota*) travelling 90 knots (167 km/hr) at 500ft (152 m) elevation. Primary observers were positioned right front and left rear. The following data were recorded: for each transect – the distance flown, stratified by sea state; for each sighting – the angle (α) formed between the horizon and a line to a group of dolphins when

[1] "No definitive work regarding the total extent of the population of Commerson's dolphin (*Cephalorhynchus commersonii*) has been undertaken in the waters of Patagonia and Tierra del Fuego. However based on the observations that have been recorded and considering the extensive amount of habitat that has not been examined, it is not unreasonable to assume that several thousand individuals could occur in that sector of their range." (C. Venegas, pers. comm. to W. E. Evans, 6 January 1983).

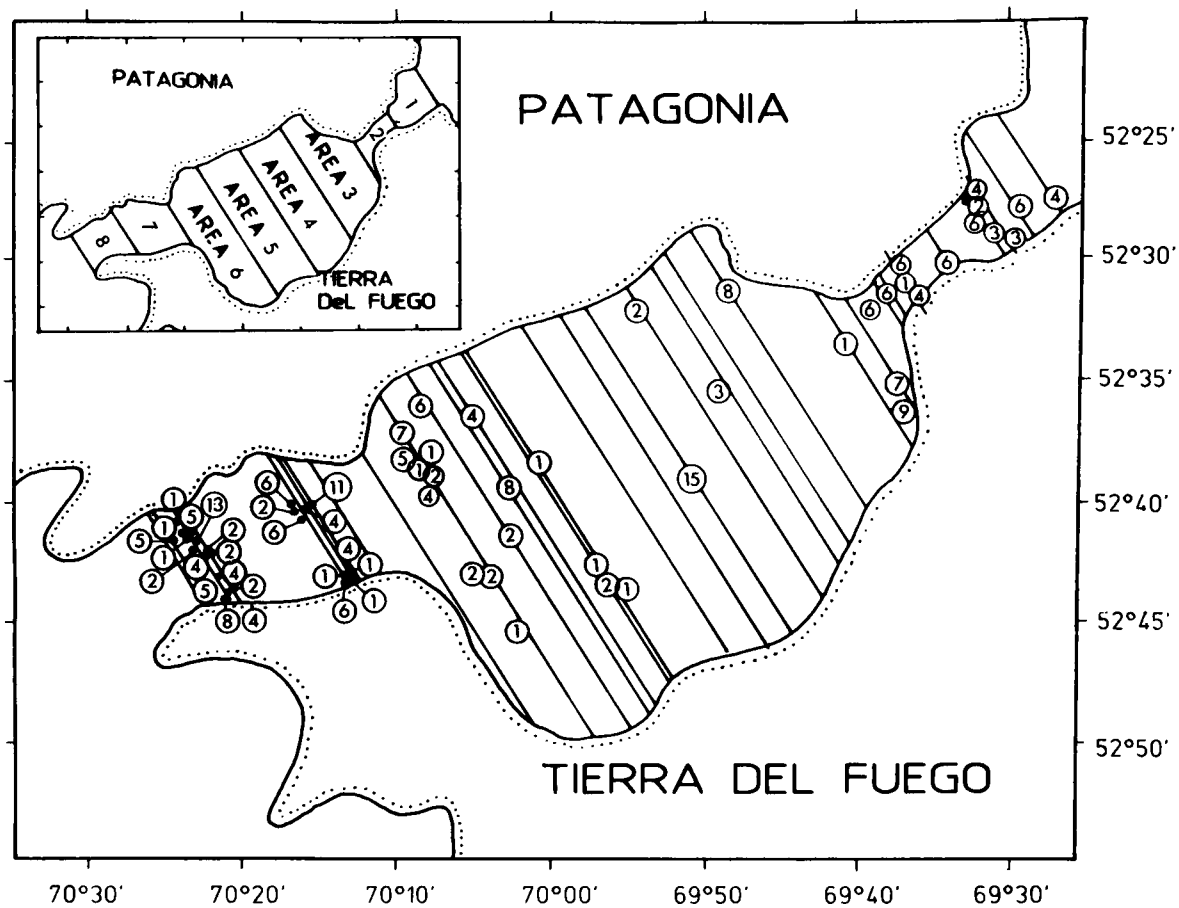

Fig. 2. Four sets of random transects flown in eight study areas (inset) in the northeastern Strait of Magellan, 20 January through 1 February 1984 and locations of sightings of *Cephalorhynchus commersonii* on – transect. Numbers in circles indicate herd size.

it was perpendicular to the aircraft, measured with a clinometer (to permit calculation of perpendicular sighting distance), counts of group size, species, location and sea state (expressed as Beaufort) at the location.

Perpendicular distance for each sighting was calculated as $x = H \tan(90 - \alpha)$, where H is aircraft altitude (i.e. 500ft, 152m).

DATA ANALYSIS

Estimates of density and numbers were made using line transect techniques pertinent to animals which travel in groups (for review and basic assumptions see Burnham, Anderson and Laake, 1980). The data were analysed using program TRANSECT (Laake, Burnham and Anderson, 1979).

As in some previous aerial surveys of dolphins (e.g. Leatherwood, Gilbert and Chapman, 1978; Leatherwood, 1979) observers on the present survey considered conditions of Beaufort 4 and above too rough for reliable data collection; so, transects were initiated only in Beaufort 3 or below. If sea state deteriorated during transect, data continued to be collected. But for the present analysis only data collected at Beaufort 3 or less were considered.

Transects covered 202.6 n.miles, distributed unequally among blocks (Table 1). Four blocks, 1, 2, 7 and 8 were shorter (3 – 8 x 5 n.miles) and, therefore, received

Table 1

Results of test of randomness of survey effort

Block	Distance searched (n. miles)	Distance searched as a proportion of total distance	Area of block (n. miles)	Area of block as a proportion of total area	Ratio of relative distance to relative area
1	7.2	0.036	21.9	0.056	0.63
2	6.6	0.033	14.1	0.036	0.90
3	28.8	0.142	57.0	0.147	0.97
4	34.2	0.169	78.3	0.202	0.84
5	49.2	0.243	80.1	0.206	1.20
6	39.9	0.197	82.2	0.212	0.93
7	25.7	0.127	32.1	0.083	1.53
8	11.0	0.054	22.2	0.057	0.95
Total	202.6	1.000	387.9	1.000	

lesser amounts of effort (6.6—25.7 n.miles) while the other four blocks, 3, 4, 5 and 6 were relatively longer (11 – 16 x 5 n.miles) and, therefore, received more effort (28.8—49.2 n.miles). Because of the possibility that the true density sampled was higher in the shorter blocks than it was in the longer blocks, a stratified estimate was constructed for these two types of areas to try and reduce the variance of N (the estimated number of dolphins) for the whole area. For the pooled data to have been a random sample of the whole sample area, the following ratios should have equalled unity for each block: the ratios of distance searched within each block as a proportion of total distance to areas of each block as a proportion of total area. This might not be the case if sections of transects in some blocks were not included in the analysis because of poor weather. As can be seen in Table 1, with the exceptions of block 1, which was undersampled, and block 7, which was oversampled, the survey achieved a fairly close approximation to an overall random sample, supporting the pooling of data among blocks.

Fig. 3 shows the frequency distribution of perpendicular sighting distances for the 59 sighting of groups (276 individuals) on-transect. The figure illustrates a critical defect in the data, namely that observers were unable to see underneath the aircraft. This violates the fundamental line—transect assumption that all groups in the vicinity of the transect-line are seen. If, however, this assumption is replaced by one requiring, instead, that all groups be seen at some perpendicular distance, x, from the transect-line, then estimates can still be calculated. The validity of this substitute assumption and its implications for the reliability of density estimates are discussed below. After inspecting Fig. 3, we decided to eliminate all sightings between the transect-center-line and 0.055 n. miles because the view of the observers was clearly impaired in this area. Our analysis used only the remaining data set (Table 2).

Density estimates were calculated for each of the two length strata and for the pooled data, using all data collected in conditions of Beaufort 3 or less from all blocks (Tables 3 and 4). The model chosen to fit to the distributions of perpendicular distance was the Fourier series, the sum of a series of Cosines, a model found by Burnham *et al.* (1980) to be generally useful. In each analysis the data were truncated at a suitable perpendicular distance to exclude any

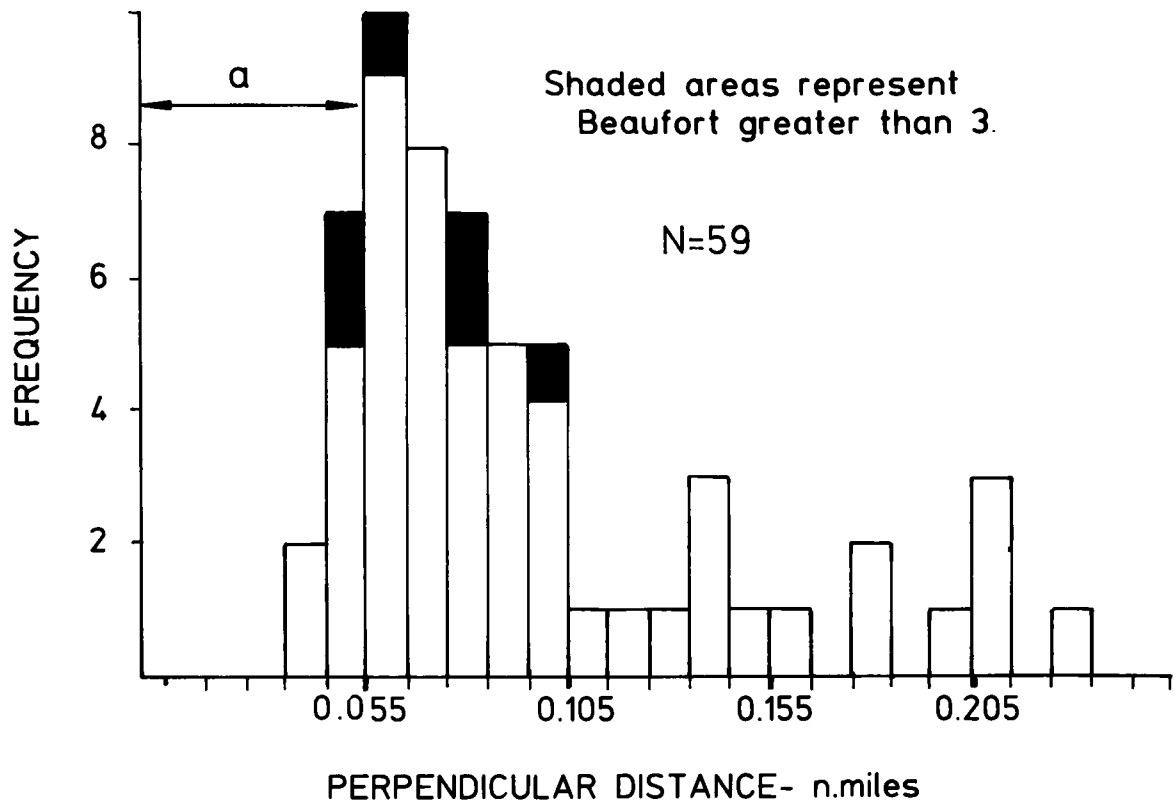

Fig. 3. Distribution of perpendicular distances for all aerial sightings of *Cephalorhynchus commersonii* on-transect. Sightings in area (←a→) were eliminated from analyses of herd and dolphin density.

Table 2

Summary of distance searched, number of sightings and size of area for each analysis

Blocks	Area	Distance searched	Total no. of sightings	Truncation distance	No. of sightings after truncation
1 + 2 + 7 + 8	90.3	50.5	32	0.07	23
3 + 4 + 5 + 6	297.6	152.1	14	0.08	10
All	387.9	202.6	46	0.05	34*

*Not the sum of the above two numbers because of the difference in truncation distances.

Table 3

Estimation of the density of groups (n = number of sightings). Numbers in parentheses are standard errors

Blocks	Variance of n	No. of terms for Fourier series model	f(0)	Density of groups as groups/n. mile	Probability of a greater X^2 for model fit
1 + 2 + 7 + 8	24.0	1 term	29.46 (6.26)	6.702 (2.016)	0.975
3 + 4 + 5 + 6	11.5	0 terms (1/w)*	20.00 (0.00)	0.658 (0.050)	1.000
All	98.0	2 terms	26.21 (4.44)	2.199 (0.741)	0.953

*The data for this analysis were fitted best by a zero term Fourier series model which is equivalent to a strip of equal probability of sighting.

Table 4

Estimates of mean group size, density of dolphins and number of dolphins. Numbers in parentheses are standard errors

Block	Mean group size	Density of dolphins	Number of dolphins
1 + 2 + 7 + 8	4.35 (0.66)	29.14 (9.83)	2,631 (888)
3 + 4 + 5 + 6	2.70 (0.73)	1.78 (0.50)	529 (149)
All	3.77 (0.52)	8.28 (3.01)	3,211 (1,168)
Stratified estimate of (1 + 2 + 7 + 8) + (3 + 4 + 5 + 6)			3,160 (900)

outlier sightings which might have adversely affected the estimation of f(0) (see Table 2). For discussion of this point see Burnham *et al.* (1980, pp. 47–8). The appropriate number of terms in the Fourier series model (Table 3) was selected using the stopping rule described by Burnham *et al.* (1980).

RESULTS AND DISCUSSION

Table 3 summarises results of the estimation of the variance of n and of the model fitting to estimate f(0), and hence the density of groups, for each analysis. Fig. 4 shows the distributions of perpendicular distance. Table 4 summarises the estimates of mean group size, density of dolphins and number of dolphins. Fig. 5 shows the distribution of group sizes. A regression of group size and perpendicular distance gave a slope of −9.06 (SE = 7.15) which was not significantly different from zero at the 5% level. The correlation coefficient was calculated to be 0.03.

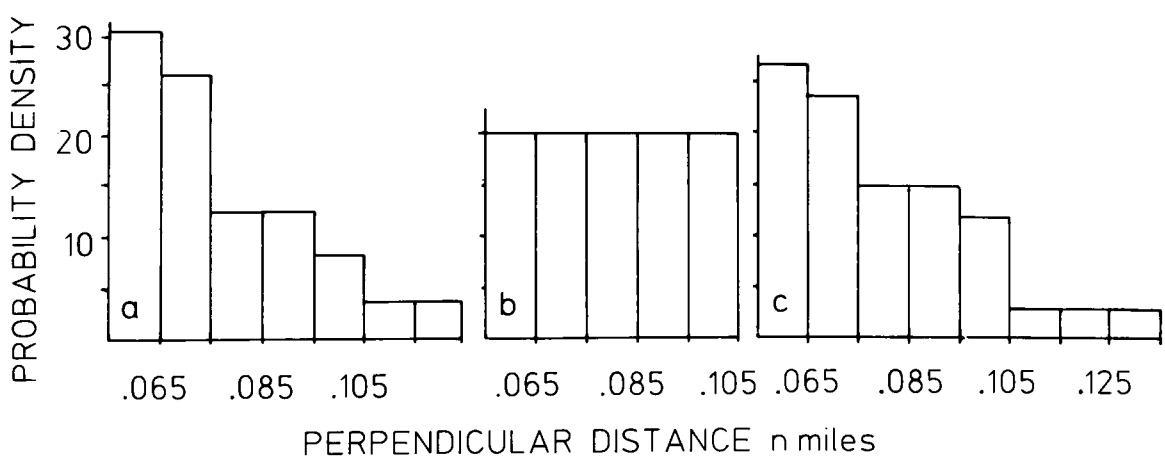

Fig. 4. Distributions of perpendicular distance for sightings collected in Beaufort 1, 2 and 3 for areas 1, 2, 7 and 8 (a), areas 3, 4, 5 and 6 (b), and all areas (c).

Tides in the survey area often exceed 20ft (*ca* 6m), resulting in strong currents, particularly in the narrows. Even so, there did not appear to be any significant relationships between number of dolphins seen on a given survey and time of day, height of tide or direction of tidal flow and no relationship between dolphin swim direction and direction of tidal flow. Such relationships have been observed in harbor porpoises (*Phocoena phocoena*) in an area of eastern Canada with similarly high tidal ranges (Gaskin *et al.*, 1985).

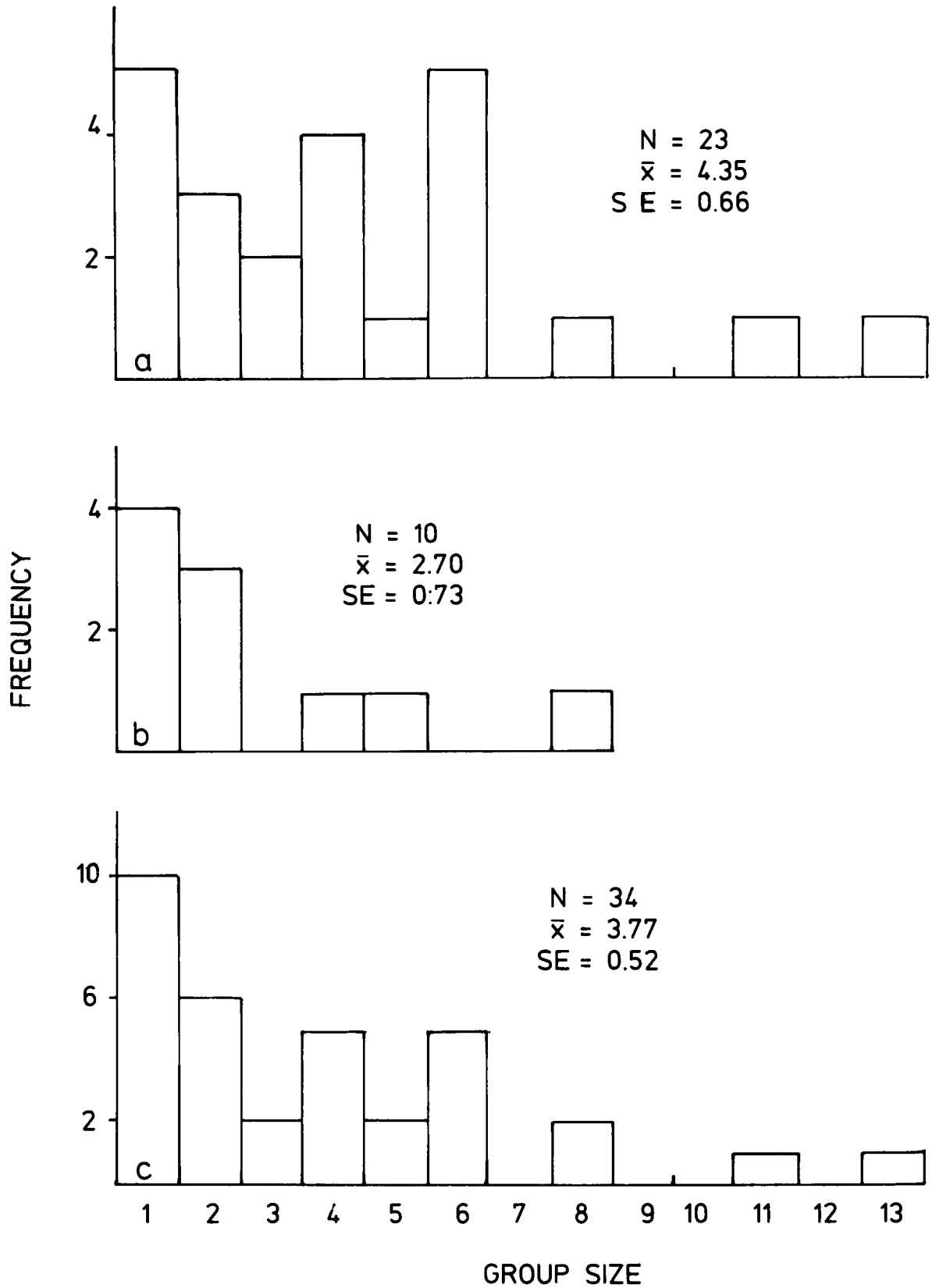

Fig. 5. Distribution of group sizes for sightings collected in Beaufort 1, 2 and 3 for areas 1, 2, 7 and 8 (a), areas 3, 4, 5 and 6 (b), and all areas (c).

The sample sizes used in the calculation of the stratified estimate are very low and almost certainly result in unreliable estimates of variance. A more appropriate method might have been to use a "bootstrap" technique (see Efron, 1982) although, with a sample size as low as 10 in the open–water areas, even this method may not be appropriate. Our best estimate of population size, therefore, is the pooled estimate of 3,211 (SE = 1,168). However, because observers were unable to see underneath the aircraft, we are assuming that all groups at a certain distance (0.055 n.miles) from the trackline were seen. If some groups at this distance were missed, the estimate will be negatively biased. Consequently this must be considered a minimum estimate. There is no information from the present survey to indicate the nature of sighting probabilities close to the transect line. However, recent aerial surveys for dolphins in the eastern tropical Pacific, conducted by US National Marine Fisheries Service (Holt and Powers, 1982; Holt, 1984), have demonstrated that the probability of sighting in the first 0.05 n.miles may be approximately the same as from 0.05–0.10 n.miles or as much as 2–3 times this value, depending upon the conditions. These results highlight the importance of using a survey aircraft with good forward and downward visibility. No such aircraft was available for the present investigations.

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Age and Body Length Characteristics of *Cephalorhynchus commersonii* from Incidentally-caught Specimens off Tierra del Fuego

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ABSTRACT

Dentinal growth layers, assuming one pale and one darkly – staining lamina form annually, have been used to determine age in *Cephalorhynchus commersonii*. Ages of incidentally – caught animals range between 0 – 18 years; 23% of these animals are from zero and one – year old groups. Females attain an average length of 134 cm in adulthood, larger than males at 130 cm. The largest animal (female) examined was 145.5 cm and 66 kg. Birth size is probably about 75 cm and birth weight about 7.5 kg. Average sizes during summer for first and second-year animals are about 99 cm and 112 cm respectively. Parturition may occur seasonally between early spring and late summer. Animals probably mature sexually at about 5 – 6 years, when male testicular weights increase to over 150 g. Physical maturity, estimated from vertebral ankylosis, is complete by 12 years of age. Estimates of survival rate for sexes combined are 0.855 for ages 0 – 18 years inclusive; 0.914 for ages 5 – 18 years inclusive and 0.673 for ages 0 – 5 years inclusive, suggesting a higher mortality rate in the juvenile segment of the population.

INTRODUCTION

The distribution of *Cephalorhynchus commersonii* (Commerson's dolphin) is restricted; the species only being recorded in the western South Atlantic and South Indian Ocean. It frequents waters round the southern tip of South America, Falkland (Malvinas) Islands, and Iles de Kerguelen (Goodall, Galeazzi, Leatherwood, Miller, Cameron, Kastelein and Sobral, 1988). Pelagic sightings have been recorded from Drake Passage (Aguayo L., 1975), but it is mostly confined to the area north of the Antarctic Convergence.

Although Angot (1954) reported a specimen of 170 cm from Kerguelen, the maximum length published for the western South Atlantic was 145.5 cm for females and 136 cm for males (Moreno, 1892; Bruce, 1915; Harmer, 1922; Lockyer, Smellie, Goodall and Cameron, 1981). Mermoz (1980) reported a

length of 158 cm, which has since been shown to be erroneous (Goodall *et al.*, 1988).

Most existing biological information for this species has been derived from incidentally killed specimens in fishery operations off Argentina and Chile (Goodall, 1978; Lockyer *et al.*, 1981). Goodall and Cameron (1980) reported incidental and deliberate catches in crab fishery operations using nets in southern Chile where an estimated 300 dolphins may be taken each year. Similarly, off Tierra del Fuego, Argentina, over 23 dolphins are taken incidentally in coastal fish nets each year, mostly between October and April. The captured dolphins are usually hauled out onto the beaches and abandoned. This species comes very close inshore into the surf and the catch of animals is likely to be random. There is as yet little evidence for seasonal, sexual or age segregation of this species, although these possibilities are discussed in the paper.

Lockyer *et al.* (1981) reported on a method of ageing this species by utilising stained thin sections of decalcified teeth. Since then more net-caught and beached animals from Tierra del Fuego have been examined, thus permitting the fuller investigation of age- and length-related characteristics given in this report.

MATERIALS AND METHODS

Data on dates of death and examination, body length, sex, testes weight, ovaries, age (from teeth), vertebral epiphyseal fusion, body weight and location were available for this study.

A total of 139 specimens found on beaches around Tierra del Fuego between 1977 and 1984 inclusive were examined and samples collected. The total comprised 23 females (including one with a term foetus), 50 males (including one term foetus) and 66 animals of unknown sex. Body length was measured for 97 animals (including 22 females and 48 males) by the standard method i.e. in a straight line from snout tip to notch in the tail flukes. Badly dried, partial or decomposed specimens were measured for skeletal length when complete.

Pairs of ovaries from 8 females and testes from 19 males were collected, weighed and fixed in 10% neutral formalin. The ovaries were examined by serial sectioning and staining with Erhlich's haematoxylin.

Teeth were collected still in the jaw, and selected for least wear and straightness before treatment. They were removed and cleaned, decalcified in 5% nitric acid, sectioned on a freezing microtome at 20 μm thickness, stained with Erhlich's haematoxylin and mounted in DPX – medium prior to examination (Lockyer *et al.*, 1981). Vertebral epiphyseal fusion was recorded after the skeleton had been cleaned by boiling, re-assembled and checked along the entire length. The vertebral count varied slightly between individuals; cervical vertebrae 1 and 2 were fused in all specimens.

A special study of the most recently forming lamina type (adjacent to the pulp cavity) was made on teeth from 75 animals for which either the month of death was known or could be estimated from the freshness of the carcase in order to investigate a possible correlation of laminae growth with time of year. The hypothesis is that pale and darkly-staining laminae form at a particular time of year. Although their mode of influence upon lamina growth is uncertain for most species, likely factors are daylength (perceived by the hypothalamus which

in turn influences pituitary hormone secretion) and food supply. There is evidence of seasonality in the growth of incremental laminae in teeth of terrestrial mammals (Grue and Jensen, 1979) and marine mammals (Perrin and Myrick, 1980).

RESULTS

Seasonal formation of dentinal laminae in teeth

Fig. 1 shows a typical stained decalcified thin section of a tooth of *C. commersonii*. The neonatal line and the two alternating types of laminae (darkly-staining and pale) are indicated, as is the lamina type adjacent to the pulp cavity.

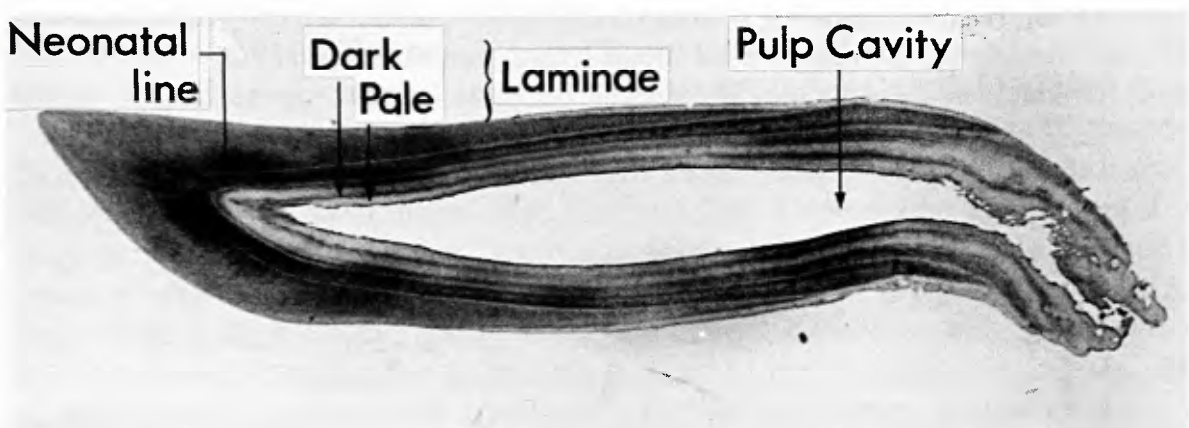

Fig. 1. Photomicrograph of a stained decalcified section through a tooth of *C. commersonii*. (Specimen no: RNP 866, date: 19 January 1981, sex: male, length: 117 cm, age: 2 years).

When examining the teeth for age determination, the type of the lamina adjacent to the pulp cavity was assumed to be that most recently forming. Because of small sample size (n) and uneven sampling throughout the months of the year, data for all specimens, regardless of year of death, age or sex, were combined (n is thus 75).

The monthly percentages of the teeth with a darkly–staining lamina at the pulp cavity edge were calculated for the months of sampling. There apears to be a preponderance of darkly – staining laminae forming between the beginning of November and the end of December (Table 1) i.e. in approximately late spring/early summer. However, there are no useable readable data for the winter months of May, June, July and August, and few instances where pale laminae are the most recently formed.

Table 1

Percentage of teeth with a darkly-staining lamina at the pulp cavity edge, by month throughout the year, for *C. commersonii*.

Month	Sample size	Number	Percentage	Month	Sample size	Number	Percentage
September and October	2	1	50	January	22	12	54
November	10	7	70	February	6	3	50
December	29	23	80	March	4	0	0
				April	2	0	0

Despite this, it appears that a darkly – staining lamina is formed in late spring, as in other dolphins (Perrin and Myrick, 1980); we can only surmise that one pale lamina probably forms in autumn. A year's growth layer may correspond to two laminae, one darkly – staining and the other pale. We have assumed this when translating tooth growth layer groups into age in years.

Age and body length characteristics

Age and length data are available for 95 of the 139 animals (22 females, 46 males, and 27 individuals of unknown sex). In Fig. 2 the length at age data are presented for all individuals.

No attempts have been made to fit arithmetic growth formulae to these data, because there appear to be differences between males and females and the sample sizes are too small for reliable analysis. However, considering only adult animals (8 years and over), the calculated mean length for males is 129.6 ± 1.0 cm (SE) and females 134.2 ± 1.9 cm (SE). Adult females appear to be larger, (t-test

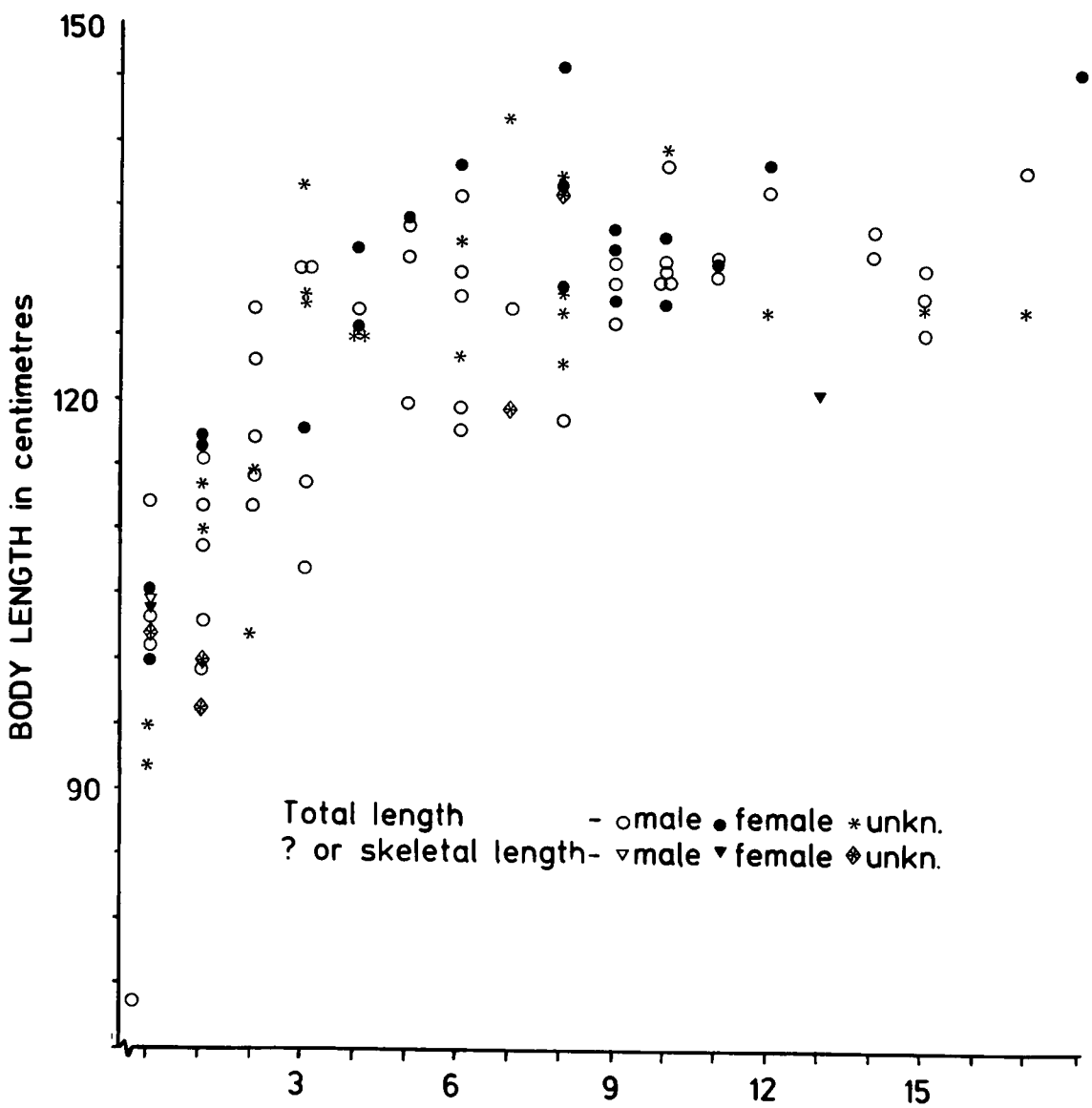

Fig. 2. Length at age distribution for *C. commersonii*, for males and females.

p>0.05, d.f.=27), and this seems true at any given age. The largest recorded animals in this sample from eastern Tierra del Fuego were 145.5 cm (female), 138 cm (male) and 142 (unknown sex). G. W. Rayner (in Brown, 1988) reported a length of 147.3 cm for British Museum specimen 1952.6.20.4, taken off Puerto Gallegos. Live-captured animals from the southwest South Atlantic have been found to be larger, the maximum being 149 cm in males and 152 cm in females (Goodall *et al.*, 1988). Animals from Iles Kerguelen are much larger, 166.5 cm in males and 174 cm in females (Robineau and de Buffrenil, 1984). The curves of length at age (Fig. 2) appear to show a marked slowing of growth at about five years; a phenomenon often associated with sexual maturation (Brody, 1968). Data on testes weight are available for 19 males, of which three contained sperm (checked both macro- and microscopically). The data for these males are shown in Fig. 3 by both age (3a) and body length (3b). There appears to be a dramatic increase in testes weight between 5–6 years and also between 127–131 cm length. The testes of the three animals where sperm were observed were all taken in December, and all animals with testes exceeding 350g were taken between November and January. These animals were sexually mature. Sperm were not observed in animals with testes weights 150–200g, and testes weights of the youngest males were less than 25g. These males were sampled in months February, April and October. Many adult Cetacea show seasonal hypertrophy and spermatogenic activity coincident with the period of conception (Perrin and Reilly, 1984; Lockyer, 1984). Although this may be the explanation for the feature appearing in Fig. 4 for Commerson's dolphin, the gestation period is unknown (and hence conception dates uncertain) so that the theory cannot be verified.

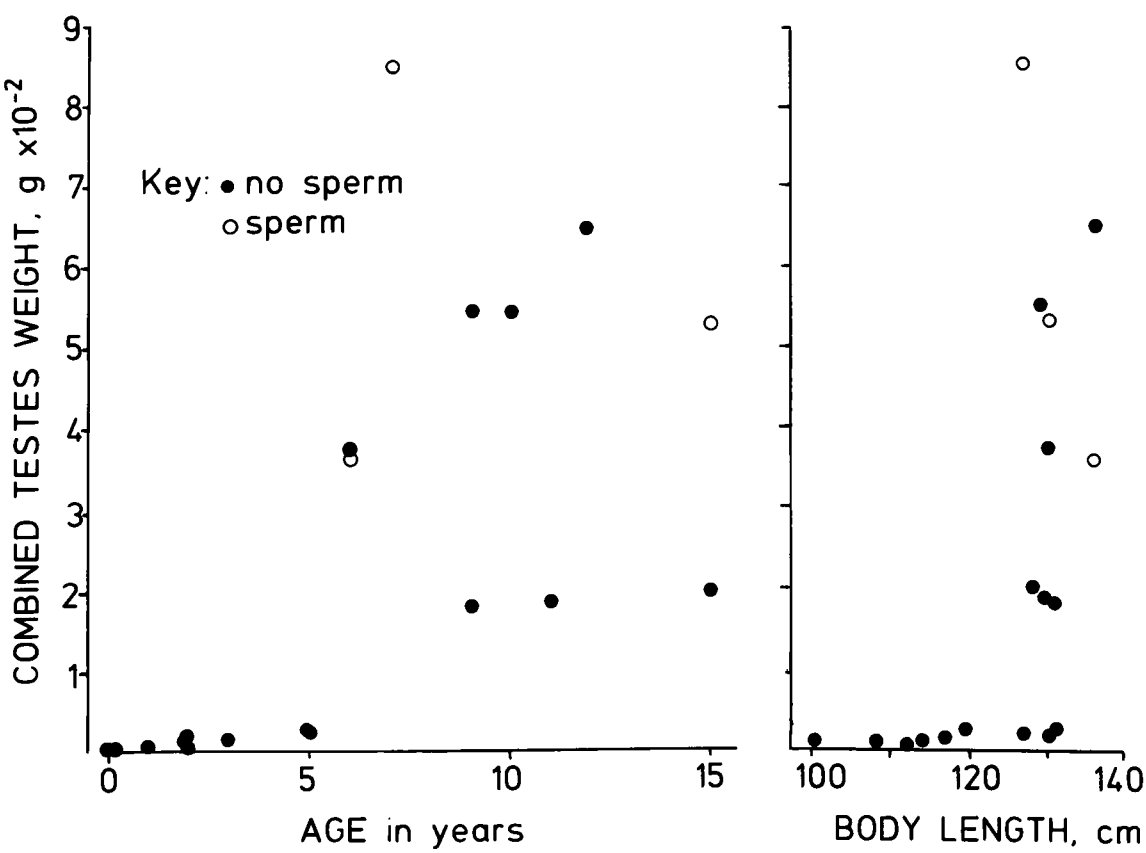

Fig. 3. Combined testes weight for male *C. commersonii*, a. by age; b. by body length.

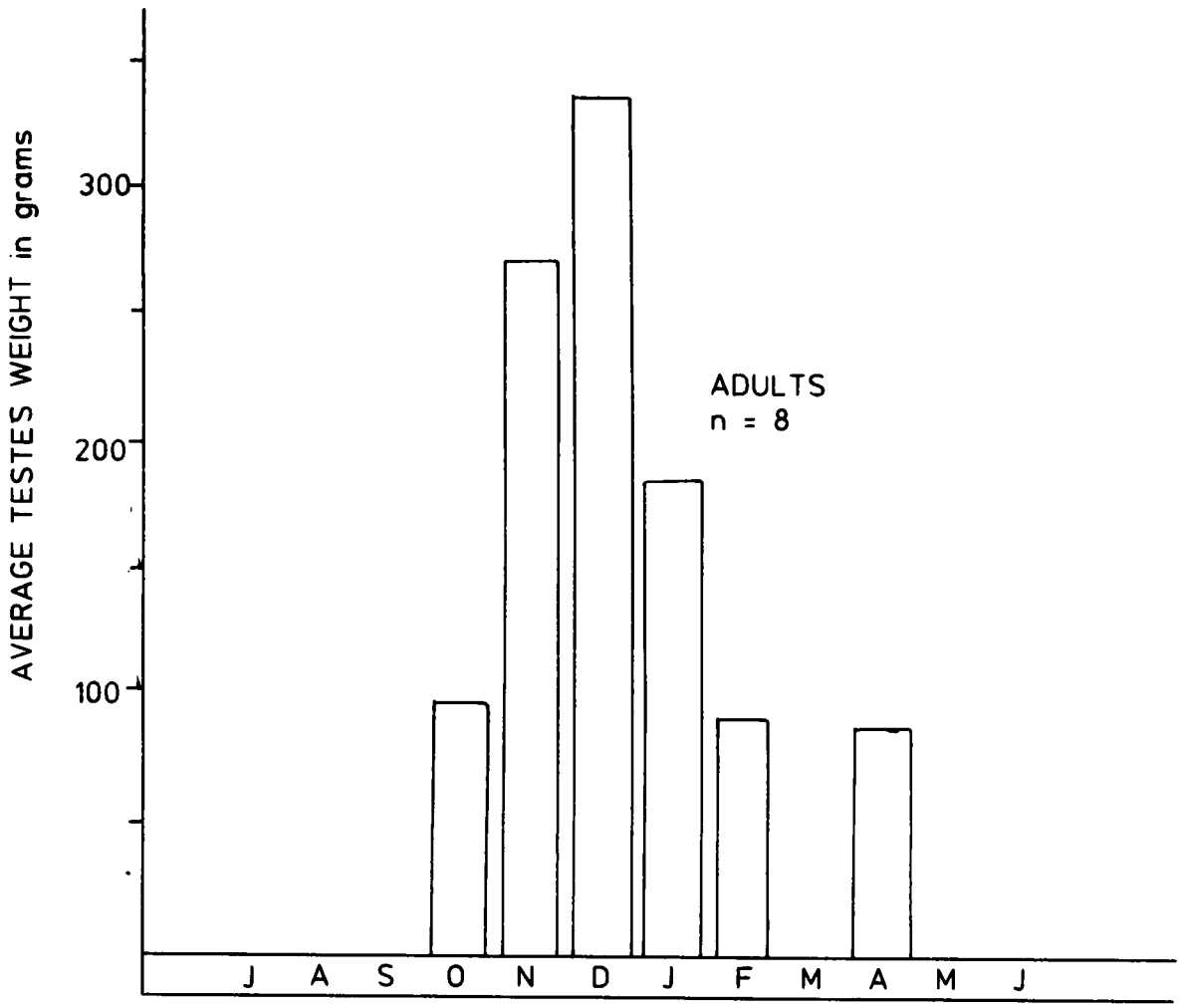

Fig. 4. Monthly variation in mean testis weight for adult *C. commersonii.*

Few data on female sexual status are available. Two pregnant females, (RNP 634 and RNP 1136), were aged eight and thirteen years respectively. These females were also physically mature (all vertebral epiphyses fused); RNP 634 found on 12 December 1977, length 145.5 cm; RNP 1136 on 19 January 1984, but the carcase was rotten and total length was greatly in excess of 120.4 cm. RNP 1041, a 127.6 cm female, examined on 19 December 1982, aged 9 years, was found to be lactating. Data together with age and length are presented in Table 2.

Table 2

Female specimens of *C. commersonii* for which ovaries were examined.

RNP no.	Body length (cm)	Age (years)	Ovary information	Sexual status
633	108	0	No corpora	Immature
1033	117.5	3	No corpora	Immature
1034	125.5	4	No corpora	Immature
1049	128.6	8	No corpora; many follicles	Pubertal
958	131.5	4	No corpora	Immature
766	132.5	10	No corpora, but material incomplete	?
1039	145.2	18	2 CA; many follicles	Mature, anoestrous
634	145.5	8	1 CL + 11 CA	Pregnant

The results suggest that females of 4 years and less are immature, but those 8 years and over are mature or maturing. The *corpus luteum* (CL) of RNP 634 occupied the whole left ovary, and measured 33 × 30 × 21 mm; the largest *corpus albicans* (CA) in the right ovary measured 12 × 11 mm in section, and the remaining 10 CAs in this ovary were mostly within a narrow smaller size range, indicating a probable similar history or terminal stages of regression. Follicles in RNP 1039 were numerous and the largest was 9 mm in diameter. RNP 1049 had a largest follicle diameter of 6 mm. The only females examined which were fully physically mature (fused epiphyses) were nos 634, 766 and 1039. The ovary weights of the mature females were 14.8 g and 5.1 g (RNP 634) and 5.3 g and 1.75 g (RNP 1039), the heaviest ovary containing the CL. The immature ovaries were about 0.35 g, but those of the pubertal female (RNP 1049) weighed 2.5 g and 0.8 g.

The male foetus of RNP 634 (145.5 cm), was term, the mother being in labour on the beach, but drowning in a pool before delivery. It was 73.4 cm in length – about 51% of the mother's body length. All first – year individuals, excluding the neonate, fall into the size range 92 – 112 cm and second – year individuals into the size range 99 – 117 cm. Data are sparse, yet females are largest at any particular time.

Fig. 5 shows the length by month of death for first and second year animals. The wide scatter of sizes within a small time period, particularly in the zero – age group where the foetus has also been included, possibly indicates a protracted calving season with births occuring as early as the start of spring and as late as the end of summer. Birth size must be ca 75 cm or more. Because data in Fig. 5 tend to be concentrated around the summer periods, the gaps in sampling do not rule out births at other times of year. Individual growth during the first year

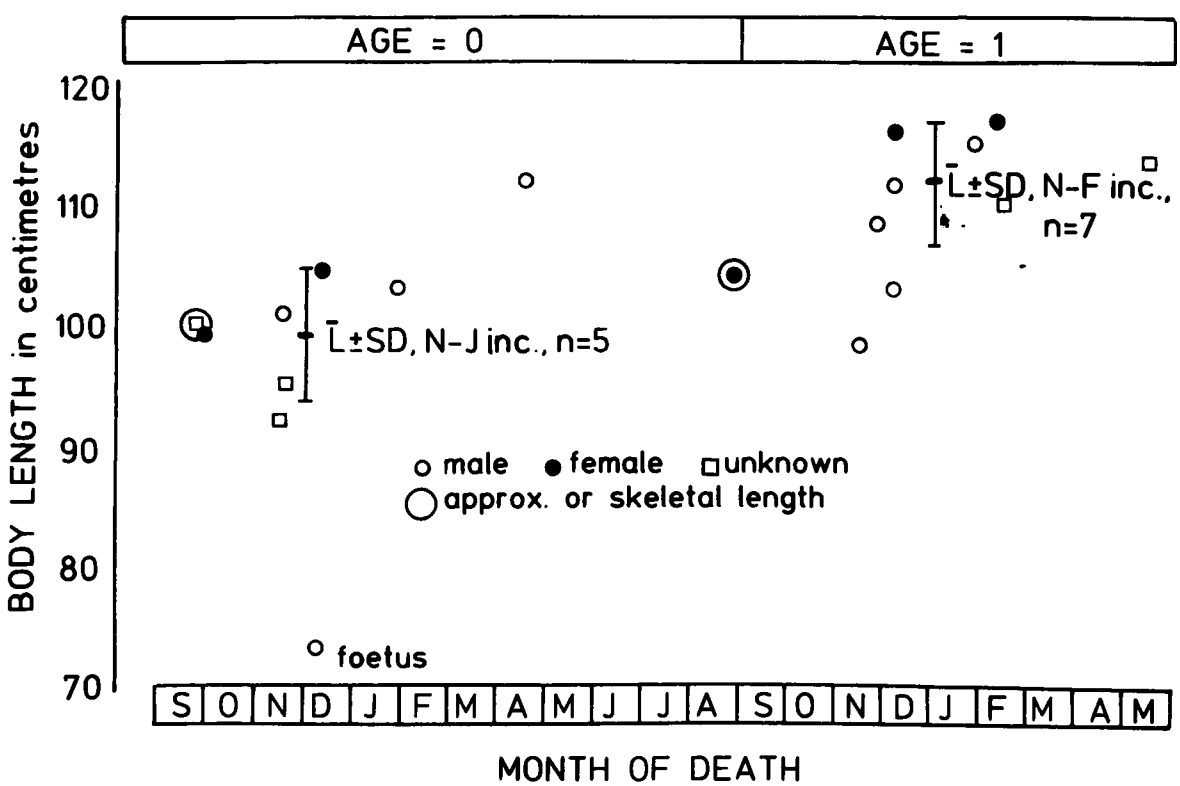

Fig. 5. Length by month of death for first and second year individuals of *C. commersonii*.

thus cannot be predicted. Considering only the animals sampled within a narrow time period from November to February inclusive, mean body lengths in the first and second year groups are 99.1 ± 2.4 cm (SE) and 111.7 ± 1.9 cm (SE) respectively.

Estimating age and length at physical maturity

Ankylosis (fusion) occurred progressively from both anterior and posterior regions of the vertebral column towards the middle, as observed for large Cetacea (Flower, 1864; Wheeler, 1930); the last epiphyses to fuse being the thoracic and some lumbar ones. Fig. 6 shows the progression of fusion with age in both sexes combined. Variation in vertebral number was slight (64–66), and differences, where present, occurred in the caudal region.

It is evident that some epiphyses start to fuse from age two years and continue up to age 11 years. By 6 years, there are no individuals without some fused epiphyses, and by 12 years all animals have total fusion; some individuals of four years have completely fused epiphyses.

Table 3 shows that fusion does not commence until the animal is over 110 cm (113 cm in males, 117 cm in females, from our records) and total fusion does not occur until body length exceeds 125 cm.

Body weight

Body weights were available for fourteen animals listed in Table 4. Adult males average 32–36 kg, but weigh up to about 40 kg, whilst the adult female, because

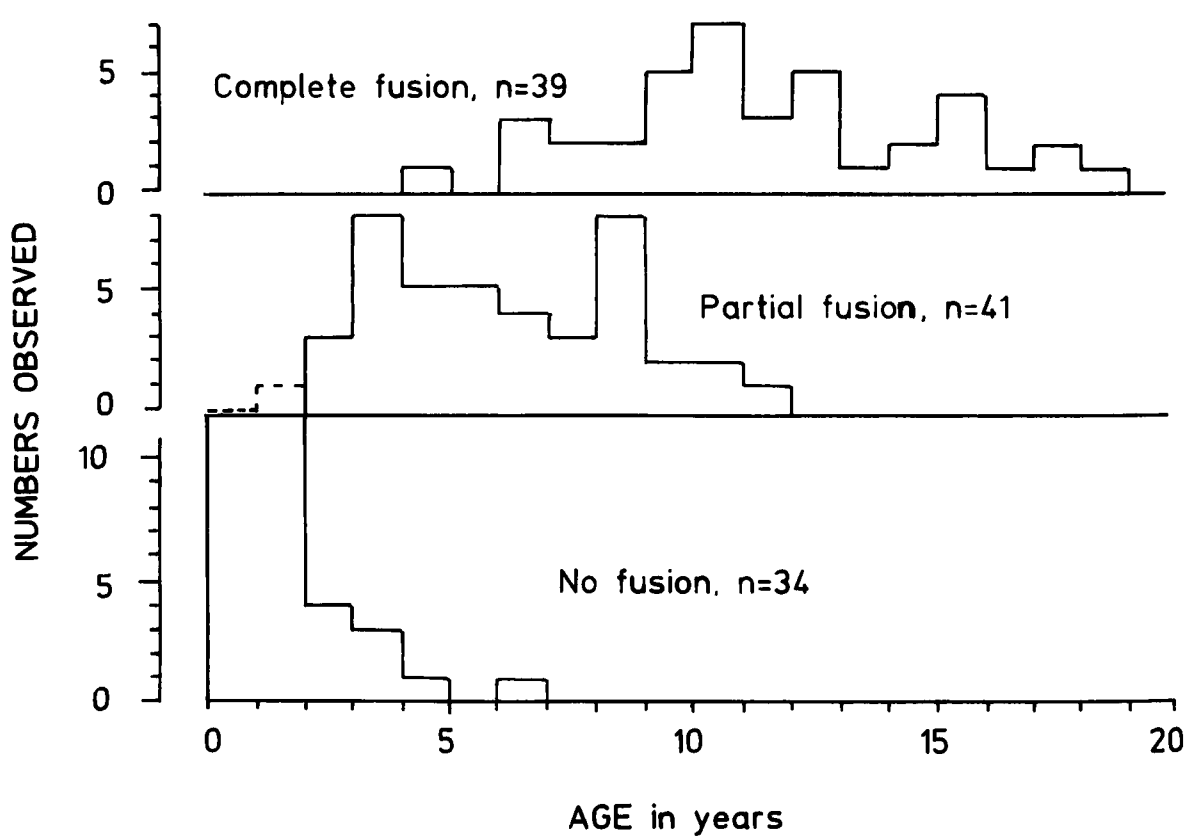

Fig. 6. Progression by age, of ankylosis of the vertebral epiphyses in *C. commersonii*.

Table 3

Ankylosis of vertebral epiphyses with body length.

Body length (cm)	No fusion			Partial fusion			Complete fusion		
	Male	Female	Unknown	Male	Female	Unknown	Male	Female	Unknown
90	-	-	-	-	-	-	-	-	-
90 - 94	-	-	1	-	-	-	-	-	-
95 - 99	1	1	2	-	-	-	-	-	-
100 - 104	3	2	3	-	-	-	-	-	-
105 - 109	2	-	-	-	-	-	-	-	-
110 - 114	4	-	3	1	-	-	-	-	-
115 - 119	2	2	-	4	1	-	-	-	-
120 - 124	-	-	-	1	-	2	-	-	-
125 - 129	-	-	-	4	2	5	9	2	4
130 - 134	-	-	-	5	4	-	6	2	1
135 - 139	-	-	-	-	-	4	4	2	1
140 - 144	-	-	-	-	-	1	-	-	-
145 - 149	-	-	-	-	-	-	-	2	-
Total	12	5 (26)	9	14	7 (33)	12	19	8 (33)	6

Table 4

Body weights for individual *C. commersonii*.
The weight/length formula used, where W = weight in kg and L = length in cm, is:
$W = 0.0000365\ L^{2.835}$

RNP no.	Date died	Sex	Length (cm)	Weight (kg)	Fresh gonad weight (g) Left	Fresh gonad weight (g) Right	Age
635	12.12.77	Male	73.4	7.3			Foetus (near-term)
773	25.01.80	Male	103.0	20.0	5	2	0
1107	07.01.84	Male	111.5	23.5	No measurement		No observation
1054	16.01.83	Male	119.6	26.0	ca 15 (11)	20 (12)	5
620	11.12.77	Male	127.0	37.0	470 (433)	460 (421)	7
619	8.12.77	Male	128.0	32.3	No measurement		6
837	25.10.80	Male	128.0	35.0	130 (109)	125 (90)	15
595	21.11.77	Male	129.0	30.0	300 (286)	300 (267)	9
731	4.01.79	Male	129.8	ca 40.0	190	185	6
637	18.12.77	Male	130.2	35.0	270 (260)	290 (273)	15
1059	23.02.83	Male	131.0	27.0[1]	50 (13)	50 (12)	5
636	18.12.77	Male	136.0	42.0	350 (329)	350 (323)	12
634	12.12.77	Female	145.5	66.0	(14.8)	(5.1)	8[2]
BMNH*	10.01.32	Female	[147.3]	50.0			No observation

* Rayner (in Brown, 1988) [1] estimated 37 [2] pregnant

of her larger size, will greatly exceed this, especially during pregnancy when one individual was recorded at 66 kg. If length at birth is *ca* 75 cm, we might anticipate a birth weight of about 7.5 kg, (the foetus of RNP 634 weighed 7.3 kg), as indicated from the term foetal weight and a weight/length relationship determined by logarithmic regression analysis (Table 4). Similarly, yearling animals between about 100–115 cm length might weigh about 21 kg.

Age distribution, and survival rate

Age data are available for 136 of the 139 animals (23 females, 48 males and 65 unknown sex). It has been assumed that net–capture is essentially a random event for all ages, although twice as many males as females were identified, suggesting that males are more vulnerable. The difference in sample size between the sexes where males outnumber females by a factor of two, hints at dissimilar mortality rates, perhaps partly caused by sexual segregation. Although the sex ratio difference in the sample is significant at $p<0.01$ (χ^2 –test), the sample sizes are small and the sex ratio in the unknown component (nearly equivalent in number to the combined sex sample size), if known, might restore the overall sex ratio balance. However Ralls *et al.* (1980) have shown that in sexually dimorphic species differential mortalities may exist. Fig. 7 is not very helpful in distinguishing age-specific mortality in males and females, in that the age frequency distribution in either sex has no clear trend, other than a sudden fall in numbers of old animals. Owing to the practical difficulties of analysing small sample sizes, we have opted to combine both sexes with the unknown component. The combination age distribution of both sexes and unknown sex for a total of 136 individuals shows a gradual fall off in age groups from birth. First and second year individuals comprise 23% of the total. Even here though, there is a dip in frequency of the 5–8 years age group (the period of sexual maturation) suggesting age-related segregation or differential capture. This distribution, apart from representing a small sample of the population, is possibly biased by the inclusion of several seasons where different factors influencing capture and stranding may have prevailed, and also by the narrow seasonal range of sampling chiefly confined to spring and summer.

Despite these problems, some idea of survival rate(s) for this species is of interest and estimates using the method of Chapman and Robson (1960) are shown below:

(1) age groups 0–18 (n=136), $s = 0.855 \pm 0.011$ (SD); (2) age groups 1–18 (n=121), $s = 0.869 \pm 0.011$ (SD); (3) age groups 5–18 (it was noted earlier that growth rate slowed markedly at age five years which might indicate sexual maturity; n=72), $s = 0.914 \pm 0.010$ (SD); (4) age group 0–5 (n=69), $s = 0.673 \pm 0.033$ (SD).

Clearly, survival is highest in the adult component of the population, and by inference, mortality is highest in juveniles.

Length distribution

Fig. 8 shows the length frequency distribution of 97 of the 139 animals (22 females, 48 males and 27 of unidentified sex). The modal peak for males is 125–130 cm, lower than that of females, 130–135 cm. These peaks correspond with the mean adult size noted in Fig. 2 earlier.

DISCUSSION

The key problem in age determination is the assessment of accumulation rate of dentinal laminae. In common with *Tursiops truncatus* (Sergeant, 1959),

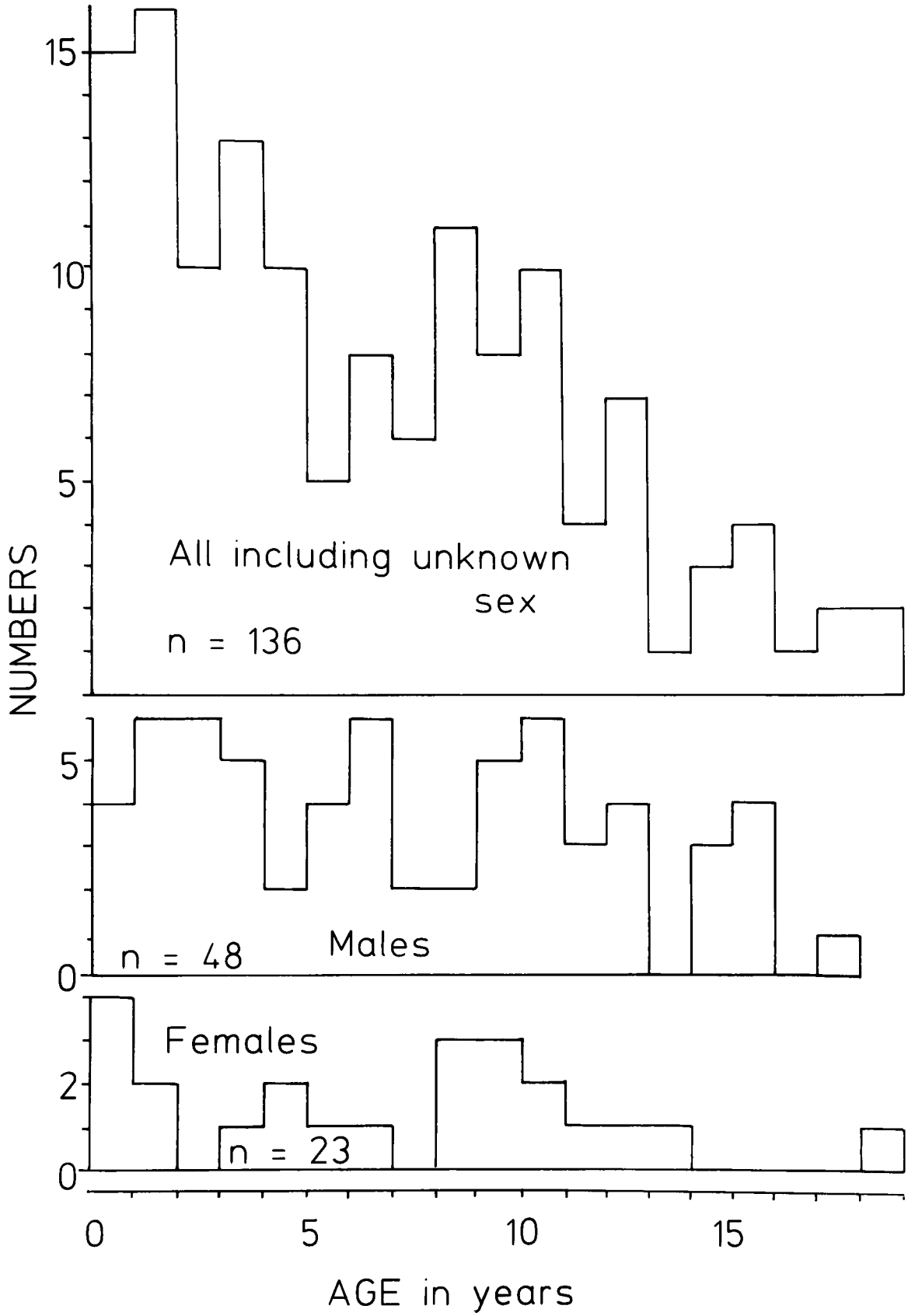

Fig. 7. Age frequency distribution of incidentally net–caught *C. commersonii*.

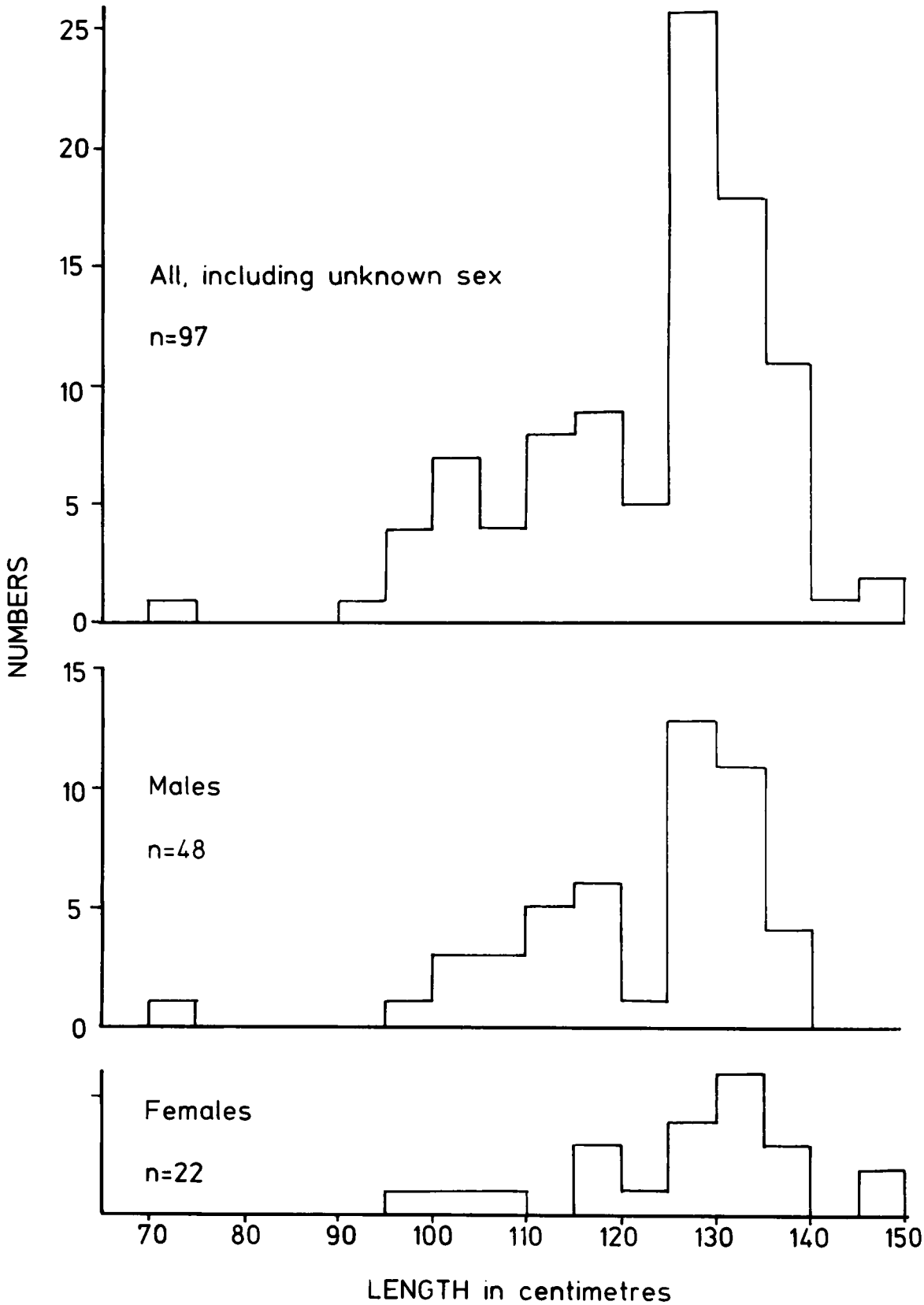

Fig. 8. Length frequency distribution of incidentally net–caught *C. commersonii*.

Globicephala melaena (Sergeant, 1962), *Stenella attenuata* (Kasuya, Miyazaki and Dawbin, 1974) and *S. coeruleoalba* (Kasuya, 1972; Miyazaki, 1977), the darkly–staining lamina seems to be predominantly at the pulp cavity edge in spring–summer for *C. commersonii*. Whilst tooth shape differs in phocoenids, there are numerous similarities between *C. commersonii* and *Phocoena phocoena*, especially in overall body size, form and anatomy, and coastal life–style. There is evidence from known– age, captive *P. phocoena* to validate the correlation of one growth layer group (one pale and one darkly–staining lamina) forming annually, at least in juveniles (Grue, reported in Perrin and Myrick, 1980, pp.38–9). Gaskin *et al.* (1984) concluded that two laminae form annually.

The life span of *C. commersonii* is rather similar to that of *P. phocoena*, where maximum ages are 12–13 years, perhaps even 15 years, and *Phocoenoides dalli* where maximum age is 16–18 years (Gaskin *et al.*, 1984). The age at sexual maturity in *P. phocoena* ranges from 3–6 years, depending on locality (Gaskin *et al.*, 1984), also close to estimates for *C. commersonii*.

Amongst our sample of females, for which ovaries were collected, was an 8 year animal with a total of 12 corpora. The fact that 10 of these were at a similar stage of regression tends to support a theory of simultaneous multiple ovulation, similar to that observed in *P. phocoena* by Gaskin *et al.* (1984) for females aged only 4 and 5 years. The mean diameter of the active CL found in the 8 year old pregnant female was larger at 28 mm than the largest CL recorded for *P. dalli* and *P. phocoena* (Gaskin *et al.*, 1984).

Seasonality in breeding and parturition has been found for all delphinids studied (Perrin and Reilly, 1984), suggesting that with more material available from all months of the year, *C. commersonii* may indeed be found to have a spring peak in calving. Gaskin *et al.* (1984) reviews data on reproductive parameters for phocoenids and the gestation period is generally 11 months or less. If this was the case for *C. commersonii*, the presence of sperm and testicular hypertrophy observed in late spring– summer (albeit for a few specimens) would fit in with a summer mating season.

The likely size at birth (75 cm) in *C. commersonii* is similar to that reported for many *P. phocoena*, ranging from 70–99 cm, according to locality (Gaskin *et al.*, 1984). As the maximum size of female *P. phocoena* is between 164 and 189 cm, the foetal length ratio to the mother is large, *ca* 43–52%, like that in *C. commersonii*.

There are few actual data on vertebral epiphyseal fusion relating to other cetacean species with a similar life span, which can usefully be used for comparison here. Best (1970) has shown that there is a large difference between sexes in age of attainment of physical maturity in the sexually dimorphic sperm whale, *Physeter macrocephalus*, being 27–35 years in females and 49–53 years in males. The possibility of differential age at physical maturity in *C. commersonii* has to be considered, but cannot be examined here with such few data. The age of commencement of fusion is 18 years in female sperm whales, illustrating a wide span of years of about 17 years between partial and total fusion, whilst the age range in males is very narrow, only *ca* 5 years. The growth pattern which may produce this characteristic, is of course quite different between the sexes in sperm whales. However, it is likely that there may be a wide variation in age of onset of physical maturity.

The problems associated with estimating biological parameters from age and body length distributions and sex ratios have been addressed by Perrin and Reilly (1984) for delphinids. Specifically, they report a progressive fall in the sex ratio (males:females) with age, and also an apparent absence of or under–representation of segments of the population, often the juvenile phase (Sergeant, 1962: Miyazaki and Nishiwaki, 1978). Combination of these factors, together with differential ages at sexual maturity, first parturition and mortality, exacerbate problems of analysis, and limit the usefulness of the data and results of analysis. Sex ratio imbalance (assuming near parity at birth) may be a seasonal occurrence, examples of which are found for *Delphinus delphis* (Kleinenberg, 1956; Tomilin, 1957; Mayarova and Danilevskiy, 1934). This seasonal factor may be important in the apparent sex ratio imbalance in *C. commersonii*, because the specimens examined here were the product of a seasonal fishery, probably operating in only part of the areas frequented by the dolphins.

As Perrin and Reilly (1984) comment, "the implications of age and sexual segregation on estimating delphinid population parameters are profound". We would comment that the estimates of survival rate(s) calculated here must be viewed with caution. The interpolated approximate mortality rate (1 – s) for the 5 – 18 year portion of the sample is 0.086, of a similar value to natural mortality estimates given by Kasuya (1976) for adult male and female *S. attenuata* (0.107; 0.075 respectively) and *S. coeruleoalba* (0.136; 0.118 respectively). The mortality rate for juveniles were also computed for *S. attenuata*, with 0.069 for males and 0.033 for females, less than values for adults, unlike the findings here where 0 – 5 year mortality rate is approximately 0.327, four times higher than for adults. However, the sudden drop in numbers of 5 – 8 year old animals in our sample probably artificially elevates the mortality rate for juveniles, and lowers that for adults.

In conclusion we would comment that this paper reports age and reproductive related parameters for the first time in this population of *C. commersonii* off Tierra del Fuego, and whilst the findings are necessarily of preliminary nature, they may help to identify areas where further information would assist analyses.

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Data on the Genital Tract and Reproduction in Commerson's dolphin, *Cephalorhynchus commersonii* (Lacépède, 1804), from the Kerguelen Islands

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ABSTRACT

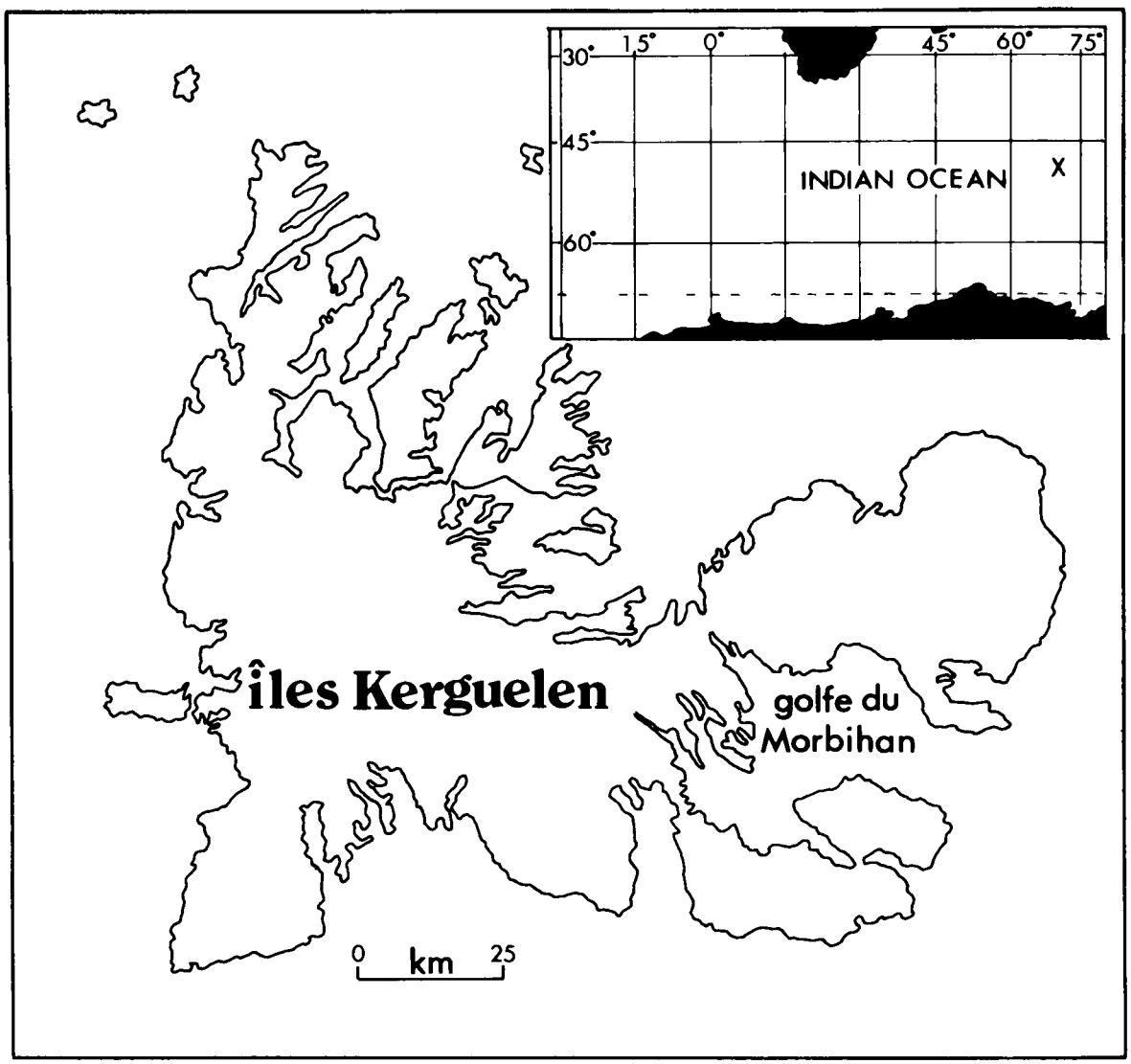
Genital tracts from a small sample of four male and seven female *Cephalorhynchus commersonii*, captured off the Kerguelen Islands are examined and described in terms of morphology and histology. Sexual maturity is probably reached at a body length of 165cm in both sexes, corresponding to ages of about 8 years in males and from about 5 years in females. The limited sample size precludes firm conclusions about the various aspects of reproduction discussed which include seasonality, ovulation and pregnancy. There is evidence of both calving and mating during December and January.

INTRODUCTION

Harrison (1969) observed that almost nothing was then known of the reproduction of several delphinid genera. Eighteen years later this remark is still true for the genus *Cephalorhynchus* which comprises four species distributed in cold and temperate waters of the Southern Hemisphere. With respect to the species *Cephalorhynchus commersonii* (Lacépède, 1804), apart from the studies included in this volume, the literature provides only a few data on pregnancy and breeding period in the coastal waters of South America (Goodall, 1978; Mermoz, 1980) and a description of mating in the Kerguelen Islands (Pascal, 1981). Almost any new data in this field are therefore valuable and our modest sample of eleven individuals captured in January 1983 off the Kerguelen Islands provides the first precise data on the genital tract and reproduction of this species in this area. Morphological data are presented only in as much detail as required to better understand the reproductive process.

Before discussing our results however, some comment on *C. commersonii* from South American and Kerguelen waters should be made. Recent work on this

species (e.g. Robineau, 1984) has revealed that animals from South American waters are demonstrably smaller than those from around the Kerguelen Islands. It is not within the scope of this paper to discuss at what level (e.g. population, sub-species or even species) these differences may be and here we simply note that they exist and thus that data from these two areas can clearly not be pooled.



MATERIAL AND METHODS

As part of a study of Commerson's dolphins from around the Kerguelen Islands, eleven animals were taken opportunistically in January 1983 in the golfe du Morbihan to the southeast of the islands (Map 1, and Robineau and Duhamel, 1984). Table 1 provides information for each individual caught. Each captured specimen was brought back as quickly as possible (usually within about 2–4 hours) to the Marine Biology Laboratory of Port-aux-Français, where the genital tracts were dissected and sampled. All genital tract measurements given in this paper were taken after fixation in 10% formalin.

In females, the mammary glands were dissected and measured, and a sample was taken from the middle of the gland for subsequent histological analysis. After separating the ovaries, the genital tract was removed *in toto*. Several samples were taken from the vagina, the central body and each horn of the uterus

Table 1

Basic data on the specimens taken for this study.

Date of capture	Specimen number	Sex	Total body length (cm)	Weight (kg)	Age (yrs)
06 January 1983	K. 83-01	Female	165.6	66	5
08 January 1983	K. 83-02	Male	166.5	78	9
11 January 1983	K. 83-03	Male	164.3	70	7
16 January 1983	K. 83-04	Female	174.0	74	9
16 January 1983	K. 83-05	Female	165.0	73	6
20 January 1983	K. 83-06	Female	172.2	86	10
24 January 1983	K. 83-07	Female	155.5	68	4
24 January 1983	K. 83-08	Female	167.0	72	7
28 January 1983	K. 83-09	Male	142.6	55	3-4
29 January 1983	K. 83-10	Female	165.0	67	4
31 January 1983	K. 83-11	Male	156.0	58	5

(Fig. 7). These were fixed in Bouin's solution and then 5μ sections were stained by PAS—Groat hematoxylin or hematoxylin and eosin.

Ovaries were fixed in Bouin's solution. When the material had been returned to France, each ovary was weighed, measured and photographed. The corpora lutea and albicantia (CLs and CAs), numbered on the photographs, were measured using slide calipers at their maximum dimensions and then sectioned along these for histological examination. The 5μ and 8μ thick sections were stained with azan or PAS-Groat hematoxylin, sometimes followed by picro-indigo-carmin solution. Corpora, lutealised follicles and Graafian follicles of over an arbitrary 300μ in diameter were measured during the histological analysis using a micrometer.

When considering the measurements of corpora and follicles it should be remembered that measurements taken on the surface of ovaries with a slide caliper are of necessity imprecise as only the external scar and the unclearly defined protrusion can be measured. Measurements taken from histological slides using the microscope micrometer are also inaccurate for two reasons: first, it is impossible to ascertain whether the section was taken exactly along the centre of the corpus; and second, the alcohol and xylene used in slide preparation cause the tissues to shrink by up to one-third.

In males, the testes were weighed and measured after fixation. The entire tract was taken and stored in 10% formalin. Samples were taken from the middle of the testis and epididymis, and after refixing in Bouin's solution, 5μ and 8μ sections were stained using PAS-Groat hematoxylin or trioxyhematein followed by erythrosin-orange or picro-indigo-carmin solution.

The ages of the animals were determined from sections of untreated teeth. A dentinal deposition rate of one growth layer group per year has been assumed (de Buffrénil and Robineau, 1984), following the initial work of Lockyer *et al.* (1981) on South American specimens.

In view of the small sample size, no meaningful statistical analyses could be carried out to test the various suggestions which arose out of a qualitative examination of the data. This should be borne in mind when reading the remainder of the paper — to avoid repetition it has not been stated every time an idea is presented that with a larger sample size, one would normally test statistically.

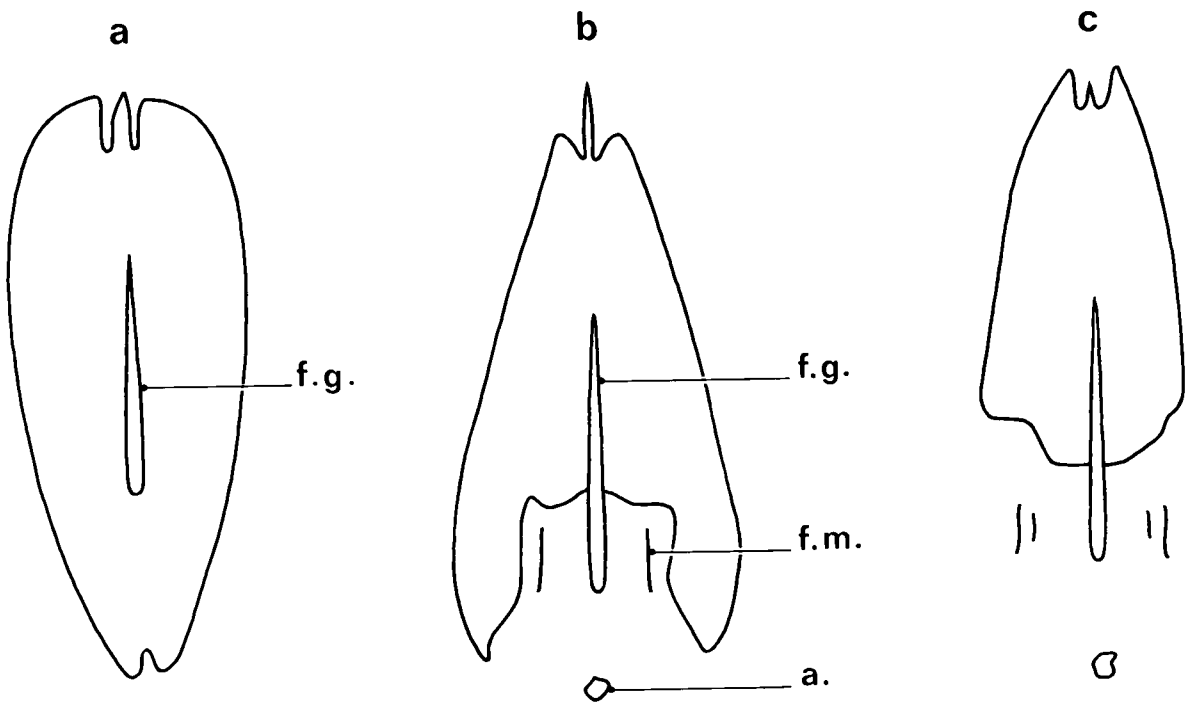


Fig. 1. Genital patch shapes in males (a) and females (b, c). f.g. = genital slit, f.m. = mammary slit, a = anus

RESULTS

Sexual dimorphism

The species appears to exhibit sexual dimorphism. The black patch, which highlights the genital region on the white belly, varies in outline between males and females (Robineau, 1984). It is oval in males and entirely surrounds their penial slit (Fig. 1a), but in females only encircles the anterior half of the vaginal slit and may have two posterior extensions on the outer side of the mammary slits (Fig. 1 b, c). Best (1988) has noticed a similar feature in a small sample (10 males, 8 females) of *C. heavisidii*, where the dentral tongue of the white "trident" found on animals of both sexes encircles the genital slit in males but terminates more abruptly in females.

Table 2

Position of the anus and genital slit, and dimensions and shape of the genital patch. Specimen numbers all 'K. 83–'. TBL = total body length.

				Distances				Genital patch		
				From umbilicus to genital slit		From genital slit to anus				
Specimen number	Sex	Total body length (cm)	Age (yrs)	(mm)	(%TLB)	(mm)	(%TLB)	Length (mm)	Width (mm)	Type
09	Male	142.6	3–4	188	13.2	132	9.2	223	100	(a)
11	Male	156.0	5	249	14.0	153	9.8	250	95	(a)
03	Male	164.3	7	152	9.2	229	13.9	245	107	(a)
02	Male	166.5	9	187	11.2	201	12.0	266	106	(a)
07	Female	155.5	4	301	19.3	62	3.9	213	95	(b)
10	Female	165.0	4	345	20.9	67	4.0	216	120	(b)
01	Female	165.6	5	317	19.1	63	3.8	135	–	(c)
05	Female	165.0	6	338	20.4	59	3.5	108	54	(c)
08	Female	167.0	7	362	21.6	48	2.8	225	–	(b)
04	Female	174.0	9	359	20.6	71	4.0	215	–	(b)
06	Female	172.2	10	360	20.9	65	3.7	185	50	(c)

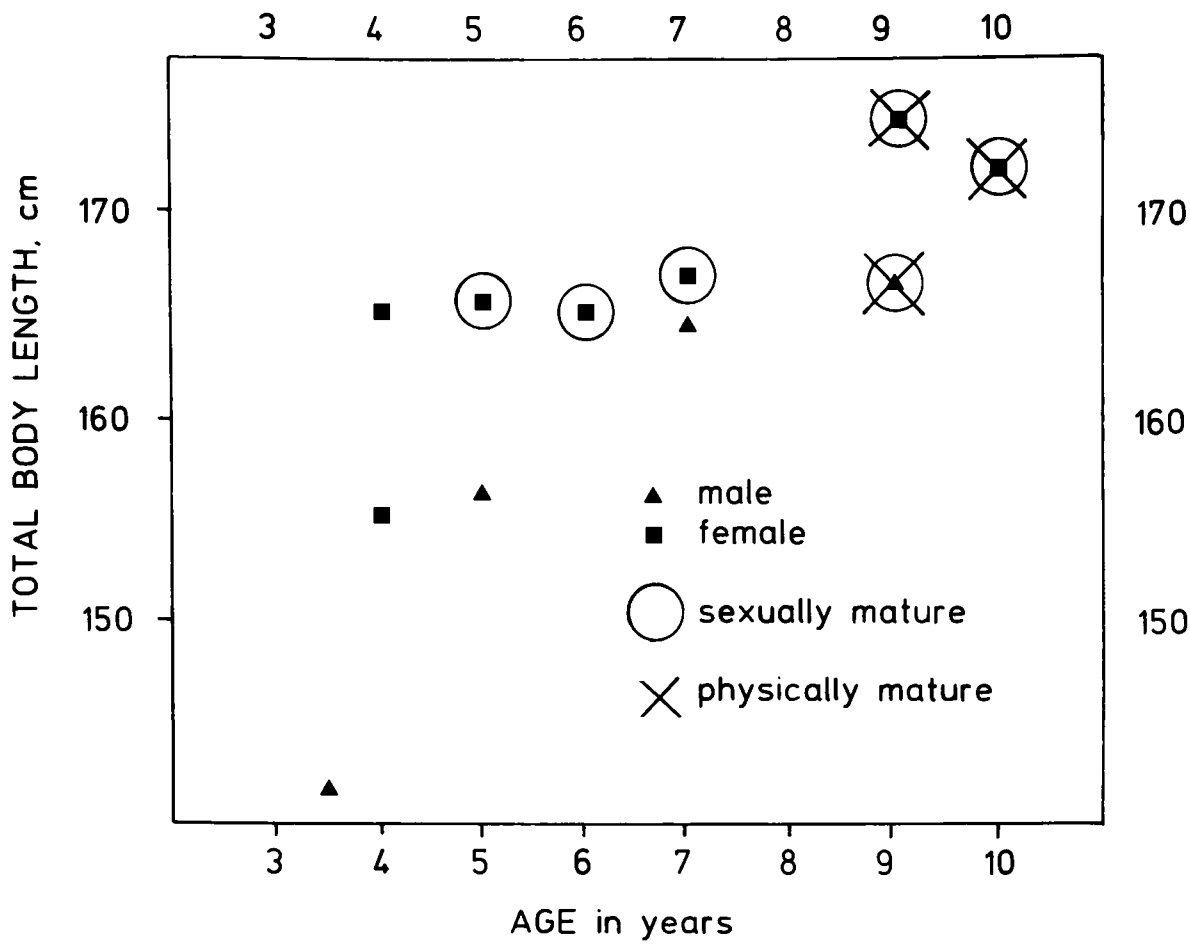


Fig. 2. Relationship between age and body length. State of physical and sexual maturity indicated

Table 2 provides the genital patch measurements for each specimen, as well as actual and proportional umbilicus to genital slit and genital slit to anus measurements. While these proportions appear stable for the females, the albeit limited data for males suggests that in relative terms the penial aperture moves forward during growth. This may be associated with sexual maturation, and in particular the increasing size of the penis.

Our sample also reveals females to be larger than males for a given age, in both total body length (Fig. 2) and cranial length (Robineau and de Buffrénil, 1985), which suggests the existence of sexual dimorphism in terms of body length for this species. This was also found for a larger sample (22 females and 46 males) of *C. commersonii* from a different area (Lockyer, Goodall and Galeazzi, 1988).

Finally, sexual dimorphism in terms of pelvic bone size might be suspected in sexually mature specimens (Table 3 and Fig. 3), as has been found in other small delphinids (notably *Delphinus delphis*, Collet, 1982).

Morphology of the male genital tract

Penis

The penial sinus occurs in about the middle of the genital slit (~10cm long). The shape of the sinus follows that of the anterior part of the penis, the pars

Table 3

Pelvic bone measurements. Specimen numbers all 'K. 83–'

Specimen number	Sex	State	Body length (cm)	Age (years)	Length of pelvic bones (cm) Right	Left	Mean
09	Male	Immature	142.6	3–4	5.5	5.4	5.45
11	Male	Immature	156.0	5	5.4	5.3	5.35
03	Male	Pre-pubertal	164.3	7	5.9	6.3	6.10
02	Male	Mature	166.5	9	7.9	7.7	7.80
07	Female	Immature	155.5	4	5.0	5.3	5.15
10	Female	Pre-pubertal	165.0	4	5.1	5.1	5.10
01	Female	Mature	165.6	5	4.7	5.3	5.00
05	Female	Mature	165.0	6	6.5	6.2	6.35
08	Female	Mature	167.0	7	5.5	5.9	5.70
04	Female	Mature	174.0	9	5.8	5.5	5.65
06	Female	Mature	172.2	10	5.3	5.3	5.30

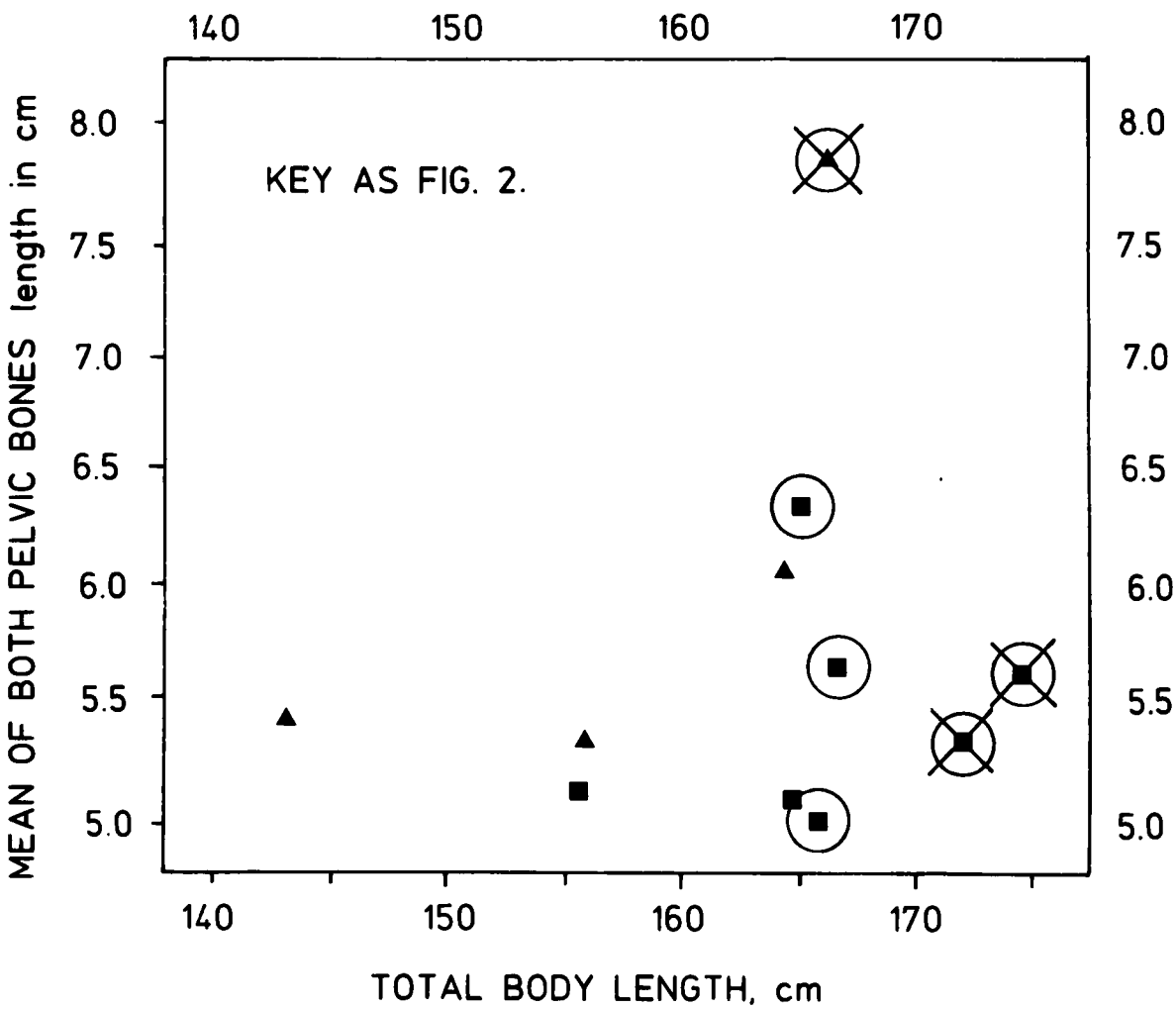


Fig. 3. Relationship between body length and mean pelvic bone length. State of physical and sexual maturity indicated

intrapraeputialis (glans penis or terminal cone), and thus is directed backwards, slightly upwards and to the right. The cutaneous covering lining the slit and then the penial sinus curls back on the pars intrapraeputialis base to constitute its envelope, the prepuce. The proximal half of the pars intrapraeputialis has an area of circular folds which smooth out on erection (Fig. 4). Beyond this almost

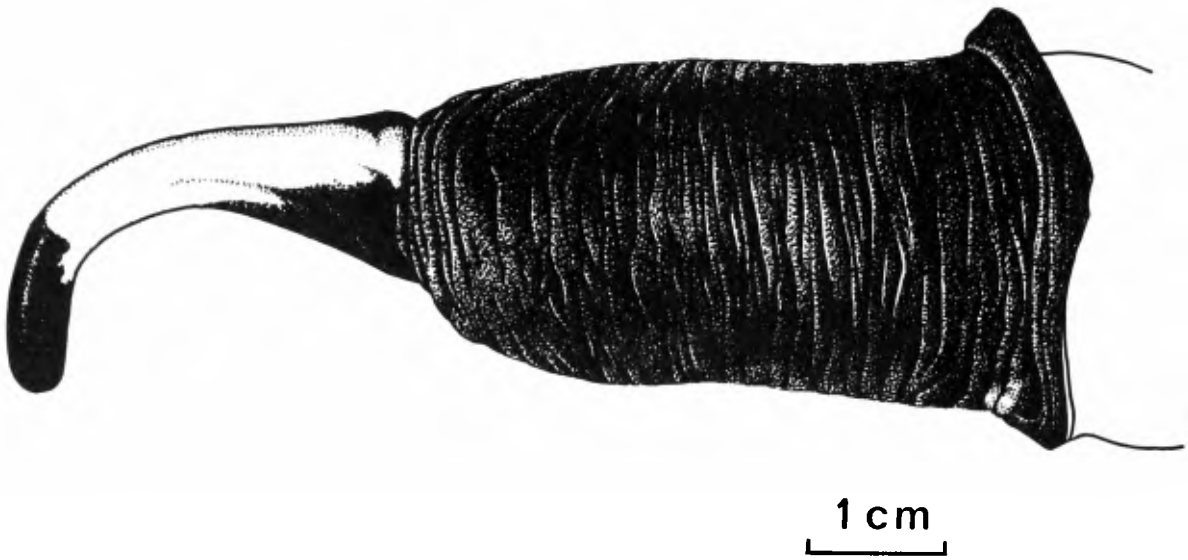


Fig. 4. The penis (pars intrapraeputialis) of a mature male

cylindrical proximal half (2–4cm in diameter) it changes abruptly to a much thinner anterior part (Fig. 4), offset on the right relative to the posterior one (Fig. 5a, b). The urino-genital meatus forms a 1.5 to 2 mm long vertical slit at the tip of the penis. When the penis is retracted, the whole pars intrapraeputialis is directed forwards, slightly downwards and to the left. Its cutaneous covering is black with irregular white patches (Fig. 4) but the penial sinus and slit appear entirely black.

Inside the abdominal cavity, the penis is wound on itself counter–clockwise, and forms a complete spiral loop (Fig. 5) before dividing into two crura. The retractor penis muscles are ventrally inserted just proximal to the pars intrapraeputialis and posteriorly fastened around the rectal duct (Fig. 5a). At the anterior, this muscle comprises two distinct muscles which then unite, the left over and further forward than the right (Fig. 5a). This suggests that the retracted pars intrapraeputialis somehow twists on its longitudinal axis. This torsion is probably cancelled out during erection such that the tapered anterior half is dorsally offset relative to the posterior half.

The shape of the pars intrapraeputialis resembles that of the common porpoise (*Phocoena phocoena*) as described by Bouvier (1889, Fig.6) and Slijper (1966, Fig. 3), but is radically different to the flattened cone of a spotted dolphin *Stenella frontalis* (Matthews, 1950, Fig. 13) or bottlenose dolphin, *Tursiops truncatus* (Green, 1972, Fig. 4–14).

Table 4 provides several measurements of the penis and its retractor muscle. The total penis length has been estimated by summing the lengths of the pars intrapraeputialis (assuming the tapered anterior part to be linear) and the intra-abdominal loop, and taking the junction with the two crura as the base of the penis. The depth of the penial sinus was measured between the aperture of the penial slit and the preputial cul–de–sac. Each of the measurements is noticeably greater in the mature specimen (no.2), in particular the penis basis muscles (*compressor prostatae* and *ischiocavernosus*, Fig. 5) and the pelvic bones (Table 3 and Fig. 3).

During erection, the straightening of the penial loop allows the penis to

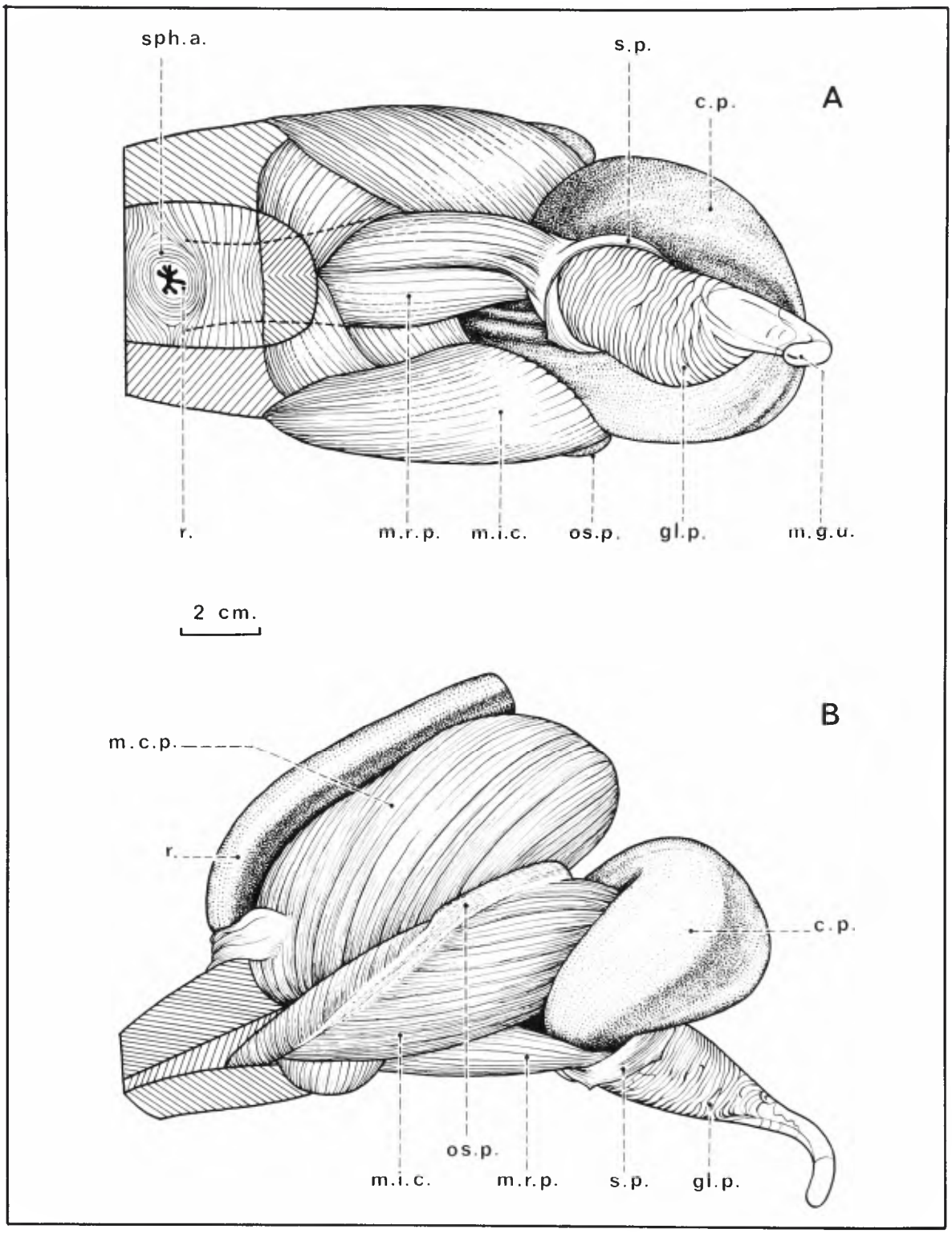


Fig. 5. The penis and its associated musculature. a: ventral view, b: right lateral view. c.p. = penial loop; gl.p. = pars intrapraeputialis; m.c.p. = prostate compressor muscle; m.g.u. = urinogenital meatus; m.i.c. = ischiocavernosus muscle; m.r.p. = penis retractor muscle; os.p. = pelvic bone; r = rectum; s.p. = penial sinus; sph.a. = anal sphincter

protrude about the length of the pars intrapraeputialis out of the penial aperture. It is also possible that despite its fibrous structure, the penial coat (*tunica albuginea*), can stretch sufficiently to allow a greater protrusion. The penis retractor muscle has a mainly elastic fibrous structure which enables it to double in length during erection.

Table 4
Penis and associated muscle measurements. All measurements in cm.
Specimen numbers all 'K. 83–'.

Specimen number:-	09	11	03	02
Age in years:-	3–4	5	7	9
Penis, total length	19.2	19.4	20.0	24.5
Penial sinus, depth along axis of penis	–	8.8	8.7	10.9
Pars intrapraeputialis, total length	7.2	7.4	8.0	9.5
length of tapered end	3.0	3.4	4.0	4.6
diameter at base	1.7	2.1	2.5	2.6
Penis, diameter at base	2.3	2.5	3.3	4.2
Penial loop, transverse diameter	4.5	5.2	6.3	7.7
Penial retractor muscle, length	6.7	7.0	7.1	8.8
maximum width	1.3	1.8	1.8	2.8

Table 5
Testis, seminiferous tubule (st) and epididymis (ep) measurements.
Specimen numbers all 'K. 83–'.

Specimen number	Testis length (cm)		Testis width (cm)		Testis weight (g)		Mean diameter (μ)	
	Right	Left	Right	Left	Right	Left	st	ep.
09	6.5	5.5	1.6	1.3	11	11	50	800
11	6.0	6.5	1.6	1.5	12	12	60	750
03	12.0	13.0	3.3	4.5	110	120	120	1,000
02	21.3	21.2	7.4	6.6	615	605	250	1,400

Testis

The testes and epidydimis (Plate IA and Fig. 6) are similar in shape and structure to those of other dolphins. The lengths and weights of each testis, and the mean diameters of the seminiferous tubules and epididymis are presented in Table 5. The results for the two immature animals (nos 9 and 11) are almost identical. The dimensions are slightly larger in animal no.3 and are dramatically larger in the sexually mature specimen, no.2 (see below).

Histological examination of the testes

Histological examination of the testes of the four males identified three stages of sexual maturation.

Immature (specimens 9 *and* 11)

Characterised by:
(1) the narrow (50 – 60μ diameter) seminiferous tubules which had no lumen and included only two cell types (spermatogonia and the more numerous Sertoli cells, plate IB), and the relatively abundant interstitial tissue with rather poorly developed Leydig cells;
(2) the lumen of the epididymis (~ 800 μ in diameter) which appeared empty and had a thin, coiled, epithelium (20 to 30 μ).

*Mature (specimen no.*2)

Characterised by:
(1) very elongated, wide (often up to 300μ in diameter) seminiferous tubules.
(2) the presence of all stages of maturing germinal cells, from relatively scarce

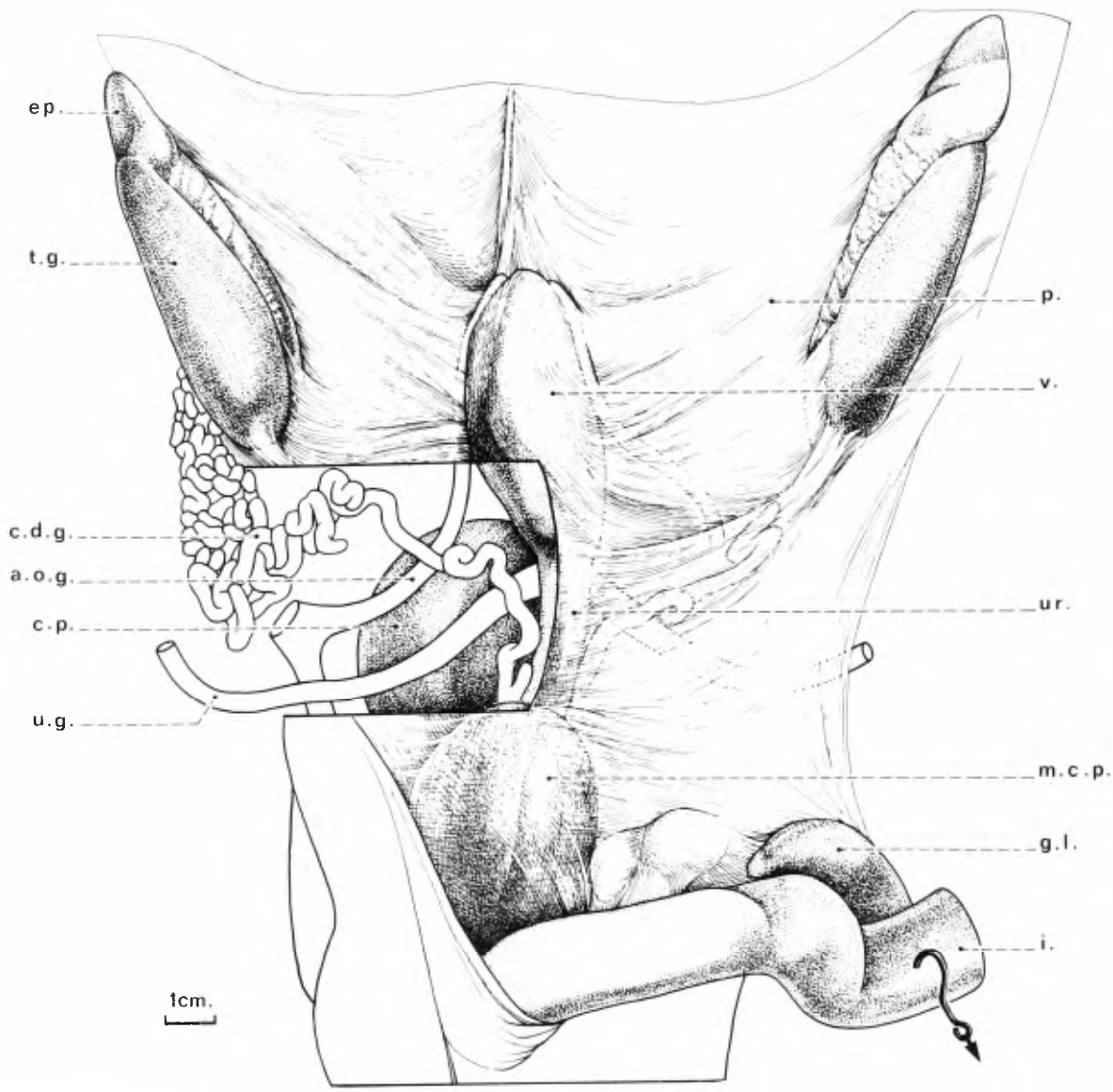


Fig. 6. Male urino-genital tract (animal no. 11, immature) cut away *in toto*, dorsal view. a.o.g. = left umbilical artery; c.d.g. = ductus deferens; c.p. = penial loop, proximal limb; ep. = epididymis; g.l. = lymph node; i. = terminal part of intestine; m.c.p. = prostate compressor muscle; p. = peritoneum; t.g. = left testis; u.g. = left ureter; ur. = urethra; v. = bladder.

spermatogonia to spermatozoa accumulated in a large lumen, which often comprised 50% of the tubule section (plate ID).
(3) the presence of sperm in the epididymis (also noted in the post—mortem examination); its very sinuous epithelium appeared to be in a secretory phase and its lumen (about 1,400μ in diameter) contained large numbers of spermatozoa (plate IE).

Prepubescent (*specimen no.* 3)

Characterised by its intermediate level of development.

The mean diameter of the more elongated seminiferous tubules was 120μ. While some tubules had no lumen and only spermatogonia and Sertoli cells, others had a lumen and numerous primary and secondary spermatocytes. In a few areas, some early spermatids had aggregated around the lumen, which represented up to 10% of the tubule in section (plate IC). The epithelium of the epididymis (mean

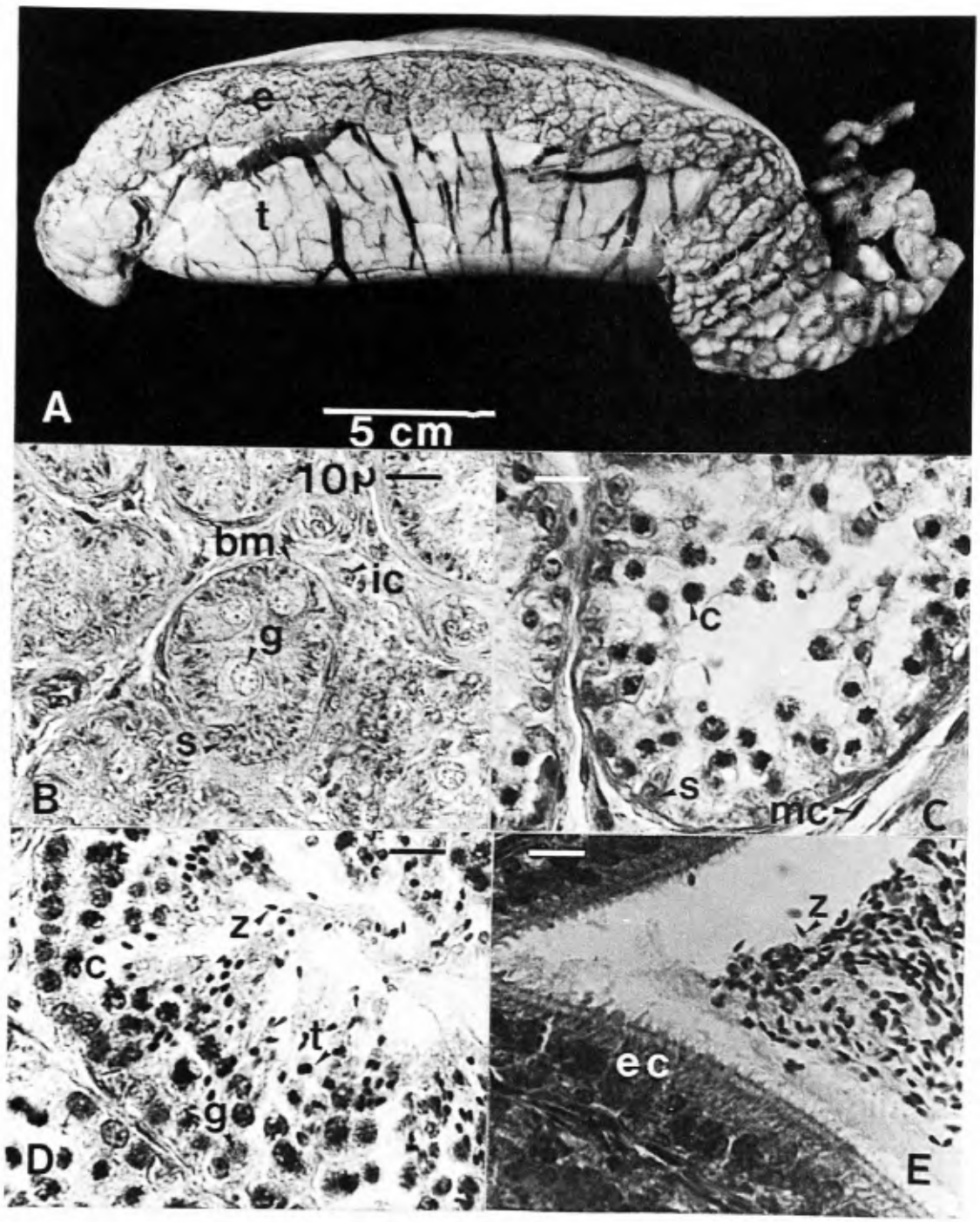


Plate I

A: testis (t) and epididymis (e) of a mature male (no.2)

B: seminiferous tubules of an immature male (no.9). bm = basement membrane of the tubule, g = spermatogonia, ic = interstitial cell, s = Sertoli cell

C: part of a seminiferous tubule of male no.3, probably pre-pubescent. c = spermatocyte, mc = myoid cell [fibrocyte?], s = Sertoli cell

D: part of a seminiferous tubule of an active mature male (no.2). c = spermatocyte, g = spermatogonia, t = spermatid, z = spermatozoa.

E: epididymis of male no.2 showing many spermatozoa (z). ec = epithelial cell

diameter of 1,000μ) formed loose folds lining a large lumen in which there were only a few cell remnants and some secretory products. This spermatogenesis suggests a prepubescent gonad but also occurs at the beginning or the end of sexual activity in mature individuals.

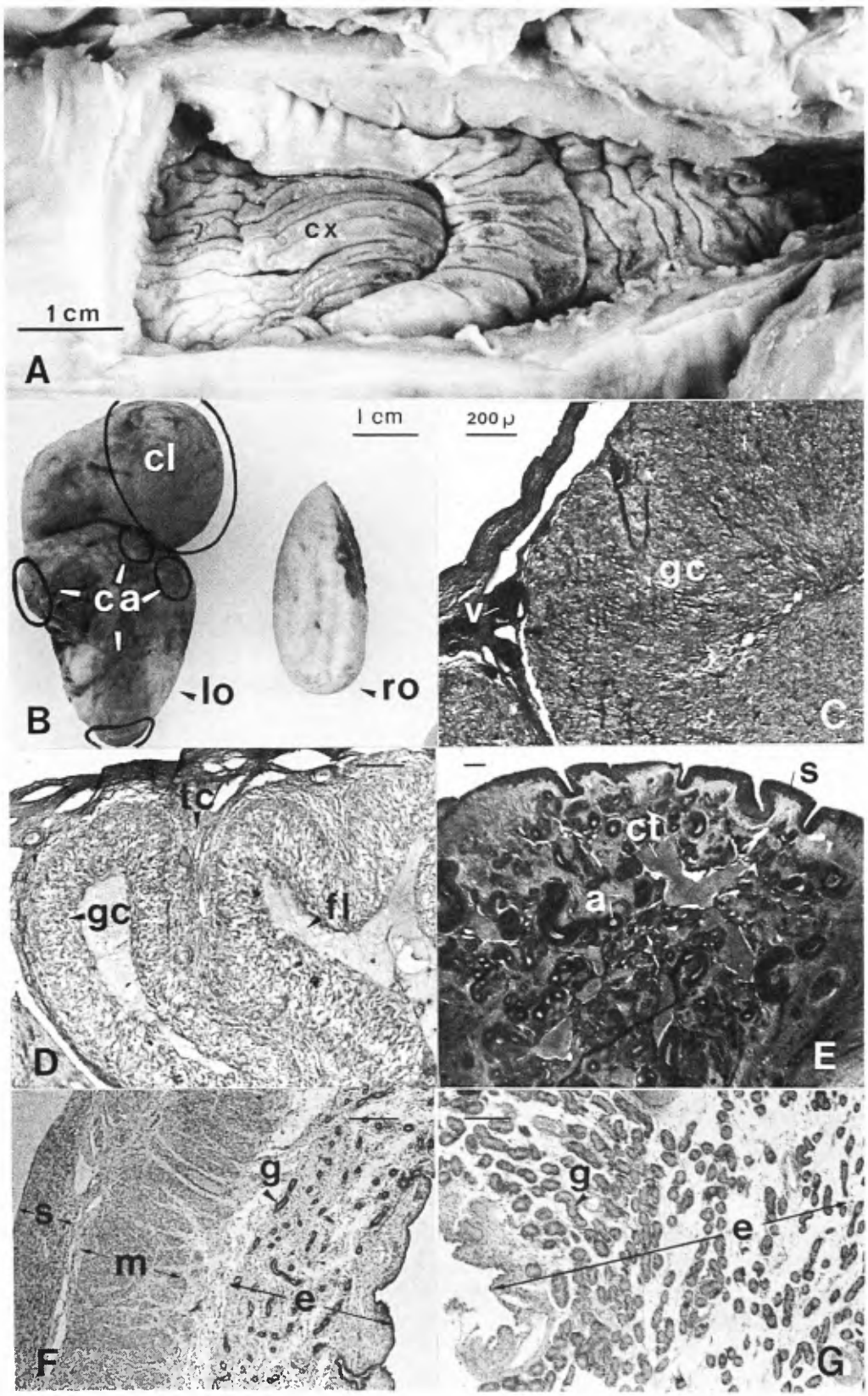


Plate II

A: cervix (cx) of female no.8. The ventral wall of the vagina has been cut away.

B: left (lo) and right (ro) ovaries of female no.4. ca = corpus albicans and cl = corpus luteum

C: corpus luteum from the left ovary of female no.4. gc = granulosa cells, v = vessel

D: lutealised follicle in the right ovary of female no.1. fl = follicular liquid, gc = lutealising granulosa cells, tc = theca cells

E: old *corpus albicans* in the left ovary connective tissue. s = scar, ct = connective tissue, a = artery

F: left uterine horn of an immature female (no.7). e = endometrium, g = gland, m = myometrium, s = serosa

G: left uterine horn of a mature female (no.4). e = endometrium, g = gland

All histological sections were stained with PAS–Groat hematoxyline.

Morphology of the female genital tract

The morphology of the female genital tract is similar to that of other dolphins. The vagina opens to the exterior via the vulva (~ 10 cm long) which had opened *post mortem* in each of the mature females. The vagina comprises a vertical portion (the vestibulum) and a horizontal portion where the cervix bulges (plate IIA), just after a large and collar-shaped ventral vaginal fold. The bicornuate uterus comprises a cervix, rather difficult to detect from the outside, an elongated body and two horns into which the uterine tubes open. Table 6 provides several measurements of various parts of the genital tract (see Fig. 7) which reflect its development. The tract dimensions in female no.5 suggest a recent parturition which was supported by the observation in the field of a distended *vulva* and confirmed by the various histological characteristics described in Table 7.

Table 6

Information on the genital tract, ovaries and mammary glands. CA = corpus albicans, CL = corpus luteum, LF = lutealised follicle. All measurements are in cm unless otherwise indicated. Numbers in parentheses indicate measurements shown on Fig. 7. * = part missing. Specimen numbers all 'K. 83–'.

Specimen no:–	07	10	01	05	08	04	06
Age:–	4	4	5	6	7	9	10
(1) Genital tract, total length	15.5	19.6	22.2	34.2	31.0	29.7	29.0
(2) Vagina, length	3.8	3.5	5.2	7.6	5.5	5.8	6.7
(3) width	3.2	4.8	5.8	5.0	5.2	4.3	6.0
(4) Uterus, length of body	8.0	14.5	16.7	19.8	20.1	19.6	18.3
(5) width of body	1.6	2.6	2.6	4.1	2.8	2.9	3.0
(6) Uterine horn, right, width	1.8	2.3	2.9	4.8	2.7	2.9	3.4
(7) left, width	1.6	2.2	2.7	6.1	3.5	3.0	4.7
(8) Oviduct, right, diameter	0.3	0.6	0.9	0.9	0.7	0.8	0.6
(9) left, diameter	0.3	0.6	0.9	0.7	0.9	0.9	0.6
Right ovary, length	2.6	3.3	3.7	3.6	2.7	3.3	3.7
weight (g)	1.25	>3.10*	5.83	2.61	2.30	2.27	2.67
corpora	–	–	1LF	–	–	–	–
Left ovary, length	2.4	3.2	3.5	4.7	3.2	5.0	4.8
weight (g)	1.45	>4.10*	3.59	6.90	6.48	16.06	16.31
corpora	–	–	–	1CL	1LF	1CL	1LF
					1CA	5CA	3CA
Serosa, depth (μm)	150	600	550	650	400	800	800
Myometrium, depth (mm)	0.58	1.7	3.8	1.4	0.8	1.2	1.6
Endometrium, depth (mm)	1.5	3.5	2.8	2.0	4.6	9.2	2.0
Mammary gland, length	22.0	20.5	25.6	28.7	22.0	34.0	24.0
height	6.0	9.0	4.3	9.2	6.0	8.8	8.0
thickness	0.3	0.8	–	4.5	1.6	1.0	1.2
milk present	0	0	0	x	0	0	0

The table also reveals that in the non-mature animals (nos 7, 10 and 1), the widths of the uterine horns are almost equal. In the mature animals by contrast (apart from no.4), the left horn is considerably wider, particularly in no.5 which had recently calved. This suggests that in this species, following the usual odontocete pattern, the foetus usually develops in the left horn (however see "Discussion").

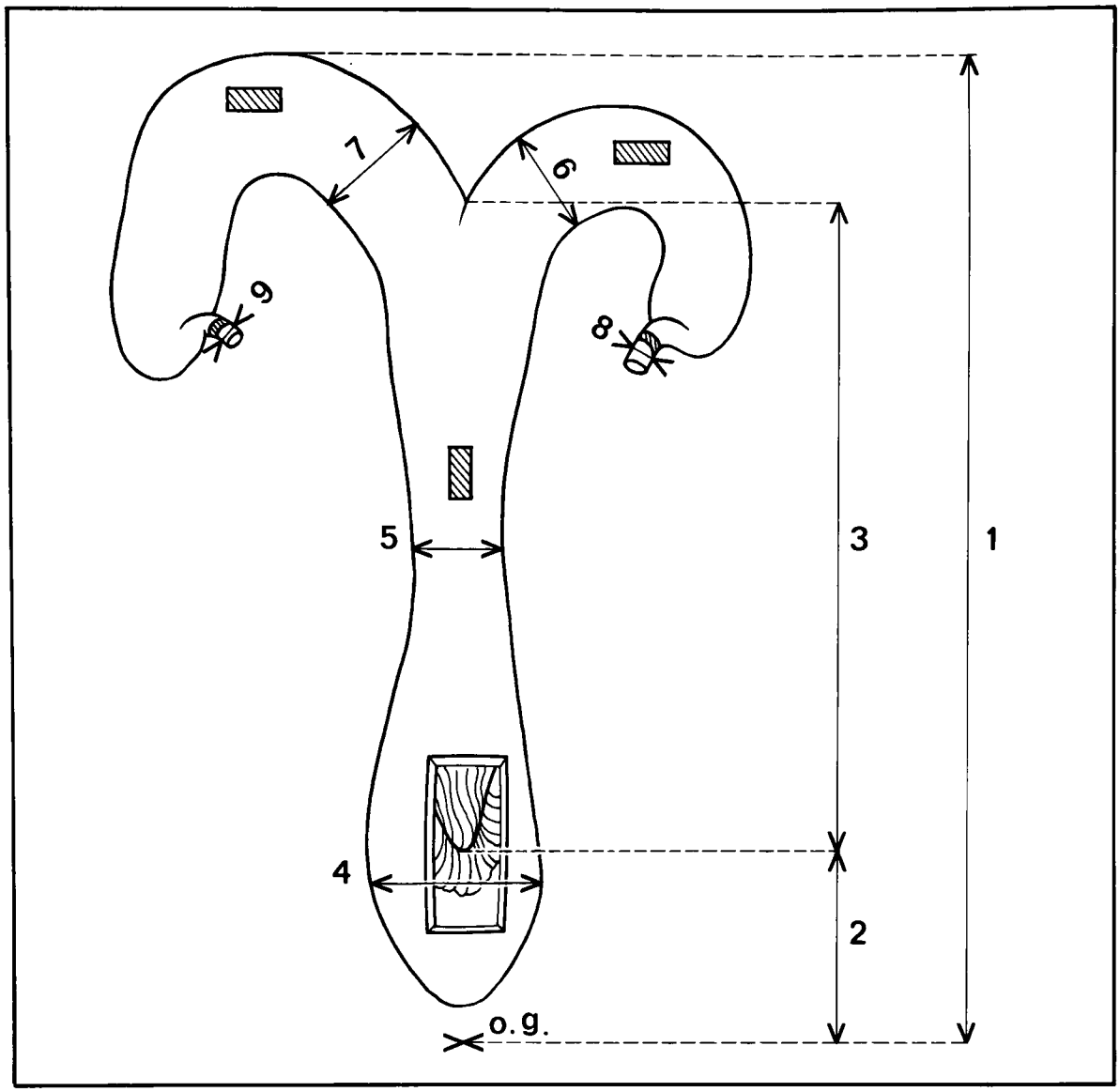


Fig. 7. Measurements taken of the female genital tract (ventral view). Numbers correspond to those in parentheses in Table 6. o.g. = genital orifice

The vaginal length measurements given in the table were taken (following a straight line parallel to the longitudinal body axis) between the projection of the central aperture of the vulva and the end of the intra-vaginal cervix, and do not therefore include the vestibulum. The "true" intromission length for female no.5 was estimated to be 12cm.

The mammary glands lie on both sides of the ventromedial line between a point behind the umbilicus and the caudal end of the genital slit. Their measurements are given in Table 6. The thickness of the glands allows a gross estimate of whether the animal is lactating as it increases considerably during the milk secretory phase (e.g. female no.5). The mammary slits (between 2.2 and 4.1 cm in length) are found on both sides of the caudal end of the genital slit (Fig. 1b). Unusually, female no.5 had two mammary slits, a small medial one and a large lateral one, on each side of the vulva (Fig. 1c).

Table 7

Summary of histological examination of ovaries, genital tracts and mammary glands of the seven females examined and conclusions concerning their reproductive status and history. CA = corpus albicans, CL = corpus luteum, LF = lutealised follicle, GF = Graafian follicle.

Ovaries	Uterus	Oviduct/vagina	Mammary glands	Reproductive status
Female no. 7 No corpora, few small GFs. Cortex lined with several layers young follicles.	Uterine coats poorly developed. [Plate IIF]	Poorly developed, inactive epithelia.	Inactive.	Typical immature female.
Female no. 10 No corpora. Many large and some very large GFs. Largest protruding onto ovary surface.	Coats quite well developed, some endometrial glands showing signs of secretion.	Oviduct epithelia inactive.	More developed than No. 7 but still inactive.	Although sexually immature as she had not ovulated, can be considered prepubescent.
Female no. 1 Recently ruptured LF on right ovary [Plate IID]. Many follicles, several atretic on left ovary.	Endometrium in glandular transformation stage. Characterises recent ovulation & suggests not fertilised.	Well developed glandular epithelium in active secretory phase.	Inactive but signs of onset of development.	Sexually mature female. Recent ovulation probably not fertilised given poorly developed endometrium.
Female no. 5 CL on left ovary (no external scar) showing signs of onset of regression. Also very large GF. Small follicles on right ovary.	Myometrium has loose structure with many large vessels. Glandular system regressed.	Oviduct epithelia inactive. Vaginal epithelia poorly developed.	Active.	Lactating female with enlarged uterus. Conceived at first ovulation, probably giving birth in year before capture.
Female no. 8 CA on left ovary which seemed to have begun to degenerate before developing structure typical of pregnant/lactating female. Also recently ruptured LF.	Poorly developed myometrium. Endometrium of uterine body in active secretory phase, that of uterine horns at end of this phase (desquamation).	Few small areas of oviduct epithelium showing signs of secretory activity. Vaginal mucosa very thick. This is characteristic of post-ovulatory phase.	Small secretions in alveoli. This is not inconsistent with view that is in post-ovulatory phase.	Sexually mature female which has had two infertile ovulations, one of which was very recent.
Female no. 6 3 CAs on left ovary, the largest unusually had a large GF in its centre. Also recently ruptured LF. Both ovaries had many very large GFs.	Well developed myometrium in left horn - at end of secretory phase, areas of desquamation.	Few small areas in oviduct epithelia in secretory phase. Vaginal epithelia poorly developed.	As for female No.8.	Sexually mature female whose most recent ovulation was probably infertile. However the uterine dimensions suggest that at least one of the CAs arose from a CL of pregnancy.
Female no. 4 5 CAs & 1 CL on left ovary - latter largest corpora in sample & had typical endocrine gland structure [Plates IIB,C]. Good correlation between CA size and degree of regression. [Plate IIE].	Considerably thicker endometrium than in other females due to oedema of its stroma. [Plate IIG] Superficial vascularisation highly developed which may suggest pregnancy. In active secretory phase.	Oviduct epithelia at very end of secretory phase. Vaginal epithelia with many folds.	Small secretions in alveoli.	Sexually mature. Most recent (6th) ovulation led to well developed CL. This along with nature of endometrium suggests it had been fertilised. CAs' structure precludes assessment of whether this is first pregnancy.

Histological examination of the female genital tracts

Table 7 summarises the results of the histological analysis for each female examined and presents the conclusions concerning their reproductive status. Terminology follows that agreed during a workshop on cetacean reproduction, (Perrin and Donovan, 1984).

DISCUSSION

Male reproductive cycle

Sexual maturity

Although comprising only four animals, the male sample provides information on both age and body length at attainment of sexual maturity. The identification of two immature males (nos 9 and 11) and one active mature individual (no.2) was unequivocal. In male no.3, histological examination revealed an intermediate stage which may have corresponded to either a prepubescent male or to a resting mature male. However, the relatively low testis weights, its age (7 years old) and the fact that the only mature male (no.2) was sexually active at the same period of time (a time when most of the mature females taken were in oestrus), suggest that the latter is unlikely. We therefore conclude that it was a male approaching sexual maturity and that the observed apparent spermatocytogenetic activity was indicative of impending sexual activity.

Given this, our results suggest that male *C. commersonii* from the Kerguelen Islands reach sexual maturity at about 8 years old and a body length of about 165cm. This appears plausible when compared to those obtained for other delphinid species (see the excellent summary by Perrin and Reilly, 1984), notably for *Stenella longirostris* in the eastern tropical Pacific (Perrin, Holts and Miller, 1977; Perrin and Henderson, 1984) whose body length at sexual maturity is similar (160 – 179cm long) and reached between 6 and 9 years old.

Lockyer *et al.* (1988) reported that in a sample of 19 *C. commersonii* males from Tierra del Fuego, a "dramatic" increase in testis weight was apparent in animals between 5 – 6 years of age and 127 – 131cm in length.

Activity cycle

The presence of only one active mature male precludes serious discussion of the possibility of a sexual activity cycle in males, which has been demonstrated for other small cetacean species (notably *Stenella spp.*: – Hirose and Nishiwaki, 1971; Perrin and Henderson, 1984; *Delphinus delphis*: – Collet and St Girons, 1984; *Phocoena phocoena*: – Gaskin and Blair, 1977). That the mature male in this study was sexually active at a time when the females were ovulating and at the same time of the year that the only observation of mating was reported (Pascal, 1981) is clearly consistent with either continuous or seasonal activity in the male. However, the mature male (no.2) was notably thinner than all other sampled animals (Robineau, 1984) which may be a result of particularly high energy consumption, related to its level of sexual activity; if so it seems unlikely this could be sustained throughout the year. It is interesting to note that the

possibility of a seasonal cycle in males from South American waters was raised by Lockyer *et al.* (1988)

Female reproductive cycle

Preliminary remarks

During the histological examinations of the ovaries, Graafian follicles larger than an arbitrary 300μ were systematically numbered and measured. Although the results from this approach are dependent on the number and size of the sections taken off each ovary, a general picture can be obtained. This suggested that the number and diameter of maturing Graafian follicles was not correlated with either the body length, age or stage in the reproductive cycle of mature females. However it is interesting to note that of the two immature specimens, female no.10, which was closer to sexual maturity, had more numerous and more developed follicles than female no.7.

Atretic follicles were quite often encountered, but there appeared to be no correlation between their frequency and the size of either the animals or their gonads, or the regression stage of the corpora. In general, we were surprised to find so many follicles with a diameter of over 3mm (the largest exceeded 6mm); other small cetacean (including *Delphinus delphis*, *Phocoena phocoena*, *Globicephala melaena* amongst others) species we have examined previously had very few such large follicles.

Attainment of sexual maturity

Sexual maturity in females, defined by the presence of at least one ovulation scar on one ovary (Perrin and Donovan, 1984), is easier to determine than for males. In the present sample, two females were sexually immature (155 and 165cm long, both four years of age) and five females were mature, the smallest being 165cm long and 6 years old (no.5) and the youngest being 5 years old and 165.6cm long (no.1). An examination of Fig. 8 shows that of the two immature females, the longer (no.10) was closer to sexual maturity and was in fact considered prepubescent from histological analysis. Of the two youngest mature females, one had recently ovulated at five years old (no.1), while the other (no.5) had probably ovulated for the first time when five years old as she was lactating (and showed signs of recent parturition) at six years of age [1].

From our sample therefore it seems reasonable to conclude that female *C. commersonii* from the Kerguelen Islands reach sexual maturity from five years of age and at a body length of about 165cm.

As is to be expected, the few published estimates of body lengths at attainment of sexual maturity for female Commerson's dolphins from South America (139 – 152cm: – Brown, 1988; Cornell, Antrim, Asper and Pincheira, 1988; Goodall *et al.*, 1988; Lockyer *et al.*, 1988) are smaller than for our animals, but it is interesting to note that Lockyer and Goodall (1985) estimated the age at attainment of sexual maturity to be 5 – 6 years, similar to our results.

[1] There are no direct data concerning the gestation period of this species, but a minimum estimate of about 10 months seems reasonable by analogy with other small delphinids (between 10 and 12 months, Perrin and Reilly, 1984).

Of the other delphinids, females of *Stenella longirostris* (the only species of similar total body length for which the required information presently exists) in the eastern tropical Pacific, reach sexual maturity between 4 and 6 years of age at a mean size of 164 – 167cm (Perrin, Holts and Miller, 1977; Perrin and Henderson, 1984).

Ovulation

Fig. 8 suggests that the number of ovulations is better correlated with total body length than age. It is interesting to note that of the five mature females, three had recently ovulated (nos 1, 8 and 6), another had recently ovulated and was perhaps in the early stages of pregnancy (no.4), while the fifth was lactating, which may suppress ovulation (no.5). The most plausible conclusion to be drawn from this is that the time of capture, January, corresponded to an ovulation period, although whether there are regular ovulation cycles at the population level cannot yet be determined.

The small sample size and lack of information on stock identity make it impossible to examine the question of ovulation rate at the population level. However it is worth briefly examining the available data with respect to the range of ovulation rates at the level of individuals.

If it is assumed that all animals reach sexual maturity at five years of age, then the annual ovulation rate would range from 0.5 (female no.5) to 1.2 (female no.4). An alternative hypothesis that the annual ovulation rate is 1.0, would imply that sexual maturity is reached between four (female no. 4) and seven (female no.6) years of age.

In fact, it is equally unlikely that all females reach sexual maturity at the same age, or that each individual has an identical ovulation rate. It seems most plausible that the ovulation rate may vary by individual, for example depending on an animal's "social" position within the group (which may itself vary with age). Similarly, an animal which ovulates but is not fertilised may shortly ovulate again (the probability of successful fertilisation may also vary with age and/or social position).

Several investigators working on other small delphinids have noted that the ovulation rate can vary according to such factors as age (e.g. *Lagenorhynchus obliquidens*: – Harrison, Brownell and Boice, 1972; *L. acutus*: – Sergeant, St Aubin and Geraci, 1980; *Stenella coeruleoalba*: – Kasuya, 1976; Miyazaki, 1977; *S. attenuata*: – Kasuya, Miyazaki and Dawbin, 1974; Perrin, Coe and Zweifel, 1976; *S. longirostris*: – Perrin and Henderson, 1984; *Delphinus delphis*: – Collet and Harrison, 1981; *D. delphis* and *Tursiops truncatus*: – Kirby and Ridgway, 1984).

Finally some comment should be made concerning the relative occurrence of ovulation on left or right ovaries. Female no.1 has recently ovulated for the first time, but from her right ovary, which is rather uncommon in small delphinids where the left usually predominates at least in the first years after maturity (Ohsumi, 1964). In addition, the few data on reproduction in this species include a female from the South American population which was reported to have six corpora albicantia on her right ovary and only one corpus luteum on her left (Brown, 1988), and a pregnant female with her foetus in the right uterine horn

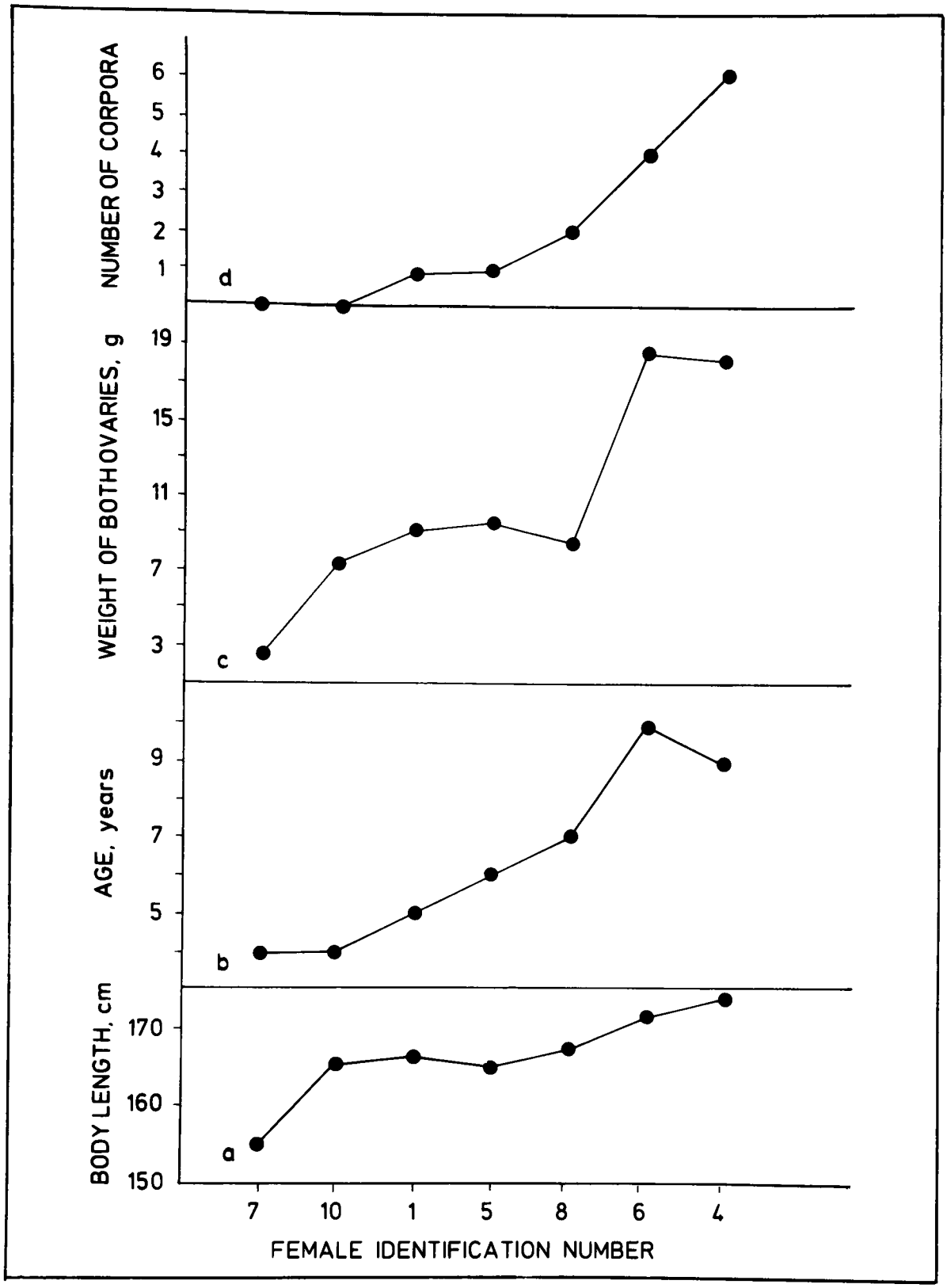


Fig. 8. Comparison of age, body length, ovarian weights and numbers of corpora

which had thus most probably ovulated from the right ovary (Goodall *et al.*, 1988). Given this relatively high incidence of "right" ovulations, it may well be that this species does not exactly follow either of the common delphinid patterns identified by Ohsumi (1964).

Pregnancy

Although a few investigators (Zimushko, 1970; Ivashin, 1984) believe that they are able to differentiate corpora albicantia arising after pregnancy and those from an infertile ovulation, most cetologists now believe that they cannot be distinguished, with the possible exception (e.g. female no.8, Table 7) of those at the very beginning of regression (Perrin and Donovan, 1984).

In our study we concluded that four females (nos 1, 8, 6 and 4) had recently ovulated, of which one (no.4) was at the beginning of pregnancy (although no embryo was found in her uterus) and the other three were unfertilised. However it must be stressed that we were only able to reach such conclusions in the light of a detailed and comparative examination of not only the gonads but also the different parts of the genital tract and the mammary glands. For example, after a preliminary examination of female no.4 we believed that she could not have been pregnant. Subsequent examination of other samples, notably those taken from her uterine horns where the rich superficial vascularisation was an indication of the onset of pregnancy (Benirschke and Marsh, 1984), however, led us to believe that she was in fact probably in the first stages of pregnancy.

Morphometric data (Table 6) can also provide information on pregnancy. For example, the size of the uterus of female no.6 renders it likely that she had been pregnant at least once. Our sample also revealed that females can become pregnant at their first ovulation (female no.5 and possibly, although it is unlikely, no.1). Similarly it showed that not every ovulation is fertilised, as female no.4, who was only nine years old, had clearly not had six successful pregnancies. This implies that the pregnancy rate is considerably lower than the ovulation rate. As a further consequence of this it is apparent that ovulation may occur several times per year, as has been noted by Kirby and Ridgway (1984) for *D. delphis* and *T. truncatus*, and Wells (1984) for *S. longirostris*.

Mating and calving periods

Any discussion of mating and calving periods must of course be prefaced by the fact that our sample is not only small but taken within a short period of time. We cannot, in fact, even state with certainty whether or not discrete mating and calving periods exist, although most cetacean species exhibit such seasonality.

However, with this proviso, the limited data available do suggest that December and January are important in terms of reproductive activity in the Kerguelen area. As we have already seen, apart from the lactating animal, each of the mature females had "recently" ovulated. From the histology of their lutealised follicles and genital tracts and based on our knowledge of terrestrial mammals (Coujard, Poirier and Racadot, 1980), they probably ovulated within the month preceding their capture. In addition to this, the only observation of mating in the Kerguelen area was on 17 January 1977 (Pascal, 1981).

As we have already discussed, it seems likely that the lactating animal had only recently given birth. This, combined with the fact that of the eight sightings of calves reported during the sighting programme around the Kerguelen Islands (January 1982–December 1984), one was in mid-January and seven were in the first half of February, suggests that calving also takes place in this area in

the austral summer. Our data do not allow us to determine whether or not mating and calving periods overlap in this species as suggested by Leatherwood *et al.* (1988) or whether the calving season precedes the mating season as is common in many other cetaceans.

The limited information on animals from Tierra del Fuego (Goodall, 1978; Mermoz, 1980; Gewalt, 1981; Cornell *et al.*, 1988; Goodall *et al.*, 1988) suggests that the breeding season is also in the austral summer, and, from observations of pregnant females and young individuals, may last from November to February.

CONCLUSION

This study has provided the first description of the morphology of the genital tracts of *C. commersonii*. It has also given some idea of values for those parameters necessary for an understanding of the population dynamics of this species in this area. It has also highlighted, however, how much we do not know. For example we have no idea of the distribution of this "stock" of animals or how large it is; we do not know if the animals in our sample from the golfe du Morbihan comprised a random sample of the whole population or whether there is segregation by sexual category which might have resulted in the large proportion of ovulating females; observations from a longer time period are needed if the questions of seasonality are to be answered.

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Food Habits of *Cephalorhynchus commersonii* off Tierra del Fuego

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ABSTRACT

The stomachs of Commerson's dolphins, taken incidentally in fishing gear off Tierra del Fuego, were examined. Contents included: three species of fish, one squid, four species of algae and seventeen species of invertebrates, as well as plant remains, sand and small pebbles. The diet indicated *Cephalorhynchus commersonii*, off Tierra del Fuego, to be a coastal generalist feeder. The mysid shrimp *Arthromysis magellanica* comprised 22.5% of the diet; followed by the fish *pejerrey* (*Austroatherina smitii* or *A. nigricans*), Fuegian sardines *Sprattus fuegensis* and tailed hake *Macruronus magellanicus* (20.4%) and by the squid *Loligo gahi* (14.1%). Diet composition indicated that the dolphins fed on or near the bottom. No more than three items were present in 70% of stomachs; the greatest diversity in any one stomach was eight items. There was no significant difference in diet relative to sex (male/female ratio in the sample, 2/1), physical maturity or locality, although more algae and sessile benthic organisms were found in the southern areas of rockier coastlines and more kelp communities.

INTRODUCTION

Studies on small cetaceans of the western South Atlantic have been initiated only in recent years. Although the area is inhabited by many species of world-wide distribution, others are relatively restricted. Such is the case of Commerson's dolphins (*Cephalorhynchus commersonii*) which range from the Río Negro on the coast of Argentina (40°30′S) to near the South Shetlands (61°59′S), the Strait of Magellan and the Falkland Islands (Islas Malvinas). In addition, a disjunct population occurs off the Kerguelen Islands (Robineau, 1984).

Little is known of the biology, ecology and food habits of this species. Hamilton (*in*: Harmer, 1922) found 'krill' and the 'pens of cuttlefish' in the stomach of a young male from the Falkland (Malvinas) Islands. Rayner (*in*: Brown, 1988) found squid beaks and fish bones in the stomach of a dolphin captured off Río Gallegos. Hamilton (1952) later noted an association of

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dolphins with kelp beds, but did not mention food habits. Weber (1929) captured Commerson's dolphins in the Strait of Magellan, and noted freshly ingested sardines vomited on the deck. Mermoz (1980), at Comodoro Rivadavia, felt that these dolphins fed on sardines (*Sprattus fuegensis*), silversides (*Basilichthys* sp.) and southern anchovy (*Engraulis anchoita*), but did not examine stomach contents. Cabrera and Yepes (1960) and Gewalt (1979) observed Commerson's dolphins chasing fish captured amidst a school of sardines.

Strandings and incidental captures have allowed a glimpse of the ecology of this species (Goodall, 1978; Goodall and Cameron, 1980; Goodall, Galeazzi, Leatherwood, Miller, Cameron, Kastelein and Sobral, 1988). Goodall and Galeazzi (1985) gave a preliminary report on the data analysed more fully in this paper. Goodall, Galeazzi *et al.* (1988) reviewed what is known of food and feeding methods of Commerson's dolphins in Argentine waters, indicating that they eat squid, fish, mysid shrimp, isopods and other invertebrates.

Although the trophic relationships of certain coastal ecosystems of northern Argentina have been well studied (Olivier, Bastida and Torti, 1968), little is known about trophic interactions in ecosystems in southern South America, where small cetaceans undoubtedly play an important role as top predators.

Studies of *C. commersonii* are important because stock levels are unknown, and the species is being exploited. They are taken incidentally in gillnets in southern Argentina and have been harpooned to bait crab *centolla* (*Lithodes antarctica*) traps in southern Chile (Goodall and Cameron, 1980). Specimens have been taken for exhibition in oceanaria in Japan, Germany and the USA, and there has been great pressure for new permits (Collet, 1984; Goodall, Galeazzi *et al.*, 1988).

Our purpose here is to analyse the stomach contents of specimens of *C. commersonii* taken in Tierra del Fuego.

METHODS AND MATERIALS

Most of the dolphins were taken incidentally in gillnets set for *róbalo* (*Eleginops maclovinus*) in Argentina, although three were taken incidentally in *centolla* nets in Chilean Tierra del Fuego (Table 1). Since we depended on incidental catches, specimens were taken during the months when fishing took place. Dolphins netted in shore fishing were taken during spring and summer (October to March), while those drowned in *centolla* nets were taken in winter (July) (Fig. 1).

All animals were examined for stomach contents. Most were in fairly fresh condition, but contents were recovered even from a few decomposed specimens. Stomachs were dissected by the Goodall team and the contents gently washed through two sieves (US Standard Grades No. 18 and 45) before fixing in 70% alcohol. Otoliths and some fish skeletal material were air dried and stored in vials. The weight of stomach fills (weight of opened, washed stomach subtracted from weight of unopened stomach) was taken when possible. Stomachs were classified as full (with some fleshy remains), with traces (only squid beaks or fish otoliths or skeletal remains) or empty (Perrin, Warner, Fiscus and Holts, 1973).

Table 1

Reference data on specimens of *Cephalorhynchus commersonii* studied, excluding those with empty stomachs. Field numbers refer to R.N.P. Goodall collection numbers. Localities are shown in Fig. 2. Collection dates where exact date of death is unknown are in parentheses.

Field no.	Sex	Age	Phys. mat.	Local -ity	Date of death (coll. date)	Field no.	Sex	Age	Phys. mat.	Local -ity	Date of death (coll. date)
574	M	0–2	2	9	(25 Jul 1977)	958	F	4	2	5	08 Jan 1982
575	F	0	1	9	28 Jul 1977	962	M	1	1	4	?? Dec 1981
576	M	3	2	9	28 Jul 1977	988	M	1	1	4	27 Jan 1982
595	M	9	3	1	24 Nov 1977	1,032	F	7–9	3	2	01 Dec 1982
620	M	7	3	2	11 Dec 1977	1,033	F	3	2	2	01 Dec 1982
633	F	0	1	1	12 Dec 1977	1,034	F	4	2	2	01 Dec 1982
634	F	8	3	1	12 Dec 1977	1,040	M	6	2	3	18 Dec 1982
636	M	12	3	2	18 Dec 1977	1,041	F	9	3	2	?? Dec 1982
637	M	15	3	2	18 Dec 1977	1,043	F	6	2	3	01 Dec 1982
731	M	6	3	2	04 Jan 1979	1,048	M	15	3	5	?? Dec 1982
740	F	0–0.5	1	4	09 Feb 1979	1,049	F	8	2	5	16 Jan 1983
746	M	5	2	4	15 Mar 1979	1,054	M	5	2	2	16 Jan 1983
747	M	2	2	4	10 Mar 1979	1,059	M	5	2	4	23 Feb 1983
766	F	10	3	2	27 Dec 1979	1,064	M	10	3	1	24 Mar 1983
767	M	4	2	5	18 Dec 1979	1,065	M	0	1	8	?? Apr 1983
773	M	0	1	5	25 Jan 1980	1,099	M	12	3	4	(17 Dec 1983)
812	M	–	3	5	(29 Mar 1980)	1,105	M	6	2	5	?? Nov 1983
837	M	15	3	2	25 Oct 1980	1,106	M	1	1	5	?? Nov 1983
871	M	2	1	6	31 Jan 1981	1,107	M	2	1	5	07 Jan 1984
874	M	11	3	2	01 Feb 1981	1,109	?	6	3	1	(13 Jan 1984)
885	M	9	3	2	(17 Apr 1981)	1,136	?	13	3	5	19 Jan 1984
954	M	10	3	4	18 Nov 1981	1,142	M	–	1	6	10 Mar 1984
957	F	5	2	5	25 Dec 1981						

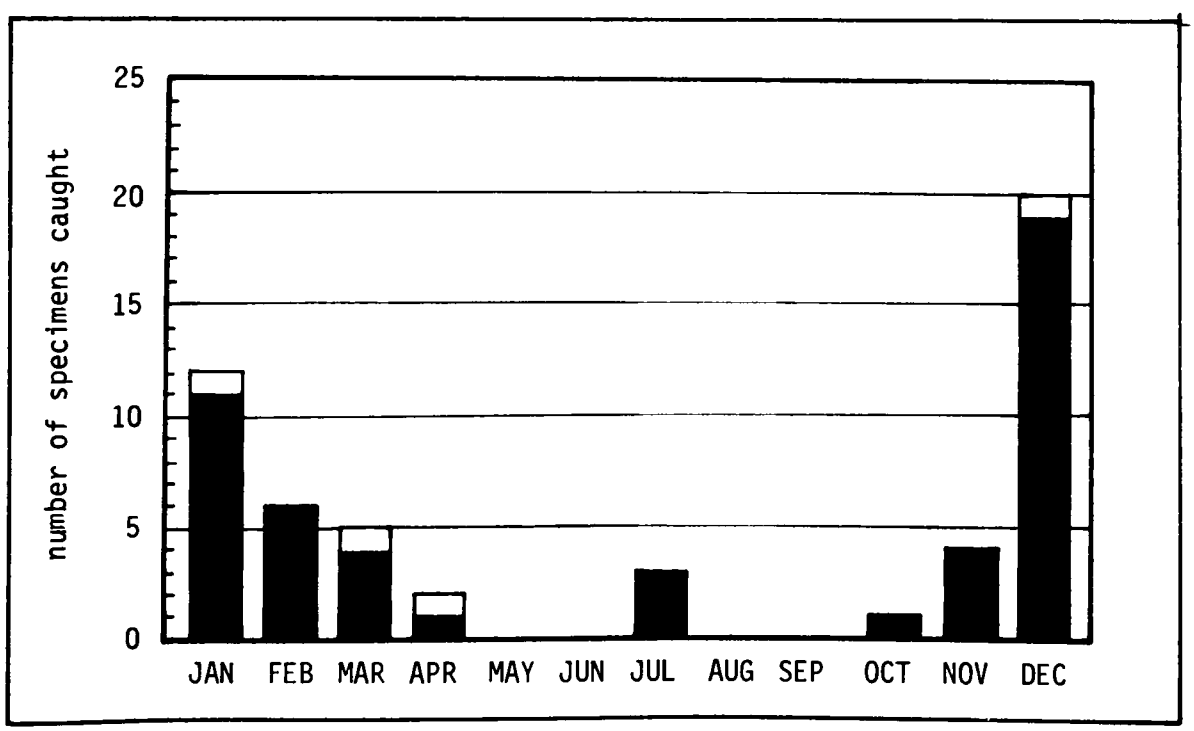

Fig. 1. Month of collection of specimens of *Cephalorhynchus commersonii* which were examined for stomach contents. In black: exact date or month of death known; in white: date animal was found (date of death could have been 2–4 weeks earlier).

Table 2
List of organisms found in stomach contents of *C. commersonii* from Tierra del Fuego.

ALGAE	**CRUSTACEA**	**ECHINODERMATA**
Cladostephus setaceus	**Mysids**	**Ophiuroids**
Macrocystis pyrifera	Arthromysis magellanicus	Ophiomixidae
Ceramium sp.	**Euphausiids**	
Polysiphonia sp.	Euphausia vallentini	**TUNICATA**
	Euphausialucens	**Ascidians**
PORIFERA	**Isopods**	Polyzoa opuntia
Demospongiae	Exosphaeroma sp.	Pyuridae
	Cirolana sp.	
COELENTERATA (Hydroids)	Gnathiidae	**PISCES**
Sertulariidae	Sphaeromatidae	Sprattus fuegensis
	Amphipods	Austroatherina smitti/
POLYCHAETA	Gammaridean	A. nigricans
Nereidae	**Anomuran crabs**	Macruronus magellanicus
	Lithodes antarctica	
MOLLUSCA	**Cumaceans**	**MISCELLANEA**
Cephalopods	Diastylis sp.	Plant remains, Plant seeds
Loligo gahi		Sand, Gravel, Pebbles
Octopoda		

In the laboratory, items were separated and identified by Bastida and Lichtschein to the lowest possible taxon. The state of food remains depended on the degree of digestion and the amount of time the animal had remained on the beach after death. Specific identification was sometimes difficult, but taxonomic determinations could be made for most diet components (Table 2).

The biomass of ingested food could not usually be determined, as the contents varied in degree of digestion. Elements such as fish otoliths, vertebral columns, cephalopod beaks and eye lenses from both groups were counted in an attempt to obtain a quantitative estimate of their incidence. Calculations of fish lengths were based exclusively on complete specimens, vertebral columns and skulls. In the case of small organisms such as mysids, biomass estimates were based on volume, as were those for colonial invertebrates and algae.

Jaccard's Index (Stirn, 1981) was used to determine diet similarity among the specimens examined. Values were calculated, partially grouped by computer and arrayed in a trellis diagram (Fig. 7). Similarity values were clustered to produce the dendogram in Fig. 8.

Osteological specimens were obtained and the dolphins were classified on the basis of the amount of fusion of the vertebral epiphyses: (1) juvenile, no epiphyses fused; (2) subadult, some fused; and (3) adult, all epiphyses fused. This information has been used to analyse stomach contents by relative age groups.

STUDY AREA CHARACTERISTICS

The animals used in this study were collected in Tierra del Fuego (see Goodall [1978] for general characteristics of this area). Coastal localities are shown in Fig. 2 and are referred to by numbers in the text. These localities represent two general areas with somewhat different coastal physiography.

(1) The northeastern coast of Tierra del Fuego, areas 1–5, has a gradually shoaling sand or mud shelf backed by sandstone cliffs alternating with low coasts having long, flat beaches. The coastline is open and fairly straight, and

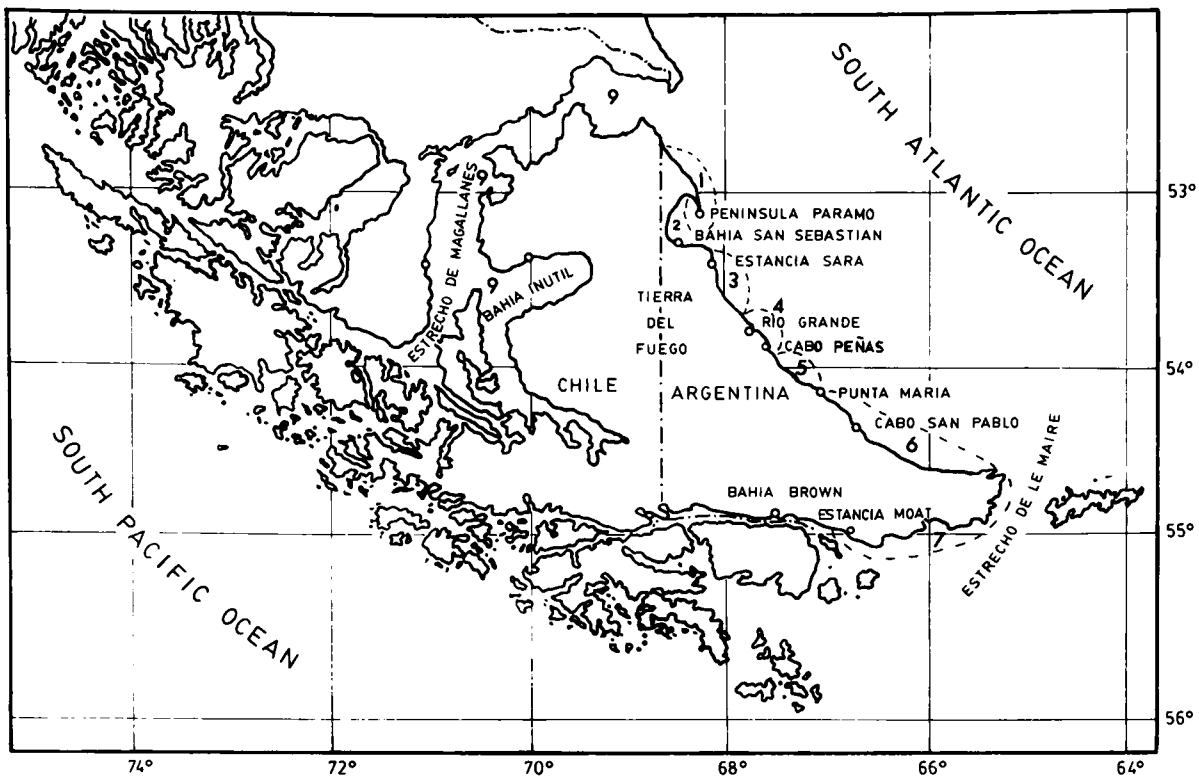

Fig. 2. Map of Tierra del Fuego showing localities where *Cephalorhynchus commersonii* specimens were collected.

is exposed to currents and a high tidal range (9.0 to 12.0m). Few kelp or other algal beds are present. Bahía San Sebastián (zones 1 and 2) is a 40km long bay with a muddy bottom, muddy water and extensive tidal flats; the tidal range is 10.6m. This is where *róbalo* can be fished from the shore. The prerequisites for this type of fishing are a flat, fairly firm mud, clay or sandy shelf that is exposed at low tide. The nets are anchored to posts set perpendicular to the coast and lie on the mud at low tide. As the tide rises, floats lift the top of the nets away from the bottom.

Area 9, in the eastern Strait of Magellan (Chile) is similar, but with less tidal range and probably stronger currents. Two specimens were from Bahía Inútil, whose shallow characteristics are very similar to those of Bahía San Sebastián, and one was from the Strait of Magellan. These three specimens were taken in nets set from floats offshore.

(2) In areas 4 and 5 the flat beach begins to be interspersed with rocky cliffs, and in areas 6–8 the cliffs become more prevalent, extending into rocky headlands and small rocky bays where kelp (*Macrocystis pyrifera*) and other algae abound. *Róbalo* fishing occurs only at river mouths. The entire eastern part of Tierra del Fuego is without access roads and is essentially a wilderness (zone 7). The tidal range diminishes to about 3m in the Beagle Channel. Bays are more protected and probably have more invertebrate life, especially in the kelp communities.

Most of our specimens come from the northern zone, where fishermen work and which is more accessible to us (Fig. 3). Dolphins are also taken incidentally at San Pablo (zone 6), but most are lost to science due to lack of communication and difficult access in bad weather.

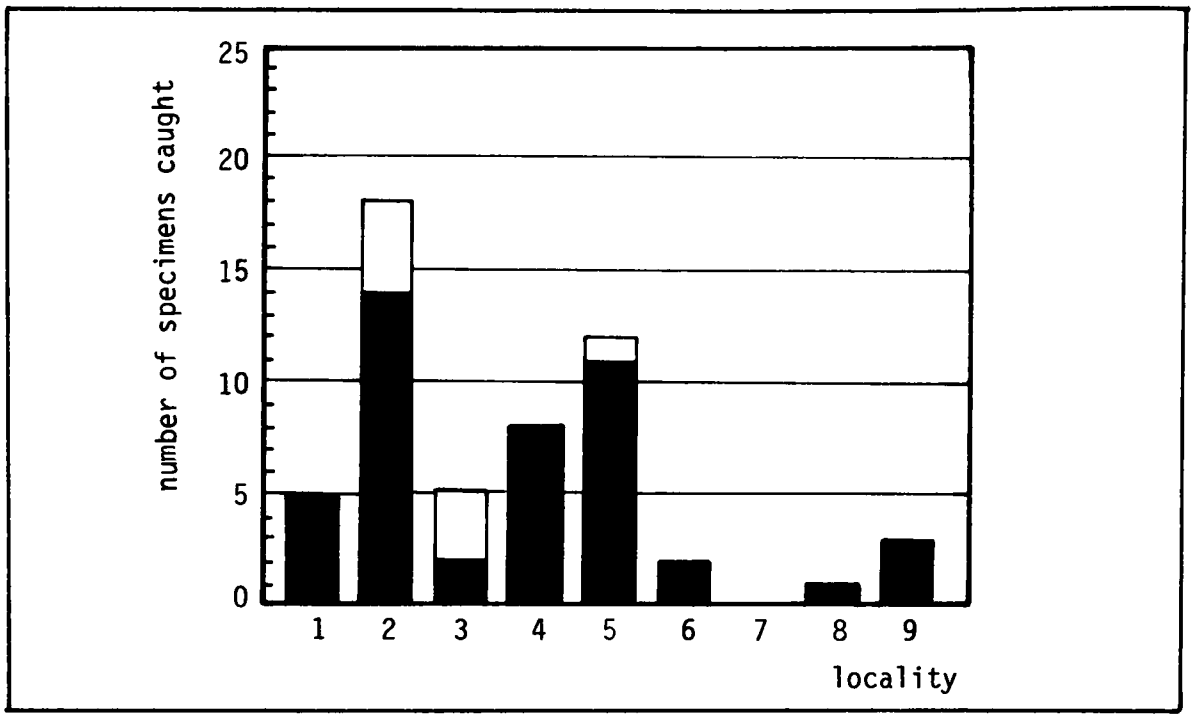

Fig. 3. Number of specimens of *Cephalorhynchus commersonii* caught in each of the localities surveyed in Tierra del Fuego. In black: animals with stomach contents; in white: animals with empty stomachs.

FEEDING CHARACTERISTICS

Goodall, Galeazzi *et al.* (1988) showed that *C. commersonii* occurs frequently close to shore, often coming inshore with the rising tide and possibly feeding on organisms dislodged by the waves. Dolphins caught in shore nets must have swum close to shore, since these nets extend no more than 50–100m from the high tide line. Feeding, at least in the study area, seems more related to the tide than the time of the day; dolphins can only be taken in the nets during the three to four hours of highest tide, when the nets are covered with water. This type of fishing works because *róbalo*, *merluza* (*Merluccius australis*) and other types of fish swim parallel to the coast at high tide, supposedly feeding on smaller fish or other organisms. Dolphins may also follow schools of small fish along the coast. Both dolphins and fish show great horizontal displacement, especially in areas such as Bahía San Sebastián, where up to 9km of tidal flat may be exposed at maximum low tide (Anon., 1978).

At least two methods of fish herding were reported by Goodall, Galeazzi *et al.* (1988). In one, the dolphins encircled the fish, taking turns crossing the ring to feed. Dolphins were also seen herding small fish such as sardines against the shore, sometimes temporarily stranding themselves in the process.

Since nearly all animals in this study drowned in nets, and were found only after the tide went down, we do not know if, in the panic of being trapped, they regurgitated their meals. We suspect this is often the case. Some animals had dark bottom sand in their blowhole, oesophagus and first stomach. In the tidal zone where nets are set, the water is always full of suspended sediments.

RESULTS

Fifty-three stomachs were examined, and 45 (85%) contained at least some food remains. *Cephalorhynchus commersonii* from Tierra del Fuego appears to feed on a wide variety of coastal prey (Table 2), although the bulk of the food biomass was formed by species that occur within the water column (Figs 4 and 5). The largest amount of food was 465g (wet weight).

Mysids

Mysid shrimps were represented in stomach contents by one species, *Arthromysis magellanica*. This was the most frequently occurring food species (71.1%) and was found in significant quantities in 28.9% of the specimens (Fig. 4); volumes reached 200cc in some cases. In the diet of all specimens, mysids were the best represented group (22.5%) (Fig. 5).

In some stomachs, mysids were almost intact and therefore easily identifiable, indicating that the dolphins had recently fed. In others, prey were so digested that only heads, eyes and some body segments were present. Among all stomach contents analysed, there was a relatively higher proportion of female mysids. Mysids were usually present in the diet along with other food items, but in four stomachs (8.8%) they were the only food. In spite of the high frequency of occurrence, mysids contributed little in terms of biomass. There was no statistical variation in frequency of occurrence of mysids with locality ($\chi^2 = 12.087$, $P < 0.01$) suggesting that *Arthromysis magellanica* is probably well distributed along this coast and may be present in the area throughout the year.

Euphausiids

The euphausiids, *Euphausia vallentini* and *E. lucens*, were found only sporadically (4.4%), but were abundant in stomach contents of *róbalo* from Bahía San Sebastián. We are not sure why they did not contribute more significantly to the dolphin diet.

Fish

This group was second to mysids in frequency of occurrence (66.7%) and was found in significant quantities in 33% of stomachs. Fish accounts for 20.4% of the total diet of all specimens (Figs 4 and 5).

Three species of fish were present: the silverside *pejerrey* (*Austroatherina smitti* or *A. nigricans*), the Fuegian sardine (*Sprattus fuegensis*) and the tailed hake or *merluza de cola* (*Macruronus magellanicus*). The most important of these was the *pejerrey*; hake were found in only two stomachs. Most of the fish remains consisted of otoliths, bones and eye lenses.

Pejerrey and sardines were separated primarily on the basis of otoliths, but when the latter were partly digested or eroded, positive identification was impossible. The taxonomy of the family Atherinidae is in need of revision, and the status of the species of *Austroatherina* is uncertain. Thus, even with fresh material, the separation of *A. smitti* from *A. nigricans* is difficult. We have therefore combined them as *Austroatherina smitti/A. nigricans*.

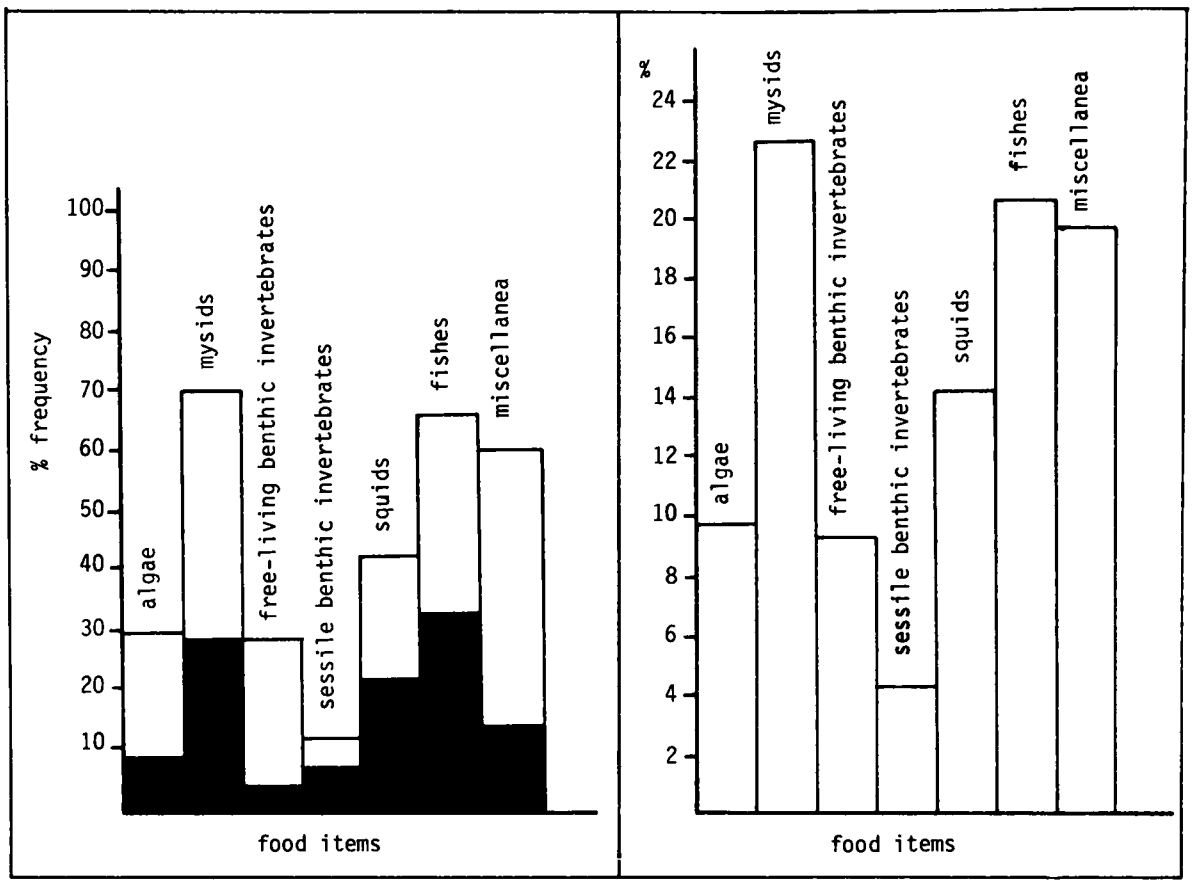

Fig. 4. Left. Percentage of frequency of occurrence of food items in stomach contents of *Cephalorhynchus commersonii*. Black sections indicate abundant occurrence.
Fig. 5. Right. Diet composition expressed as percentages of the total stomach contents examined.

Estimated total lengths of fish ranged from 5 to 30cm, with the usual length being 10 to 15cm. No statistical differences in the occurrence of fish were detected for locality ($\chi^2 = 3.96$, $P < 0.01$).

Cephalopods

This group was represented in stomach contents by the squid *Loligo gahi*. Octopus beaks were found in only one specimen. Cephalopods were the third most important food item in frequency of occurrence (44.4%) and were found in significant amounts in 22% of the specimens. In the total diet of all specimens, this group reached 14.1% (Figs 4 and 5).

Squid remains in stomachs consisted mainly of beaks, radulae, eye lenses and pens. One complete squid weighed 92g and in only two other cases did we find parts of the mantle. Estimated squid sizes ranged from a few centimeters to over 20cm in mantle length.

Although squid were found in stomachs throughout the year, they were most abundant in spring. There were no statistical differences with locality ($\chi^2 = 8.48$, $P < 0.01$), although fewer squid were found in the stomachs of animals from locality 4 than from other sites. In terms of biomass, the contribution of squid to the diet is probably as important as fish.

Algae

Four algal species occurred in stomach contents. Algae were found in 30% of the stomachs (in significantly high quantities in 8.1%) (Fig. 4), comprising some 10% of the total diet (Fig. 5). The most frequently encountered and most abundant was the brown algae *Cladostephus setaceus*, followed by *Macrocystis pyrifera*. Other algae (*Ceramium* sp. and *Polysiphonia* sp.) were found in minimal amounts.

Algal remains were easily identifiable due to their resistance to digestion, the main alteration being normally a change in color. In one stomach *Cladostephus setaceus* formed six matted, nest-like balls 3 to 4cm in length, with fine sediment and a few squid beaks lodged inside.

Algae were not found in the three specimens taken during winter in Chile but were abundant in some stomach contents during spring and summer. There was a strong association ($\chi^2 = 26.62$, $P < 0.01$) of algae with localities 4 and 5, the transition area between the two zones described above. The bottom communities of this region have not been studied.

Free-living benthic invertebrates

At least seven species of crustaceans, one polychaete worm and one brittle-star are included in this category. All were found in low amounts, although their frequency was relatively high (28.9%; 4.4% in significantly high quantities) (Fig. 4). Free-living benthic invertebrates accounted for almost 10% of the total food of all specimens (Fig. 5).

The most abundant species were the isopod *Cirolana* sp., which inhabits soft bottoms and is usually buried in the sediment, and a polychaete (family Nereidae), also characteristic of soft bottoms. We feel, because of the frequency of occurrence and low grade of digestion, that these organisms were ingested directly by the dolphins.

Locality variation was not significant ($\chi^2 = 6.05$, $P < 0.01$), although these invertebrates seemed to be more frequent in locality 5. The contribution of this category to the diet biomass was low.

Sessile benthic invertebrates

The most common of the five species in this category was the colonial tunicate *Polyzoa opuntia*. This category as a whole was present in 11.1% of the specimens (6.7% in significant quantities). These invertebrates constituted 4.2% of the total diet. In some cases, colonies of *Polyzoa opuntia* found in stomach contents had lost their original structure and appearance, taking the form of a brown fibrous mass. As in the case of algae, this food item was restricted to localities 4 and 5, although differences with other localities were not significant ($\chi^2 = 9.89$, $P < 0.01$). The total diet biomass contribution of this group was low.

Miscellaneous

Included here are elements not originally from the marine environment such as plant remains which were probably suspended in the water or had drifted to the bottom, and non-food items such as sand, gravel and small pebbles.

These were found in 60% of the animals and in significant quantities in 8.8%. They represented 19.7% of all stomach items (Figs 4 and 5).

We believe that these items were ingested directly by the dolphins and were not part of the food of the prey. The presence of these elements in the stomach contents could provide further evidence of association of *C. commersonii* with the bottom, but some of the sand and mud must have been ingested while the animals were trapped in the nets, as mentioned above, and a few specimens may have been contaminated with sand or plant debris during dissection on the windy beach. There were no significant differences in the occurrence of this item by locality ($\chi^2 = 6.06$, $P < 0.01$).

Diversity of food items in stomach contents

To determine diet diversity, the different items were grouped in a frequency histogram (Fig. 6). Maximum diversity in any one stomach was eight food items, while the highest frequency (35.6%) corresponded to three food items. The variability in composition of these three was low, and in most cases was mysids (80.0%), fish (70.0%) and squid (60.0%).

The greatest variety of prey was found at locality 5, where one specimen had eight food items in its stomach. Mean values for the number of prey by locality were calculated and three stood out (locality 2, $\bar{x} = 2.7$ items per stomach;

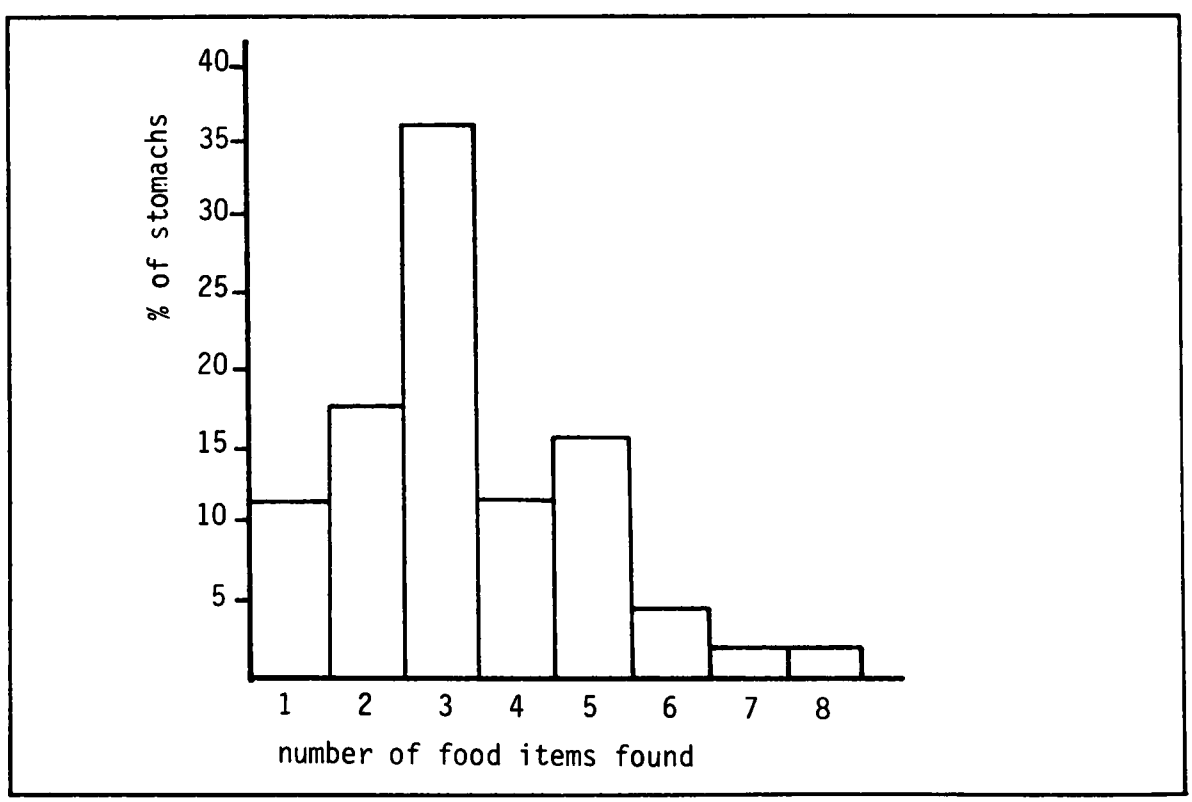

Fig. 6. Trophic diversity in studied stomach contents of *Cephalorhynchus commersonii*.

locality 4, $\bar{x} = 4.4$; and locality 5, $\bar{x} = 4.5$). Composition of diet between localities 2 and 5 was significantly different [$F = 8.8$ (df 1, 22)], but no difference was apparent between localities 4 and 5 [$F = 0.01$ (df 1,17)].

Diet similarity

Since specimens of *C. commersonii* were collected in several localities and different months of the year, diet variation related to these factors was analysed. As mentioned before, quantitative data were not available for all food items, and, therefore, we calculated diet similarity using Jaccard's Index, which is based on the number of prey items shared by different dolphin specimens. Affinity values were grouped into four categories: low (0–9), medium (10–29), high (30–59) and very high affinity (60–100). Of the 990 comparisons between pairs of samples, 15.5% showed a very high affinity, 40.8% a high affinity, 33.7% a medium affinity and 10.3% a low affinity.

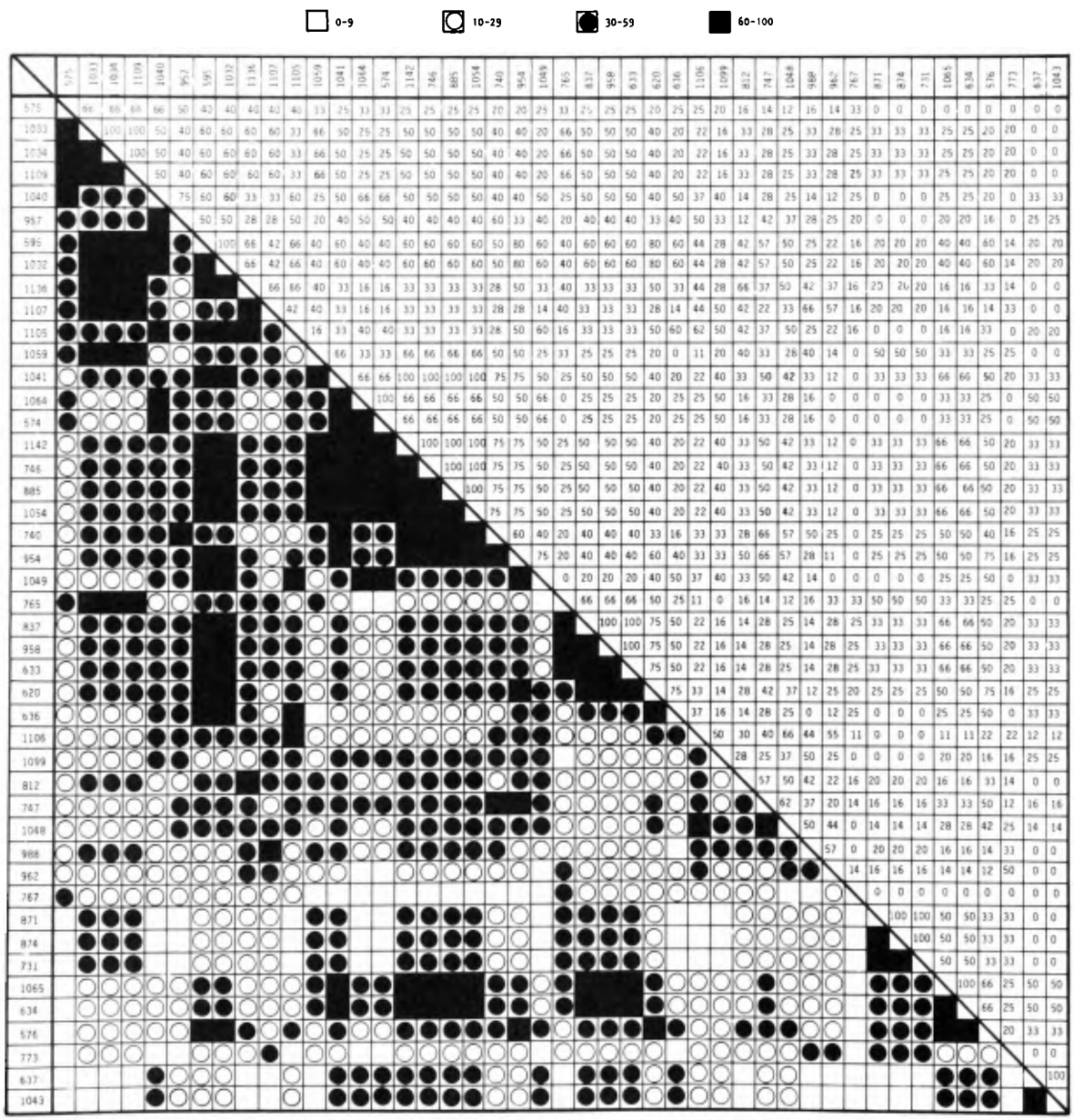

Fig. 7. Similarity between the diets of specimens of *Cephalorhynchus commersonii* collected at Tierra del Fuego.

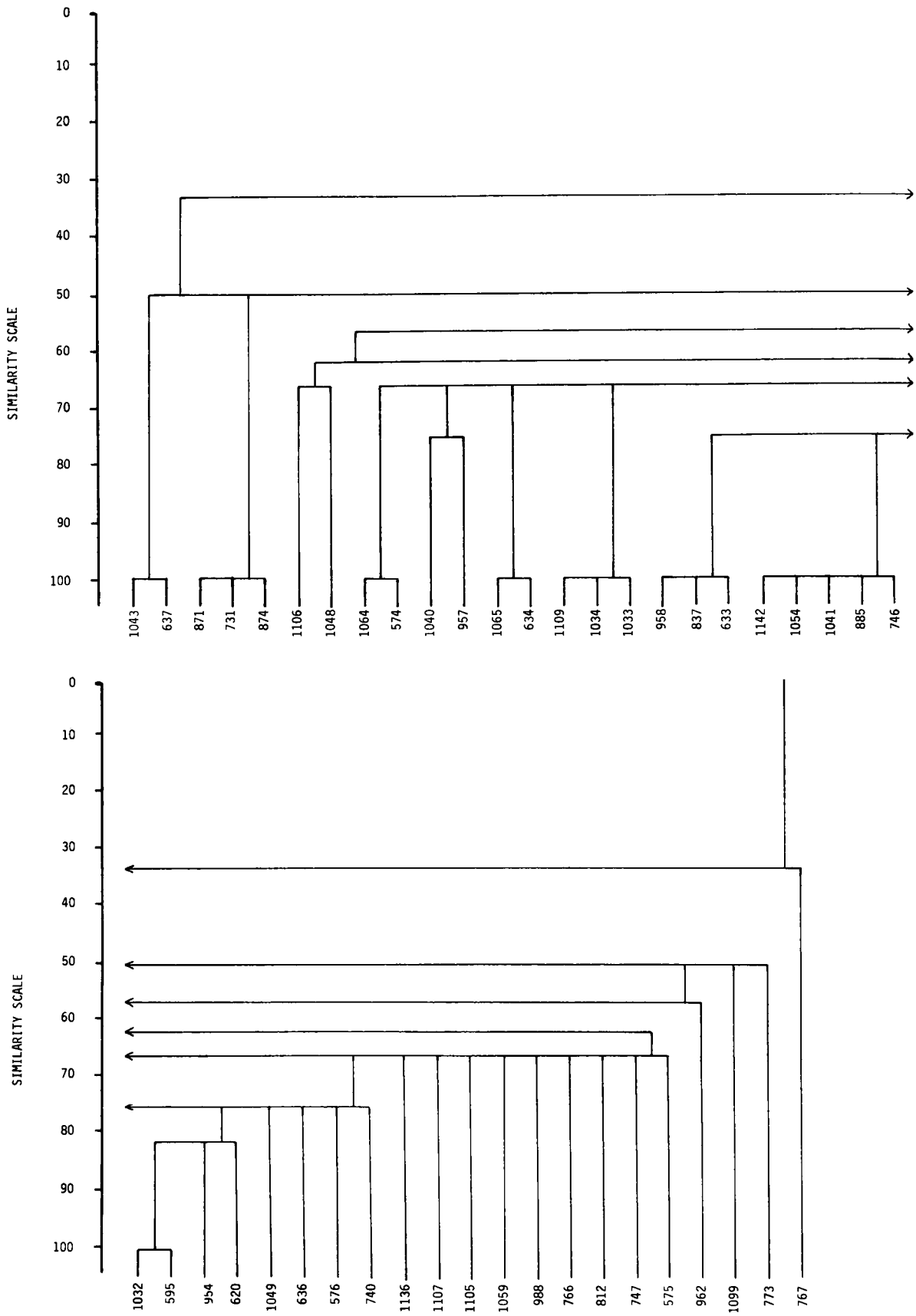

Fig. 8. Cluster analysis diagram showing the relationships in diet composition of specimens of Commerson's dolphins collected in Tierra del Fuego. Numbers along bottom represent field numbers of specimens.

The results, arrayed in a trellis diagram (Fig. 7), show the great similarity in the diet of Commerson's dolphins from Tierra del Fuego. The relationships between individual specimens in terms of diet composition, based on cluster analysis of similarity values, are shown in Fig. 8.

Based on the trellis diagram and cluster analysis dendogram (Figs 7 and 8), samples were examined for age, sex and locality-related differences. No differences in diet composition of these three age groups were observed; specimens with high affinity in their diets belonged to different age groups. No differences were observed in relation to the sex of the dolphins, although some groups of high affinity belong to males (Fig. 8) due to their abundance in relation to the females (ratio 2/1).

DISCUSSION

Over 25 organisms were identified in the diet of the Commerson's dolphins. Three species of fish, one of squid, four of algae and at least 17 species of other invertebrates were found.

Fish

Records of Commerson's dolphins sighted with fish (Weber, 1929; Mermoz, 1980; Cabrera and Yepes, 1960; Gewalt, 1979, 1980; Goodall, Galeazzi *et al.*, 1988) refer mainly to *pejerrey* and sardines. Accordingly we found these in significant quantities in the stomach contents.

Mermoz (1980) observed that both silversides and the southern anchovy, as well as the Fuegian sardine, were present in the bay of Comodoro Rivadavia, some 900km north of Tierra del Fuego, and concluded that all three could be eaten by dolphins. Although there is as yet no direct evidence, in this northern part of their range the dolphins could feed on the anchovy, which is also the prey in coastal and offshore waters of 33 species of fish, five species of marine birds, four marine mammals and three species of cephalopods (Angelescu, 1982).

The higher frequency of occurrence of atherinids in our study is probably related to the fact that these fish are less seasonal and migratory than the sardines. Thus, they occur more regularly in the dolphin diet.

It is particularly interesting that the dolphins prey on the Fuegian sardine. Two populations of this species have been identified, the *S. f. santacruceña* from southern Patagonia and the *S. f. malvinense* around the Falkland (Malvinas) Islands (Cousseau, 1982; Gru and Cousseau, 1982). Since the Commerson's dolphin is found in both areas, it may be possible to define populations feeding on different fish stocks, giving us a better understanding of prey-predator interactions. A similar situation might occur with the atherinids from the two areas.

Schools of Fuegian sardines are known to migrate to inshore waters of southern Patagonia and the Falkland (Malvinas) Islands in late spring, summer and early autumn, sometimes reaching high concentrations (Norman, 1937; Cousseau, 1982). The absence of this species in the stomach contents of the three specimens taken during winter (in area 9) could be related to this pattern.

Squid

Earlier records of 'cuttlefish' (Hamilton, *in*: Harmer, 1922; Rayner, *in*: Brown, 1988) probably refer to squid, as this word in earlier English works includes squid and octopus, and not only what is now recognized as cuttlefish (IWC, 1985). In view of our results, Hamilton's and Rayner's specimens were also probably *Loligo gahi*.*

In the northern part of its range, *C. commersonii* may prey on the high summer concentrations of *Loligo brasiliensis*. *Loligo gahi* does not occur in coastal waters north of Santa Cruz Province (about 46°S) and may be replaced by the former species in the diets of small cetaceans. Since *L. gahi* is not a commercial species, little is known of its biology and ecology; presumably, its ecological role in the southern waters of Argentina would be similar to that of *L. brasiliensis* in northern coastal waters, where it is eaten by small cetaceans such as the Franciscana *Pontoporia blainvillei* (Pinedo, 1982; Bastida and Lichtschein, 1986), the southern sea lion *Otaria flavescens* (Baldas, pers. comm.) and many species of coastal fish (Olivier *et al.*, 1968).

Mysids

The mysid *Arthromysis magellanica*, a major food item in the diet of Commerson's dolphins, is also an important food source for *Sprattus fuegensis* (Ramírez, 1976) and is probably the prey of many other coastal species. Although we consider that *A. magellanica* is ingested by the dolphins during pelagic feeding, these mysids can, under certain conditions, also be associated with bottom habitats (Ramírez, 1976). From an ecological point of view, *A. magellanica* would play the same role that the sergestid shrimp *Peisos petrunkevitchi* does in the coastal ecosystem of the Mar del Plata area (Olivier *et al.*, 1968).

Other invertebrates

Some of the small crustaceans found in stomach contents were probably ingested by fish and were therefore secondary prey. These were not considered in this study. The invertebrates included in Table 2 were ingested by the dolphins; as indicated by the low degree of digestion and by their absence in the stomach contents of possible predators of those organisms.

We do not know how the dolphins ingest benthic invertebrates and whether species such as the tunicate colonies (*Polyzoa opuntia*) are detached from the bottom by the dolphins or taken while suspended in mid-water as a result of turbulence. These colonies are sometimes found on Fuegian beaches after storms. In waters of the Buenos Aires Province, the bottlenose dolphin *Tursiops gephyreus* is frequently observed playing with colonies of *Polyzoa opuntia*, which sometimes reach considerable lengths. These were probably detached during storms (Bastida and Lichtschein, pers. observation).

*Note added in proof. These squid are now recognised as *Loligo sanpaulensis*, M. C. Pinedo (pers. comm.). For a complete description of this new species see T. F. Brakoniecki, 1984. *Bull. Mar. Sci.* 34: 435–8.

Goodall, Galeazzi, Sobral and Cameron (1988) found that a large percentage of Commerson's dolphins of both sexes have a worn, serrated border on the leading edge of (mainly) the left flipper. They speculated that the dolphins might use the flippers to scrape or stir up the bottom. Since some of the prey items are usually buried, it might well be that they do stir the bottom in search of food. On shallow bottoms, however, benthic invertebrates may be suspended in the waters as a result of turbulence.

It was interesting that *centolla* was found in some stomachs since this possibility had been mentioned by fishermen (Goodall, Galeazzi, Leatherwood *et al.*, 1988). During the crab moulting season (late October to December on the northeast coast of Tierra del Fuego) this might become a more important diet item. The *centolla* move to shallower waters at moulting time. However, we were able to obtain dolphin specimens only during the *róbalo* season, which runs from mid-November to March or early April, prohibiting a more thorough study of Commerson's dolphin food habits during the rest of the year.

Trophic interactions

The dolphins were caught in shore nets set less than 100m from the high tide line. Dolphins have also been observed swimming (presumably feeding) very close to shore and even in the breakers (Goodall, Galeazzi, Leatherwood *et al.*, 1988). The trophic level occupied by *C. commersonii* in Tierra del Fuego depends on the kind of prey ingested. The main role of *C. commersonii* within the ecosystem is probably played at levels 3 and 4, with many prey alternatives, which would imply a higher chance of adapting rapidly to changes in prey availability. The prey species consumed by Commerson's dolphins are also major foods of other cetaceans, pinnipeds, penguins and fish of the area. At present there are no important fisheries in the area that could be considered a source of competition for food. More information is obviously needed on the trophic habits of the major prey species, as well as their seasonal variations and migratory patterns.

Other Species of *Cephalorhynchus*

Three other species of the genus *Cephalorhynchus* inhabit waters of southern South Africa, New Zealand and Chile. In addition, a distinct form of *C. commersonii* occurs at the Kerguelen Islands (Robineau, 1984). The Kerguelen Commerson's dolphins eat similar food items to those of Tierra del Fuego, including fish, squid, free-living and sessile invertebrates (Robineau and Duhamel, 1984).

Hector's dolphin (*C. hectori*) in New Zealand waters, like *C. commersonii*, feeds on both pelagic and benthic fishes just beyond the surf line (Baker, 1978). Due to the presence of sand-dwelling stargazers in stomach contents, Baker felt that this species feeds on the sea floor and could possibly take invertebrates as well as fish. His statements were based on the analysis of only two specimens.

Slooten and Dawson (1988) report Hector's dolphins to be opportunistic feeders, feeding at the bottom and throughout the water column selecting for prey (mainly fish and squid) by size rather than species.

Off southwestern Africa, Heaviside's dolphin (*C. heavisidii*) eats hakes, gobies, maasbankers and cephalopods (Best, 1984). The total diet is

'a mixture of bottom dwelling organisms (Congridae, Octopodidae), demersal species that may migrate off the bottom (even to the surface) at night (*Merluccius* sp.), mesopelagic species that may exhibit vertical migration ... and pelagic species that can be found from the surface to near the sea floor on the continental shelf ...'.

No stomach contents have yet been collected for the Chilean dolphin (*C. eutropia*). The only pertinent references are early statements that they eat fish (Lesson, 1827) and more recent ones that they may feed in tide rips (Goodall, Norris, Galeazzi, Oporto and Cameron, 1988).

All of this suggests that the four species of *Cephalorhynchus* are coastal, generalised feeders. Future studies of food habits and perhaps direct observation of feeding methods should prove interesting.

RECOMMENDATIONS FOR RESEARCH

This study provides information on *C. commersonii* only in the southernmost part of its range. Similar studies along the coast of Patagonia, in the Strait of Magellan and the Falkland (Malvinas) Islands are needed to complete the picture. The impact of *C. commersonii* on various prey species is unknown.

Food habits of prey species should be studied throughout their range, and information is needed on their migratory movements. Benthic communities within the study area especially need to be examined.

Incidental and direct takes may be one of the major causes of dolphin mortality, and should be carefully monitored in the future.

The concept of management of whole ecosystems (Edwards, 1976; Gulland, 1977) should be the basis for studies of this and other cetacean species in the western South Atlantic.

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Flipper Serration in *Cephalorhynchus commersonii*

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ABSTRACT

Saw-tooth serrations were found on the leading edge of the left flippers of 32 of 66 (49%) specimens of Commerson's dolphin, *Cephalorhynchus commersonii*, beach-cast or taken incidentally in shore nets in Tierra del Fuego. No flipper serrations were found in neonates or juveniles but they were evident in physically subadult and mature animals. In this latter group, probably all sexually mature, 81% of the males and 36% of the females had serrated left flippers. Difference of left flipper serration between sexes was not statistically significant. The right flipper bore serrations only in four females (80% of those with serrated flippers) and one male (4%), always when already present to a greater extent on the left flipper. This difference was highly significant for females. Histological analysis showed no evidence of wear or damage; serrations seem the normal state for adults of this species. Serrations grow in length until the age of about six years, the approximate age of sexual maturity.

INTRODUCTION

During a study of specimens of Commerson's dolphin, *Cephalorhynchus commersonii*, stranded or taken incidentally in shore nets set on mud flats for *róbalo* (*Eleginops maclovinus*) and *merluza* (*Merluccius australis*) (Goodall, 1977; 1978; Goodall and Cameron, 1980; Goodall, Galeazzi and Lichter, 1988), it was noticed that many of the animals had an unusual series of serrations along the leading edge of the left flipper. Although some species of cetaceans have bumps or knobs on their flippers, saw-toothed serrations have not been reported in the literature. This paper analyzes the development of these serrations and examines their relationship to sex, age and maturity.

METHODS AND MATERIALS

Periodical surveys for stranded or incidentally captured cetaceans were made along the coasts of northeastern Tierra del Fuego from 1976–1985. Standard measurements were made of all animals (Norris, 1961) and tracings were made

Table 1

Specimens of *Cephalorhynchus commersonii* from the Tierra del Fuego collection which retained flippers, organized by physical maturity (O, fetus or neonate, 1, juvenile, 2, subadult, 3, adult), sex (M, male, F, female), age and left/right flipper serration (Y, yes, N, no)

RNP no.	Sex	Physical maturity	Age	Serration	RNP no.	Sex	Physical maturity	Age	Serration
1136N	-	0	0	N/N	0746	M	2	5	Y/N
0635	M	0	0	N/N	1105	M	2	6	Y/N
1158	M	0	0	N/N	0769	M	2	6	Y/N
					0619	M	2	6	N/N
0779	-	1	0–0.5	N/N	1040	M	2	6	Y/N
0577	F	1	0	N/N	0875	M	2	8	Y/N
0575	F	1	0	N/N	0415	M	2b	10–11	N/N
0633	F	1	0	N/N					
0740	F	1	0–0.5	N/N	0985	F	3	10	Y/-
0596	M	1	0	N/N	1055	(M)	3	12	Y/-
0773	M	1	0	N/N	1099	M	3	12	Y/-
1065	M	1	0	N/N	0648	M	3b	9	Y/-
0962	M	1	1	N/N	1053	-	3b	12	Y/N
0851	M	1	1	N/N	1136	-	3	13	Y/N
1106	M	1	1	N/N	1032	F	3	7–9	N/N
0966	M	1	-	N/N	1041	F	3	9	Y/Y
1107	M	1	2	N/N	0653	F	3	9	N/N
0871	M	1	2	N/N	0766	F	3	10?	Y/Y
0872	M	1	3	N/N	1039	F	3	18	Y/N
1142	M	1b	-	N/N	0634	F	3b	8	Y/Y
					1074	F	3b	12	N/N
0650	-	2	4	Y/-	0647	M	3a	9	Y/N
0632	M	2a	3	Y/-	0812	M	3	-	Y/N
0958	F	2a	4	N/N	0731	M	3	6	Y/N
1033	F	2	3	N/N	0620	M	3	7	Y/N
1034	F	2	4	Y/Y	0595	M	3	9	Y/N
0957	F	2	5	N/N	0885	M	3	9	Y/N
1043	F	2	6	N/N	0954	M	3	10	Y/N
1049	F	2	8	N/N	1073	M	3	10	Y/N
0680	F	2	9	N/N	0778	M	3	11	Y/N
0574	M	2a	0–2	N/N	0874	M	3	11	Y/N
0866	M	2a	2	Y/N	0956	M	3	14	Y/N
0961	M	2a	3	N/N	1048	M	3	15	Y/N
0576	M	2	3	N/N	0637	M	3	15	Y/N
0767	M	2	4	Y/N	0837	M	3	15	Y/Y
1054	M	2	5	Y/N	1141	M	3b	-	Y/N
1059	M	2	5	Y/N	1110	M	3b	17	Y/N
					0636	M	3b	12	Y/N

of flippers, dorsal fins and flukes. Attention was taken to mark on tracings where the serrations started and ended. X-rays were taken of most of the flippers; the serrations are often visible on the x-rays and can be measured.

The animals were aged through a study of tooth sections (Lockyer, Smellie, Goodall and Cameron, 1981; Lockyer, Goodall and Galeazzi, 1988). Skeletons were examined for physical maturity using the following classes: 0) foetus or neonate; I) juvenile animals with no fusion of vertebral epiphyses; II) subadults with some fusion; and III) physically mature adults, with complete fusion. Smallest animals in each class were marked a, largest b.

Chi-square, chi-square modified by Yates, and Student's T tests were used to analyse the presence of serrated flippers in relation to the physical maturity and sex of the specimens (eliminating those of unknown sex, without both flippers or of unknown physical maturity). Although serrated flippers were found on

Commerson's dolphins from other areas (Table 3), only those taken during our study in Tierra del Fuego were used in the analyses.

We attempted to determine a pattern for the development of the serrations by using a Serration Index: SI = (LS/LF + RS/RF)/2, where LS is the length of the serration on the left flipper (taken along the curve), RS is the length of the serration of the right flipper, LF is the anterior length of the left and RF of the right flipper.

Histological sections of serrations and normal flippers were made, stained and examined under a microscope with transmitted light.

Measurements were made (using photographs of x-rays) of the anterior and posterior length of flippers as well as the length of digits II and III (from the center of the uppermost border of the epiphysis of the first phalanx (metacarpal) to the lower border of the seventh in the case of digit II and the fifth in digit III). In order to compare the spacing of the serrations with teeth of animals of the same species, ten teeth on the middle upper right jaw were measured in a straight line tip to tip (n = 90 animals) and ten serrations were measured in a straight line from hollow (where the teeth might fit) to hollow (22 left and two right flippers).

RESULTS

The flippers of *C. commersonii* are black on both surfaces, with an elliptical outline and rounded tip. The skin is normally black, smooth and shiny. Nearly half the specimens found had serrations on the leading edge of the left flipper (Figs 1 and 2). The serrations are saw-toothed, fairly evenly spaced indentations (Fig. 2) of an opaque greyish-black colour, slightly lighter than the rest of the flipper, without the sheen of the normal black skin. The serration tissue is extremely hard and horny. Seen from the side, the notches form a regular saw-tooth edge. Seen in cross-section or from the front, the notches appear double, divided by a long continuous notch which splits the line of notches from top to near the bottom.

No parasites were found on the flippers. There were no tooth or scratch marks leading into the notches, although tooth holes and rake marks were found occasionally on other parts of flippers. The serrations seem to be cut into the leading edge of the flipper, rather than growths out from it.

The serrations are found only on the anterior edge of the flipper, following the natural contour (Fig. 1). The notching first begins on the mid-lower leading edge, about 2/3 of the way from the anterior insertion of the flipper to the rounded tip (Fig. 1).

Left-handedness

Sixty-six of 72 specimens found (including young) retained both flippers. Thirty-two of these (49%) had serrated left flippers. Right-flipper serrations were infrequent (5 animals) and appeared only when serrations already existed to a greater degree on the left (when right are serrated, both are serrated). This greater frequency of serrations on the left flipper was highly significant ($p < 0.001$).

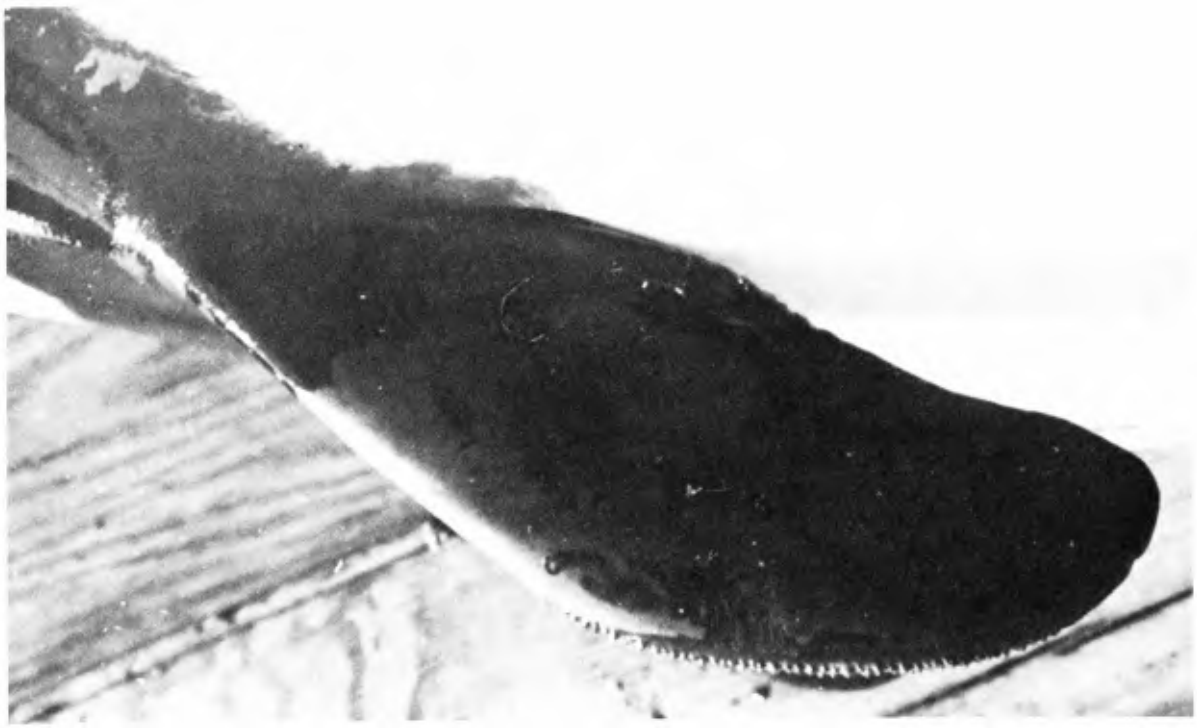

Fig. 1. Serrated left flipper of specimen USNM 395353.

Fig. 2. Detail of serrations on the leading edge of a dried flipper.

Relation to physical maturity

The notches are apparently related to maturity. An analysis was made of all animals (66, both with and without serrations) for which physical maturity status was known (Table 2). This selection included three animals of physical class 0, 16 juveniles (class I), 21 subadults (class II) and 26 physically mature animals (class III).

All of the neonates and juveniles had smooth pectoral fins. Ten of the 21 subadults had some serrations on the left flipper (and one of them on both); 22 of the 26 physically mature animals had serrations on the left flipper while four of these had serrations on both (Table 2).

Table 2

Summary of flipper state in specimens of *Cephalorhynchus commersonii* of known sex and physical maturity incidentally taken or beachcast in Tierra del Fuego. Animals show right flipper serration only when it is already present on the left. Sex was unknown for four animals. Sample size: 44 males, 18 females; total 66.

Physical maturity classes	Serration	Total animals	Observed frequency (No. animals) Males	Observed frequency (No. animals) Females	Physical maturity classes	Serration	Total animals	Observed frequency (No. animals) Males	Observed frequency (No. animals) Females
Class 0 neonates	none	3	2	-	Class II subadults	none	11	5	6
	left	-	-	-		left	10	9	1
	both	-	-	-		both	1	-	1
	Total	3	2	-		Total	21	14	7
Class I juveniles	none	16	11	4	Class III adults	none	4	1	3
	left	-	-	-		left	22	16	4
	both	-	-	-		both	4	1	3
	Total	16	11	4		Total	26	17	7
					Total	none	34	19	13
						left	32	25	5

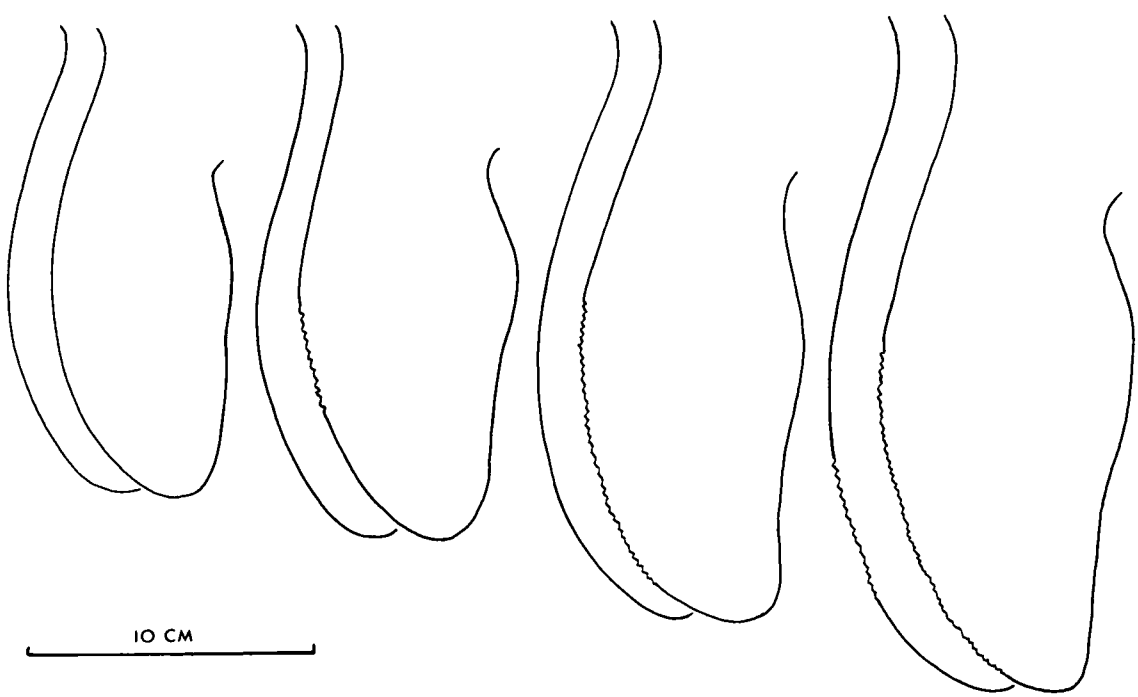

Fig. 3. Progression of formation of serrated edges of, left to right, (a) near term fetus, (b) subadult with serrations beginning, (c) very large subadult with nearly all vertebral epiphyses fused to centra, (d) 8 year old physically mature adult female with serrations to both flippers. All views of left side of body.

In the younger animals the serrated line was very short (i.e. just forming), while in adults the longest notched line measured 13.3cm along the slight curve of the flipper's leading edge (Fig. 3). Serrations appear and the row increases in length with the physical maturity of the animal ($p<0.05$).

Relation to age

The serration characteristic begins fairly early in the animal's life. The youngest animal with some serrations was a two year old male. Serrations grow rapidly

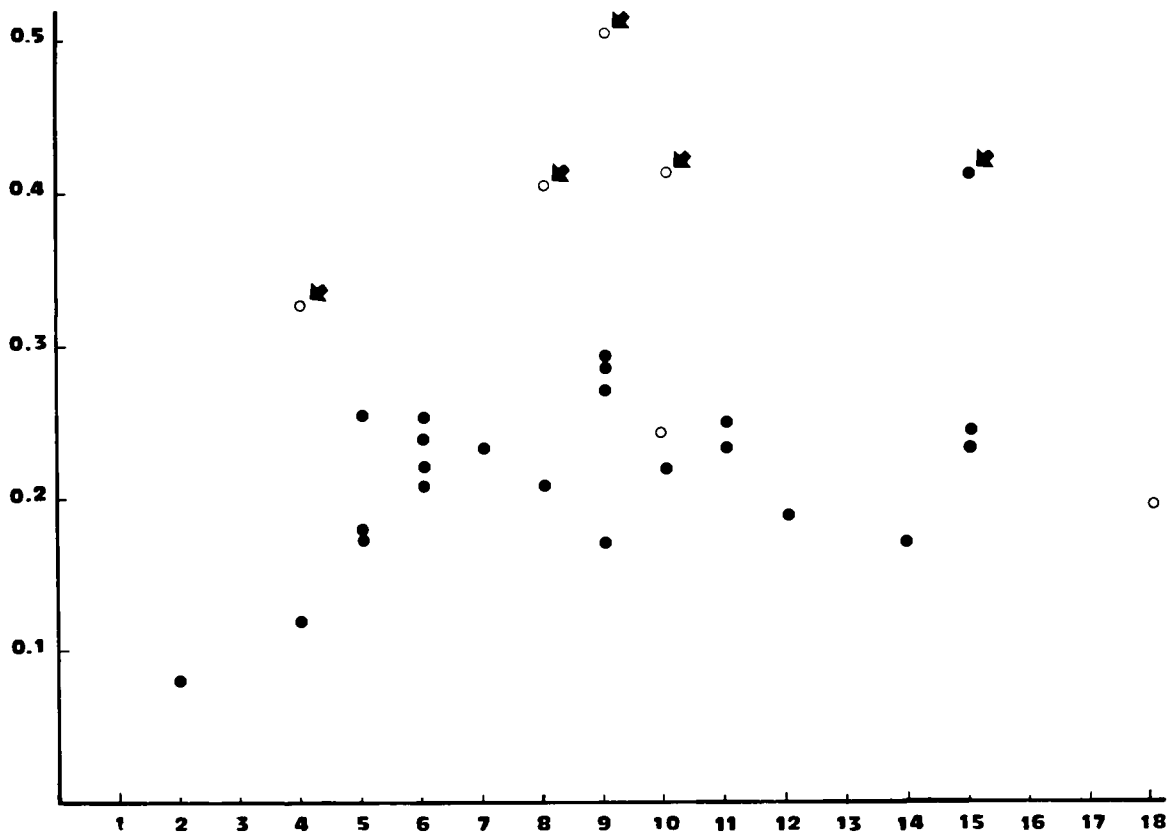

Fig. 4. The serration index of length of serrated edges on flippers plotted against physical age. Closed circles are males, open circles females. Arrows mark the animals with serrations on both flippers.

in subsequent years until about the age of five or six years (Fig. 4). Five years is the approximate age of sexual maturity (Lockyer *et al.*, 1988). All animals over 12 years of age (n = 6, all physically mature) had serrated flippers.

After five or six years, the length of serrated row does not increase (r = 0.3), but it does increase up to the age of six years (r = 0.7).

Serrations and sex of the specimen

The sample contained more than twice as many males as females at each maturity level: 44/18 in the total sample; 31/14 in subadults and adults (classes II and III) combined. The left flipper was serrated on 25(81%) of Class II and III males, but only one (4%) of those had both flippers serrated. Five of the 14 females in these classes (36%) had the left flipper serrated; four of those (81%) also had serrations on the right.

Incidence of serration in the left flipper was statistically similar in both sexes, but serration in both flippers is highly significant for females ($p < 0.01$).

Histological analysis

The normal epidermis on flippers of Commerson's dolphins was found to be thick and well stratified, being thicker on the leading edge of the flipper as has been found for bowhead whales (*Balaena mysticetus*) (Haldiman, Henk, Henry, Albert, Abdelbaki and Duffield, 1985). The epidermis within the serrations

Table 3

Incidence of flipper serration in specimens of *Cephalorhynchus commersonii* from collectors other than the Goodall team. These animals were not included in the statistical analyses. Key: BMNH = British Museum of Natural History, London; USNM = US National Museum, Washington DC; AAL = A. A. Lichter collection, Buenos Aires; CNP = Centro Nacional Patagonico, Puerto Madryn, Argentina.

Museum no.	Sex	Maturity	Age	Serration	Details
BMNH					Off Rio Gallegos. Rayner, in 1936
1952-6.20.4	F	3b	-	N/N	(lack of serration seen in photo)
USNM					
395353	M	2	7	Y/N	Norris, in Strait of Magellan, 1968
395352	F	2	7-8	N/N	
5500154	F	2?	-	N/N	Collected Puerto Deseado 1978 for Sunshine
5500155	F	3?	-	-/N	Aquarium. Confiscated in NY.
5500156	M	3?	-	Y/N	Taken to Mystic Aquarium.
-	F	-	-	Y/N	
Sea World	M	-	-	Y/N	One of 12 live-captured in St. of Magellan, 1984. (Leatherwood, pers. comm.)
Duisburg Zoo					
Yogi	M	3	-	Y/N	One of 6 live-captured at Puerto Deseado, 1978.
Pepe	M	3?	-	Y/N	One of 5 live-captured, Comodoro Rivadavia, 1980.
Buzo	M	?	-	Y/N	One of 6 live-captured, St. of Magellan, 1984.
-	M	-	-	N/N	
-	F	-	-	N/N	
AAL s/n	M	-	-	Y/N	Taken incidentally off Puerto Madryn, Chubut
AAL s/n	-	-	-	N/N	Argentina
CNP 030685-02	M	-	-	Y/N	
CNP 850823	F	-	-	Y/Y	146cm, with fetus

follows the rises and hollows of the serrations in a fairly uniform thickness; signs of tears or damage in the under layers are not evident, although there was some sloughing on the outer surface within the serrations of the fresh flipper.

Flipper size

Serrated left flippers seemed more robust than unserrated right flippers on the same animal. Although the direct exterior measurements were slightly longer in the serrated left flipper (n = 6), this was not statistically significant. Likewise, the bones of digit II (the longest) were slightly longer and more fully developed (epiphyseal fusion more pronounced) in the serrated left than in the smooth right flipper (n = 8), but this was not significant statistically.

DISCUSSION

It is evident that serrated flippers are common in this species and that they are a natural development of growth. The presence and extent of serration seems to provide a quick index to the maturity of the animal.

Flipper serrations in *C. commersonii* were first noticed by K.S. Norris who on 10 December 1968 wrote in his journal of R.V. *Hero* cruise 68-1 of capturing

one of these dolphins in the Strait of Magellan: 'It was a male and proved to have a peculiar serrated edge on its left pectoral. One wonders if this is a normal secondary sexual character, or simply an anomaly'. Such serrations were not mentioned by Moreno (1892), Bruce (1915), Harmer (1922), Hamilton (1952), Angot (1954), Spotte, Radcliffe and Dunn (1979) or Gewalt (1979), the only other authors to have fresh specimens until recently.

Animals with serrated flippers have been found at all areas along the Fuegian coasts and off Patagonia (Table 3). One male from the Strait of Magellan, now at Sea World, has a serrated flipper (S. Leatherwood, pers. comm.). One male of the four animals taken from Puerto Deseado (USNM 550156) by the Japanese in 1978 and later confiscated by authorities in New York had a serrated left flipper; one subadult female did not. The left flipper of Carmencita, another of the four animals, who lived four years at Mystic Aquarium, was missing when the carcass arrived at USNM (Goodall, pers. observation). As determined by a photograph, the large female taken by Rayner in 1932 off Río Gallegos (BMNH 1952.6.20.4) seemed to have smooth flippers (Brown, 1988).

Animals taken by the Duisburg Zoo (6 in 1978 from Puerto Deseado, 5 in 1980 from Comodoro Rivadavia and 6 in 1984 from the Strait of Magellan) were not examined for flipper serration (Gewalt, pers. comm.). Two frozen specimens from the 1984 group, a young male and female, had no serrations (Goodall, pers. observation). Three of these 17 animals, one male from each capture period (still alive in June 1984) all have serrations on the left flipper but none on the right (A.J. Goodall, pers. observation; R. Kroger, *in litt.* 4 August 1984). No serrations were found on 11 animals taken at Kerguelen, although some were adult (D. Robineau, pers. comm.). The serrations on Commerson's dolphin flippers were not especially noticed until tracings were made, and trainers at Duisburg Zoo thought their dolphins had no serrations until flippers were actually touched or seen in a certain light.

Occurrence in other species

Rough leading edges of the flippers are sometimes seen in other species which have strong intra-sexual contact (such as fighting), as in *Delphinus*, *Lagenorhynchus* or *Tursiops* (M.W. Cawthorn, pers. comm.). Raised tubercles are typical on the dorsal fins of *Phocoena spinipinnis* (Brownell and Praderi, 1985; Goodall, pers. observation) and are sometimes found to a lesser degree on the forward edges of flippers as well in this species and in *P. phocoena*. This is carried even further in *Neophocaena* spp., specimens of which have a row or rows of 'minute wart-like excrescences' on their back, where the mother seems able to carry the calf without it slipping off (Pilleri and Chen, 1979).

Within the genus *Cephalorhynchus*, raised or rugose nodules are seen in specimens of *Cephalorhynchus hectori* (Baker, 1978, p. 331; Slooten and Dawson, 1988). Best (1988) found 'serrations' on the leading edges of one or both flippers in 10 of 16 specimens of *C. heavisidii* examined, in sexually mature animals of both sexes (100% males; 60% females) and in immature males. As in *C. commersonii*, they were never found on the trailing edge. However, the serrations on Heaviside's dolphin were not cut in as in Commerson's dolphin, but stuck out beyond the line of the flipper, like 'imperfections found at mould

joints after casting'. These serrations did not contain scar tissue and seemed to be natural, of unknown 'causation and function'.

Serrations have not been mentioned as yet for *Cephalorhynchus eutropia* (Goodall, Norris, Galeazzi, Oporto and Cameron, 1988) but it may be possible that future examination may reveal them.

Possible uses of serrations

Most cetologists we questioned had never seen such serrations and did not know what to make of them. Some believed that they looked like abrasions but others considered them a secondary sexual characteristic, which might be involved in courtship or other sexual behaviour. The following ideas or suggestions emerged from discussions with a number of colleagues.

Tactile use

Although these serrations seem rather sharp for such purposes, many cetaceans have been observed to 'caress' as part of sexual stimulation in 'grooming' behaviour. Commerson's dolphins at Sea World frequently use their flippers for tactile stimulation, 'vibrating' the front edge of the flipper across the body, the genital slit or flippers of other animals (W.E. Evans, L.H. Cornell, pers. comms). It has also been suggested that adults may massage the teeth of young to help in teething. Although we found the spacing of serrations of adult flippers to be similar to that of teeth of juvenile Commerson's dolphins, a direct relationship could not be established.

Defence and aggression

The serrations could act as a formidable weapon when used to rake or strike a glancing blow and their possession may have some dominance signal value. Commerson's dolphins at Sea World have been seen to use their flippers aggressively (L.H. Cornell, pers. comm.) and rake marks (source unknown) have been seen on dolphins.

Visual display

In addition to acting as a dominance signal, another possibility is that a jagged flipper might produce finely divided trails in the water (see bioluminescent trails illustrated by Wood, 1973, p. 189). Having them on one side might act as a guiding mechanism to other individuals.

Feeding adaptations

Serrated flippers might be used in fanning sandy or silty sea floors to stir up food items. Commerson's dolphins live mainly over shallow continental shelves and are known to take many bottom organisms (Bastida, Lichtschein and Goodall, 1988; Robineau and Duhamel, 1984). Favouring one side is known in other cetaceans; the gray whale sucks up invertebrates from the bottom through the right side of its mouth, leaving it abraded (Pivorunas, 1979; Oliver, 1983). Commerson's dolphins in captivity at Sea World showed no side-swimming but frequently swam upside down and were able to maintain a constant distance from the bottom (Evans and Cornell, 1985; Cornell, Antrim, Asper and Pincheira, 1988; S. Leatherwood, F. Wood, pers. comms).

Swimming adaptations

The serrations may assist the calf in riding a parent's flipper, seen in several species (L. Cornell, pers. observation). Dolphins of various ages at Sea World were seen to glide along behind another animal, 'resting' or touching a flipper on the flukes of the animal in front (Goodall, pers. observation); this seems to be common behaviour (aquarium attendants, pers. comms). Perhaps the lower edge of the serrations provides enough traction to give the posterior animal a short ride.

We can only speculate as to the 'causation and function' of these unusual serrations. Detailed observations in the wild should provide many more clues.

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High Frequency Pulses Produced by Free-Ranging Commerson's Dolphin (*Cephalorhynchus commersonii*) Compared to those of Phocoenids

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ABSTRACT

Phocoenoides dalli, a high latitude, Northern Hemisphere littoral/pelagic phocoenid, and *Cephalorhynchus commersonii*, a high latitude, Southern Hemisphere littoral delphinid, live in coastal waterways at opposite ends of the world and are convergent in body form and coloration. Both produce very similar high frequency narrowband pulses. If, as believed, these signals are used for echolocation, they may be specialised for finding moving prey or prey living on or near the bottom and among acoustic clutter. Past studies with *Phocoena phocoena* have indicated they can detect 0.1 – 0.2 mm diameter monofilament nylon fiber. This infers that monofilament drift nets made of similar material could be perceived. Disregarding the nets as non – prey targets may explain why thousands of porpoises become entangled each year in gill nets. There are records of Commerson's dolphins becoming entangled in similar nets. Because their acoustic signals are similar to those of phocoenids (especially *Phocoenoides dalli*), we speculate that mortality from entanglement and drowning in gill nets will continue as a significant problem for *Cephalorhynchus* as well as phocoenids.

INTRODUCTION

Although Evans (1973) had suggested that odontocete echolocation pulse waveforms and energy density spectra might differ among species as a function of the acoustical characteristics of their habitat and type of prey species, until recently all pulses or clicks known to be used for echolocation were short duration (50 to 100 μs) and broadband (up to 150 kHz), with peak energy at 15 to 120 kHz, depending on species. Typical pulse waveforms and energy density spectra for species experimentally demonstrated to use echolocation are

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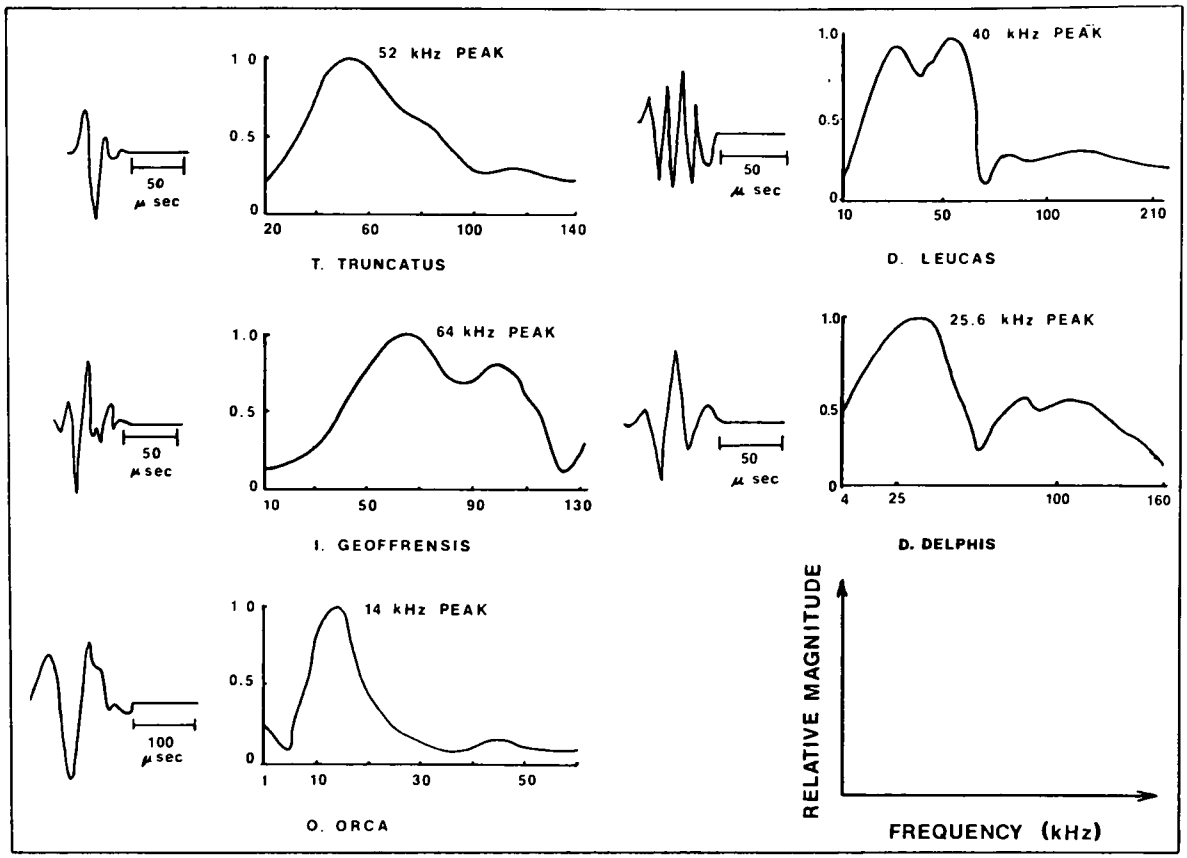

Fig. 1. Representative pulse waveforms and associated spectra for odontocete cetaceans.

presented in Fig. 1 (Wood and Evans, 1980). Møohl and Andersen (1973) described very narrowband pulses (10 to 15 kHz wide, peak frequency 128 kHz) produced by the harbor porpoise (*Phocoena phocoena*). The duration of those pulses was relatively long (200 to 400 μs). This confirmed earlier work by Dubrovskiy, Krasnov and Titov (1970). In 1979, Dubrovskiy (pers. comm.) demonstrated that the harbor porpoise could use these pulses to detect 0.1 mm diameter nylon filaments. This is slightly better than demonstrated for a blind – folded *P. phocoena* (0.2 mm) in the experiments by Busnel and Dziedzic (1966). Close examination of pulses produced by the Dall's porpoise, *Phocoenoides dalli*, revealed that this species produces pulse waveforms similar in duration and energy density spectra to those of the harbor porpoise (Awbrey, Norris, Hubbard and Evans, 1979). These narrow – bandwidth pulses with peak energy above 120 kHz were postulated by Purves and Pilleri (1983) to be produced exclusively by phocoenids.

The idea that phocoenids and delphinids had distinctly different high frequency signals was disproved when Kamminga and Wiersma (1981; 1982) and Shochi, Zbinden, Kraus, Gihr and Pilleri (1982) reported on the waveform and spectra of pulses produced by specimens of the delphinid, *Cephalorhynchus commersonii*, being maintained at the Duisburg Zoo, Duisburg, Federal Republic of Germany. The recording system was limited beyond 150 kHz. Using 1/3 octave band analysis they described narrowband pulses with peak frequencies of 124 kHz to 130 kHz and 120 to 180 μs durations. The pulse waveforms and spectra are comparable to those described earlier for the Dall's porpoise (Awbrey *et al.*, 1979).

High-resolution time and frequency analysis of sounds from Commerson's

dolphins held at Sea World, San Diego, although similar to those recorded at Duisburg Zoological Park, revealed frequency modulated components and spectral contributions up to 300 kHz (Hackbarth, Awbrey and Evans, 1985). Since it had been speculated that cetacean vocalisations in captivity are significantly different from those in the wild, we mounted an expedition to the areas around Punta Arenas, Chile and the Falkland Islands to record the sounds of wild *C. commersonii*. This paper reports on the emissions of free–swimming Commerson's dolphins that are investigated with the same high–resolution method as the sounds from free–swimming Dall's porpoises and captive Commerson's dolphins.

METHODS

The recording locations for both species are indicated in Fig. 2. The system used to record the two groups of six to eight Commerson's dolphins encountered just outside Stanley Harbour, East Falkland Island, was the same one used for

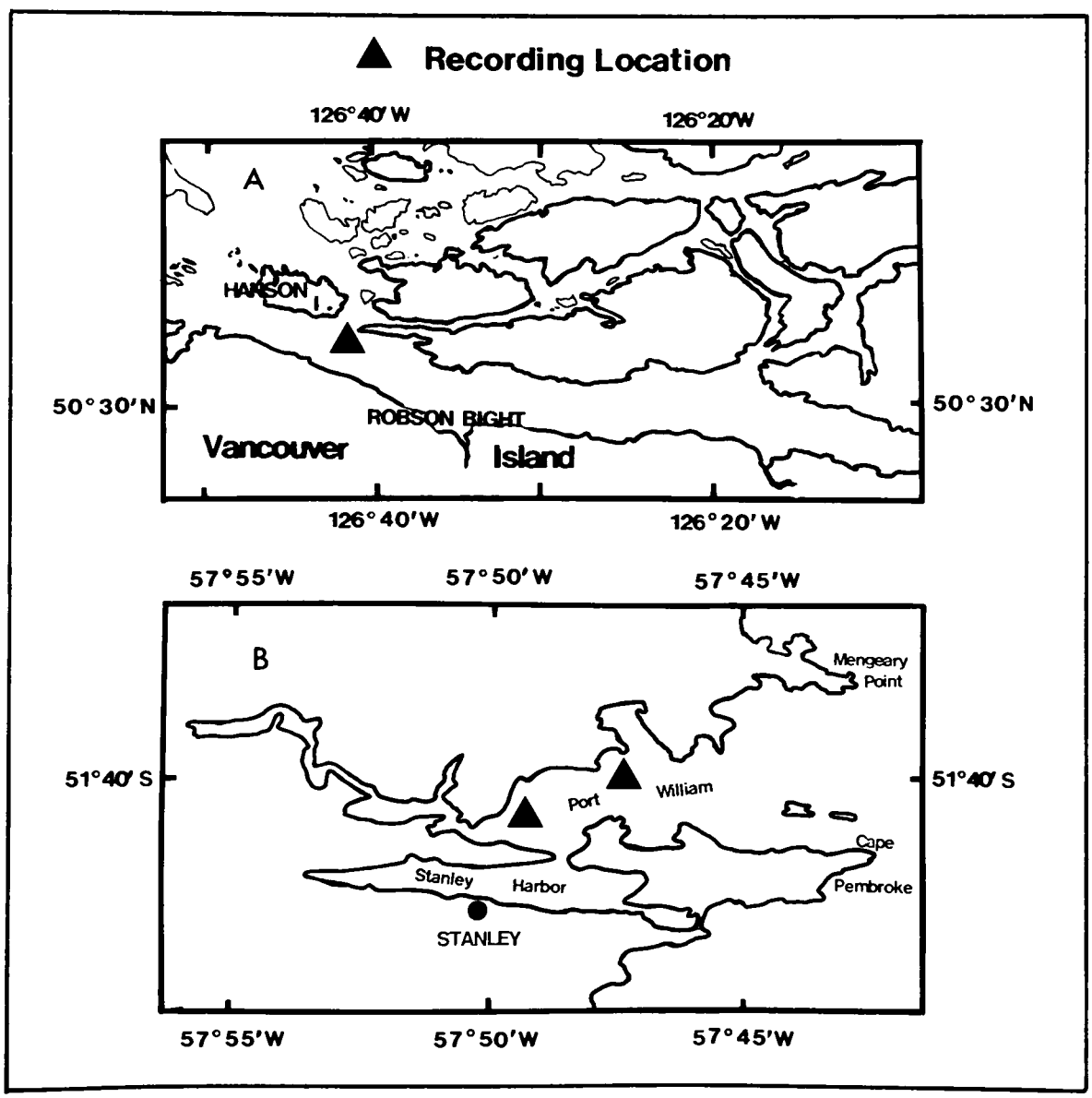

Fig. 2. Field recording locations for Dall's porpoise (*Phocoenoides dalli*) near Hanson Island, British Columbia, Canada (A) and Commerson's dolphins (*Cephalorhynchus commersonii*) near the entrance to Stanley Harbour, East Island, Falkland Islands (B).

recording the high frequency sounds of one group of 30–40 Dall's porpoises recorded between Hanson Island and Vancouver Island, British Columbia, Canada (Awbrey *et al.*, 1979). It consisted of a *Racal Store* 4 tape recorder, operated at 152.4 cm/s (60 ips), a *Bruel and Kjaer* 8103 hydrophone and a *Princeton Applied Research* model 113 preamplifier. All signals were recorded on two separate channels set 20dB apart to avoid saturation. This battery–operated system has a flat response (±3dB) from 300 Hz to 150 kHz. The upper end is limited by the frequency response of the hydrophone (−10dB at 200 kHz). We were not able to record *C. commersonii* in the coastal waters adjacent to Punta Arenas due to weather and time constraints.

An initial analysis of the vocalisations of free-swimming Dall's porpoise and free-swimming Commerson's dolphin, using a *Spectral Dynamic* SD 345 real–time spectrum analyser, indicated even greater similarity between pulses of the Dall's porpoise and those of the Commerson's dolphin than previously noted. For greater resolution and more flexibility in sound comparison, these signals were analysed by computer. This assured the comparability to previous sound analysis from captive Commerson's dolphins, where the same system was used (Hackbarth *et al.*, 1985). The analog tapes were played back at 1/32 of the recording speed, amplified by 10 to 20 dB when necessary, digitised (LPA–11 analog-to-digital converter, 12 bit resolution over ± 5V amplitude range) at 25 kHz for an effective 0.8 MHz sampling rate, and fed into a VAX 11/750. The analysis program was the Interactive Laboratory System V4.2 (Signal Technology, Inc.). The spectrograms represent the magnitude of the spectral energy density of overlapping 40 μs long, Hamming-weighted signal segments every 5 μs. Effective frequency resolution for the energy density spectra is 1.5 kHz.

RESULTS

Dall's porpoise vocalisations are presented in Fig. 3. A typical single pulse (Fig. 3a) is about 500 μs long, slightly amplitude–modulated every 85 μs and fades out very slowly. The spectrum is extremely narrowband. Its peak at 134 kHz lies 50 dB above mean level. At the points 30 dB below the peak it is only 5 kHz wide. A second peak 30 dB below the main peak appears at 147 kHz. Spectrogram analysis of the first 320 μs reveals a slight initial downward frequency modulation.

Each component of a double pulse (Fig. 3b) is only about half as long as a single pulse and may show considerable amplitude modulation. The first component shows more spectral broadening above the dominant frequency of 139 kHz than the second component because of its more pronounced frequency modulation and higher harmonics at the beginning.

A typical Commerson's dolphin's pulse is presented in Fig. 4. As shown here, the first 100 μs long amplitude mode very often is prominent in the 350–500 μs single pulses. The spectrum in Fig. 4 shows a maximum of sound energy around 133 kHz. The 17 kHz bandwidth measured 30 dB below the peak and the spectral sidelobe around 262 kHz, both are consequences of initial downward frequency modulation and prominent harmonics. Free-swimming Commerson's dolphins also produce double pulses. As has been observed for most species

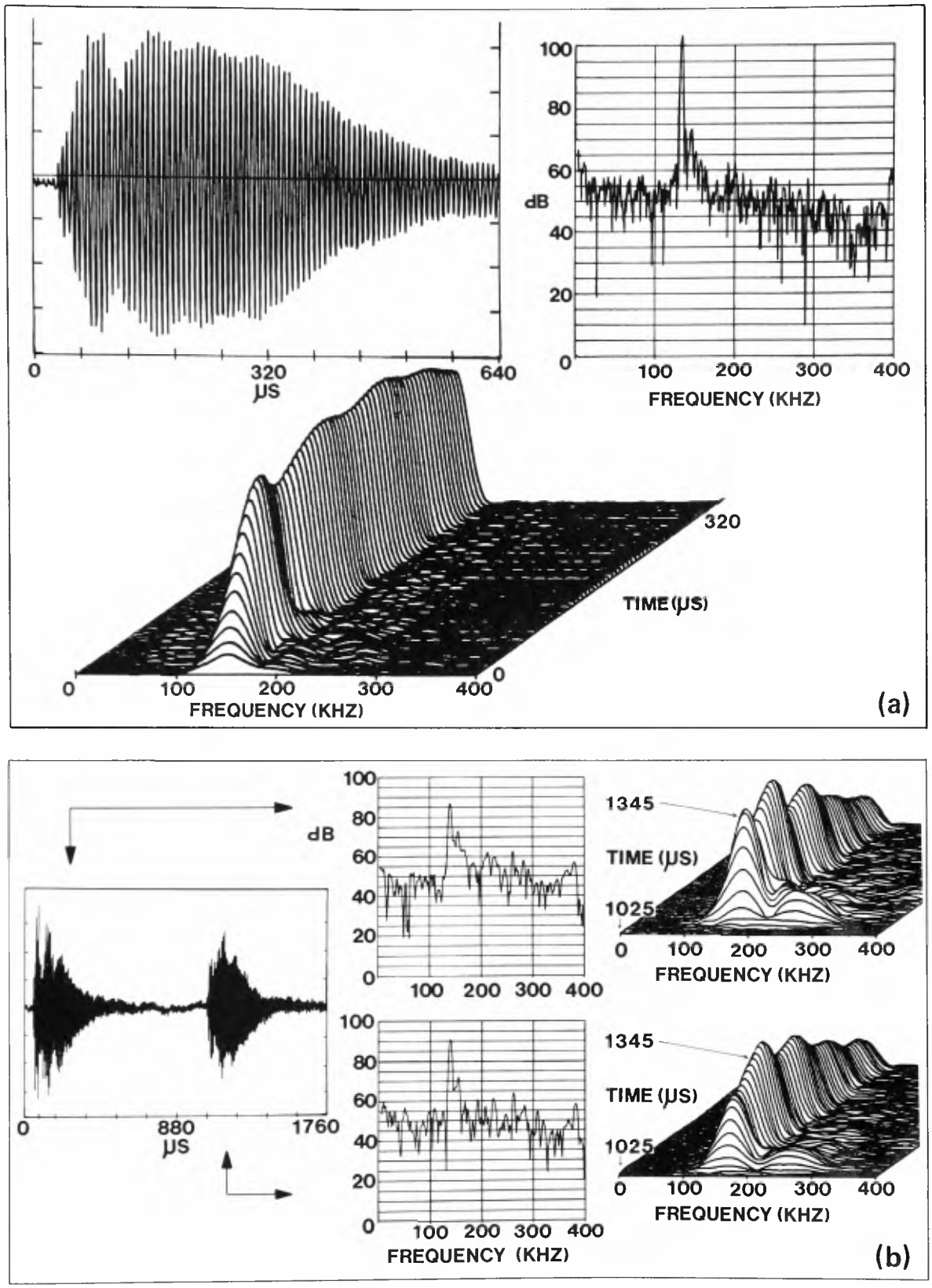

Fig. 3. Vocalisations of free-swimming Dall's porpoise (a: a single pulse, b: a double pulse). Shown from left to right are the waveforms in relative amplitude, the energy density spectra in dB relative to the energy density at bottom line, and the spectrograms with the amplitude density in arbitrary units.

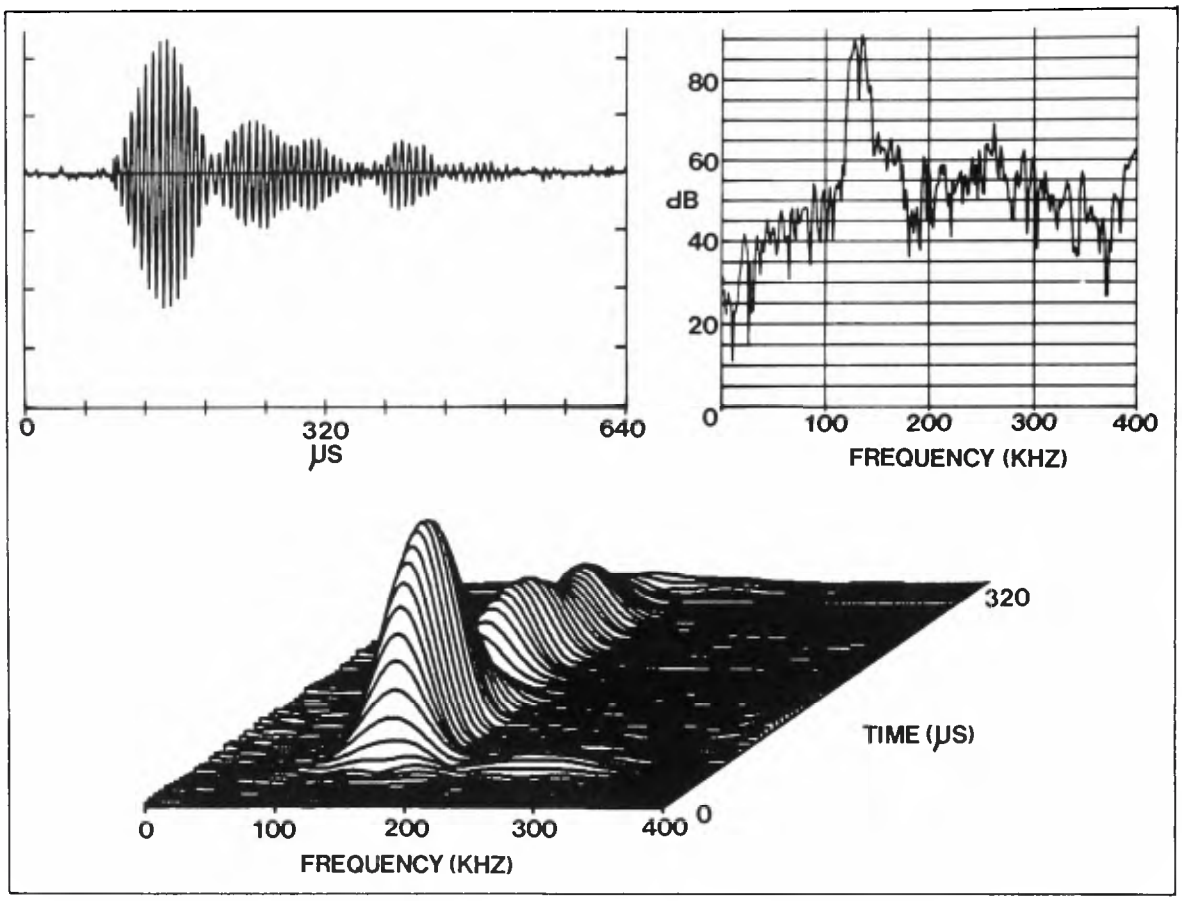

Fig. 4. Analysis of a single pulse emitted by a free swimming Commerson's dolphin. The scaling for the waveforms, energy density spectrum and spectrogram, respectively, is as for Fig. 3.

producing high frequency pulses, the field is very directional. In the case of both Dall's porpoise and Commerson's dolphin, the head of the individual being recorded had to be pointed directly at the hydrophone $\pm 5°$ for reception of signals presented in Figs 3 and 4.

DISCUSSION

The comparison of Figs 3 and 4 reveals a remarkable conformity between vocalisations of Commerson's dolphins and Dall's porpoises. This leads us to the question whether their peculiar high frequency, narrow bandwidth echolocation signals might also make the Commerson's dolphin susceptible to entanglement in gill nets. Awbrey, Norris, Hubbard and Evans (1979) postulated that the nature of their echolocation signals could explain some of the incidental take of the harbor porpoise and the Dall's porpoise in the North Pacific salmon gill net fishery (Jones, 1984).

The unusually narrow bandwidth centered around a relatively high frequency between 120 and 140 kHz raises the question about its theoretical advantages for echolocation in the natural environment of the animals. This kind of signal is properly suited to carry precise Doppler information in its echo, and energy concentration within a narrow frequency band enhances the signal-to-noise ratio if the echo is hidden in broadband interference. An appropriate sonar receiver, e.g. a bank of narrowband neuronal filters tuned to center frequencies

around 120 to 160 kHz, would enable detection (and identification) of fast–moving prey, such as squid. Although the target strength of a non–moving squid is very low, its jet-propulsive movement (Gosline and DeMont, 1985) disturbs the water and so might yield considerable echo amplitude when acoustically illuminated by a sonar pulse. The Doppler shift in the carrier frequency could probably evoke the dolphins's attention.

Commerson's dolphins eat mainly fish and a variety of invertebrates that live on and near a cluttery sea bottom (Bastida, Lichtstein and Goodall, 1988; Goodall, Galeazzi, Leatherwood, Miller, Cameron, Kastelein and Sokrol, 1988). Here the short wavelength of a 130 kHz signal could serve to resolve structural surfaces if the information processing is adequate. Commerson's dolphins might also ensonify their environment with pulses of wider bandwidth as has been shown recently for captive animals (Hackbarth *et al.*, 1985). Pronounced frequency modulation and numerous phase shifts broaden the energy density spectrum considerably, as shown in Fig. 5.

These considerations and the experimental results discussed earlier (Busnel and Dziedzic, 1966; Dubrovskiy, pers. comm.) lead us to infer that odontocetes using these signals might be able to "perceive" gill nets in spite of the low target strength of static monofilament material. Emitting narrowband pulses while hunting, they might only be alert for the detection of Doppler shifts in echoes from moving prey and generally be ignoring returning signals that are altered in a different manner.

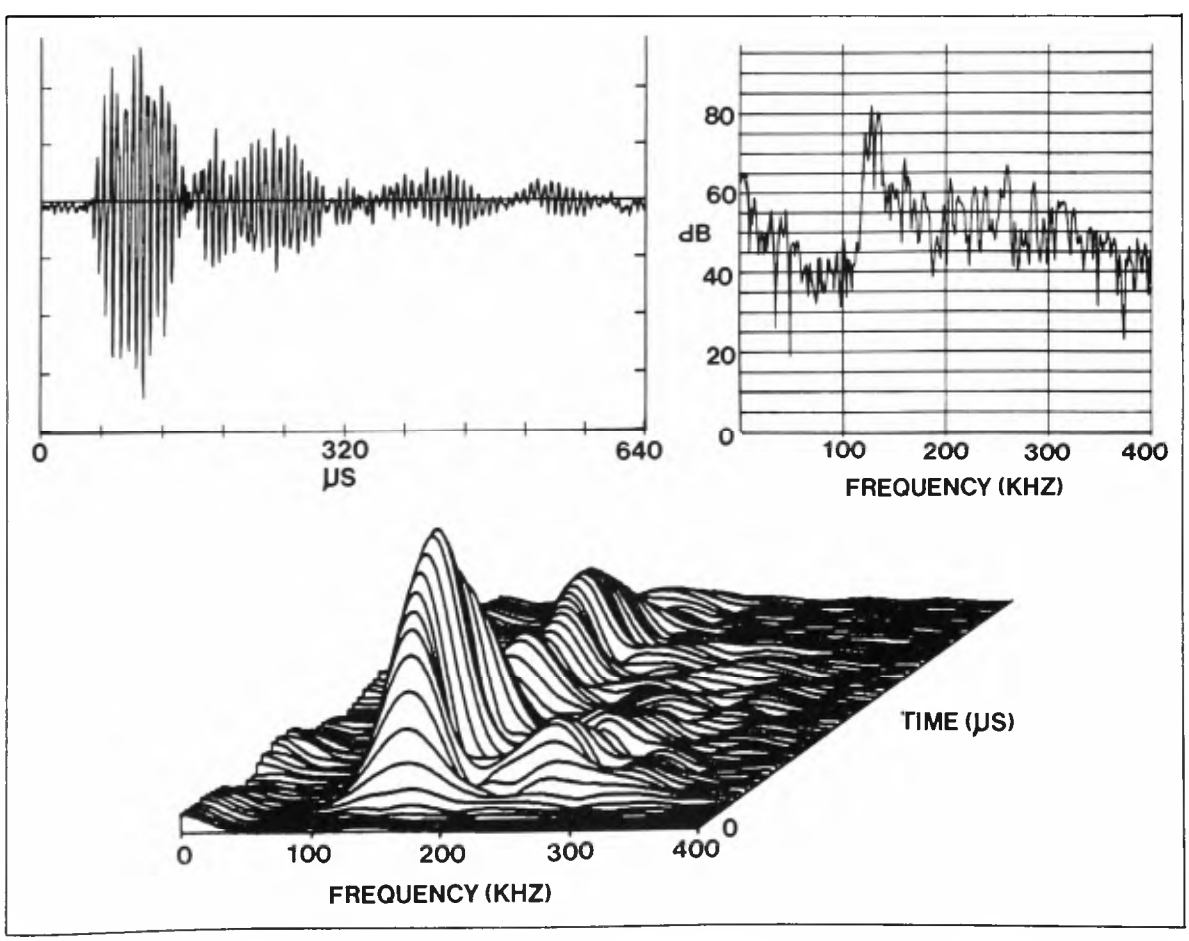

Fig. 5. Waveform, energy density spectrum and spectrogram of a single pulse emitted by a captive Commerson's dolphin. Scaling as in Fig. 3. From Hackbarth *et al.*, 1985.

The hypothesis of non-awareness as reason for net entanglement can be supported by comparison with an airborne sonar system. Bats seem to establish a spatial memory that completely dominates the echolocation system in a well-known environment where they do not expect new obstacles. Schnitzler and Henson (1980) suggested an "attention gate" that is "closed for obstacle information but open for prey detection".

We know that porpoises are seriously affected by the North Pacific gill net fishery (Jones, 1984). If the nature of their echolocation system is a factor it may also be a problem for the Commerson's dolphin, and perhaps all species of the genus *Cephalorhynchus*.

ACKNOWLEDGMENTS

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Commerson's Dolphins (*Cephalorhynchus commersonii*) Live-captured from the Strait of Magellan, Chile

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ABSTRACT

Twelve Commerson's dolphins (five males and seven females), collected off Punta Sara, Chile in November/December 1983 were transported to the Sea World facilities in San Diego, California. Males ranged from 124.5–144cm ($\bar{x}=136.3$) and 33.8–40.4kg ($\bar{x}=36.6$), females from 139–146.5cm ($\bar{x}=143.2$) and 35.4–44.5kg ($\bar{x}=39.7$). Animals were collected with breakaway hoopnets as they rode the bow wave of the collecting boat, held for 7–16 days in temporary holding pools where they were conditioned to accept dead fish and then transported to San Diego. There, housed alone or adjacent to false killer whales or beluga whales, the animals acclimated to captivity, taking 3–4kg of Atlantic herring daily. These dolphins are tractable and trainable and are subjects of various biological and behavioral studies. Frequent copulations resulted in pregnancies and three successful births. There are at present seven animals in the colony and further pregnancies have been confirmed. Collection, transport and acclimatization techniques are described. Basic measurements, information on reproductive status, husbandry (including feeding regimes, normal blood values, and parasites) and some aspects of behavior are reported.

INTRODUCTION

Until very recently there has been little information published on Commerson's dolphins, *Cephalorhynchus commersonii*, known in southern South America as *tonina overa*. The species occurs from about Península Valdes, Argentina, southward to Drake Passage (including waters in Tierra del Fuegian inlets, bays and fjords, and the Strait of Magellan to near Punta Arenas), around the Falkland Islands (Islas Malvinas), and around Kerguelan Island (Fig. 1) (for review see Goodall, Galeazzi, Leatherwood, Miller, Cameron, Kastelein and

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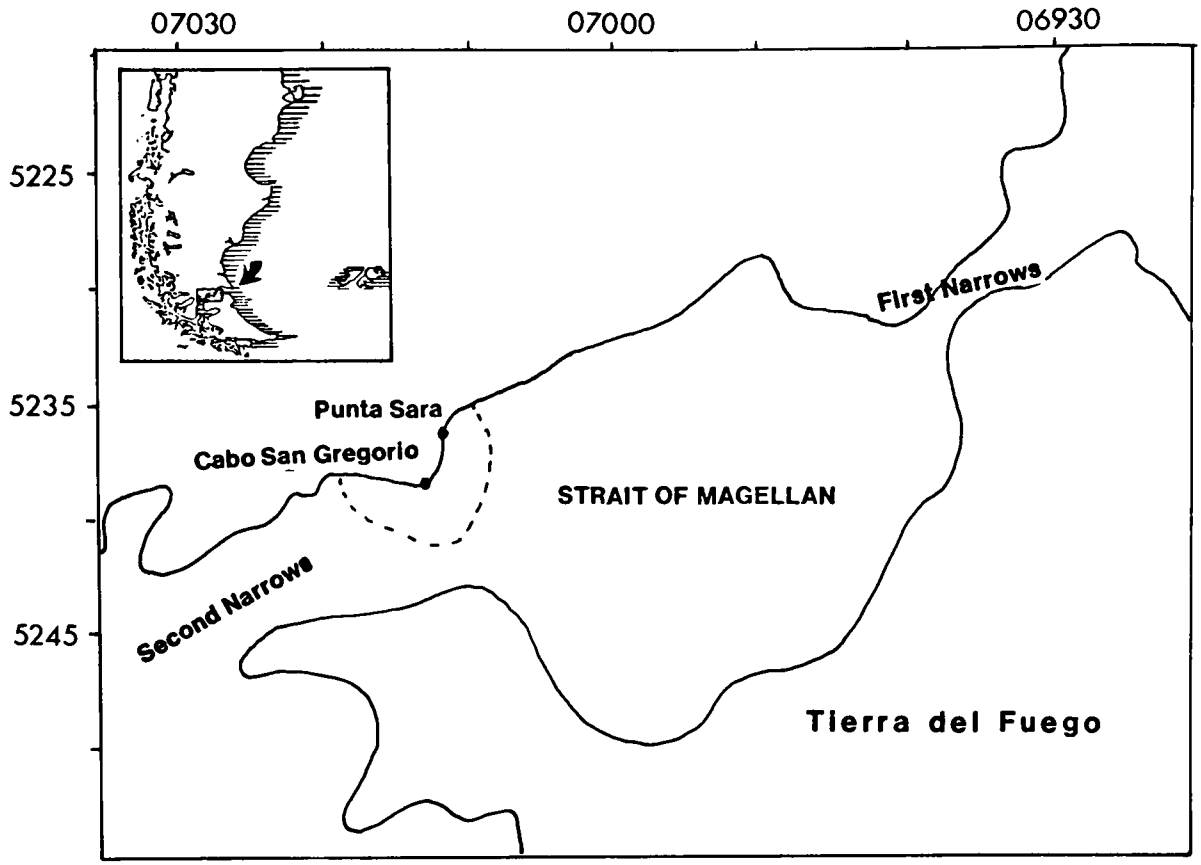

Fig. 1. Southern South America (inset) and a portion of the northern Strait of Magellan, showing the area where Commerson's dolphins were collected.

Sobral, 1988). Dolphins of this species are known to have been killed in directed fisheries or incidentally around the Falklands (Bruce, 1915; Harmer, 1922) and in both Argentine and Chilean portions of their range (Sielfeld, Venegas and Atalah, 1977a and 1977b; Goodall, 1978; Goodall and Cameron, 1980). Annual mortality in the late 1970's may have been as high as 2,400 animals (Sielfeld and Venegas, 1978; Goodall and Cameron, 1980). Although dolphins have been protected by law in Argentina since 1974 (Goodall and Cameron, 1980) and in Chile since 1977 (Sielfeld *et al.*, 1977b), as elsewhere, such laws have proven difficult to enforce and mortality of undetermined magnitude continues (Leatherwood, Kastelein and Miller, 1988b). Commerson's dolphins and Peale's dolphins, *Lagenorhynchus australis*, have been most frequently killed, although black or Chilean dolphins, *C. eutropia*, are increasingly taken as fisheries shift to the Western Strait of Magellan.

In 1983, representatives of the Chilean Ministry of Fisheries and the University of Chile, Santiago, concerned about effects of these mortalities on Commerson's dolphin populations, requested that Sea World co-operate with them in a long-term study of the status and basic biology of Commerson's dolphins in Chilean waters. Joint expeditions, involving Sea World and Chilean government personnel, were made to the eastern Strait of Magellan, between Punta Arenas and Punta Dungeness, between April and July 1983 and in November/ December 1983. In planning and subsequent field work Sea World staff were joined by representatives from Sea World Research Institute, Hubbs Marine Research Center, the veterinary college of the University of Chile and

the Patagonian Institute (see Leatherwood, Kastelein and Hammond, 1988a; Leatherwood *et al.*, 1988b; Goodall *et al.*, 1988).

Plans were made to maintain a breeding colony of Commerson's dolphins in San Diego. Accordingly, Sea World applied for and received permits from the United States and Chile for collection, export and import of 12 dolphins.

C. Venegas (*in. litt.* to W.E. Evans, 6 January 1983) reports that several thousand Commerson's dolphins probably inhabit Chilean waters. Observations made from shore, boat and aircraft during the 1983 reconnaissance surveys suggested that Venegas' estimate was conservative. Aerial surveys conducted in January and February 1984, using randomized transects to estimate population size in portions of the eastern Strait and reconnaissance surveys to define range and relative abundance elsewhere in Chile, reinforced these impressions. (See Leatherwood *et al.*, 1988a, 1988b).

This paper describes the collection, transport and captive acclimation of Commerson's dolphins, summarizes preliminary information on captive growth, reproduction, nutrition, hematology, parasitology and behavior and outlines plans for future research.

METHODS AND RESULTS

Collection and initial captive acclimation

Commerson's dolphins were seen in abundance near Punta Sara (Fig. 1) during 1983 reconnaissance surveys. Accommodation for personnel and collecting vessels was available nearby at the Empressa Nacional del Petroleo (ENAP) oil company camp. A field team was assigned to Punta Sara to search for, collect, care for and transport the animals.

Despite high winds and generally hostile weather, 12 animals were collected between 24 November and 2 December 1983 (Table 1). Gewalt (1979) had reported, based on experience in eastern Argentina, that Commerson's dolphins 'are very swift and flexible swimmers and though they sometimes swam very near our boat, it was quite impossible to catch them with a sling, a net or by hand'. Further, prior expeditions by Gewalt and others had collected Commerson's dolphins only with beach seines in shallow water (Gewalt, 1979; 1981; Goodall and Cameron, 1980; Goodall *et al.*, 1988). Contrary to that experience, we found Commerson's dolphins in the Strait of Magellan to be eager bow riders. All 12 animals were collected from the bow of F/V *Nautilus I*, a 13m fishing boat chartered at Punta Arenas, using breakaway hoopnets as described and illustrated by Ridgway (1972), Asper (1975) and Leatherwood and Reeves (1982) (see Fig. 2). Once aboard the vessel, animals were placed on foam pads and kept wet for the short trip to the pier at Punta Sara.

The collection process was uneventful, largely because these dolphins exhibited no aversion to boats. They were observed to ride bow, stern and beam waves of boats of all sizes, from freighters and tugs to small motorized skiffs. In addition, the animals were observed riding wind waves almost daily. (Such wind-wave riding behavior was also observed in our temporary holding pens). Commerson's dolphins have also been reported wave riding on ground swells in deep water and breaking waves near shore (Goodall *et al.*, 1988).

Table 1

Commerson's dolphins collected off Punta Sara, Chile, 1983. PSU = Portland State University. * = measurements taken during postmortem examination.

ID	Date collected	Sex	Length (cm) 4 May 1984	Weight (kg) 29 Mar 1984	Weight (kg) 4 May 1984	Location	Date of death
Cc 1	24 Nov 1983	Male	137	38.1	43.5	Sea World	-
Cc 2	24 Nov 1983	Female	141	37.6	39.0	Sea World	-
Cc 3	25 Nov 1983	Female	145	43.5	43.9	Sea World	18 Jun 1984
Cc 4	25 Nov 1983	Female	142	39.5	41.3	Sea World	-
Cc 5	27 Nov 1983	Male	141	40.4	40.8	Sea World	-
Cc 6	30 Nov 1983	Male	135	34.0	38.1	Sea World	-
Cc 7	01 Dec 1983	Female	144	37.6	40.4	Sea World	-
Cc 8	25 Nov 1983	Female	146.5*	44.5*	-	Sea World	5 Feb 1984
Cc 9	29 Nov 1983	Male	144*	-	-	PSU	13 Dec 1983
Cc 10	01 Dec 1983	Female	139*	-	-	PSU	13 Dec 1983
Cc 11	02 Dec 1983	Male	124.5*	33.8*	-	Sea World	19 Dec 1983
Cc 12	02 Dec 1983	Female	145*	35.4*	-	Sea World	21 Dec 1983

Fig. 2. Commerson's dolphins in the bow-wave of the F/V *Nautilus I*, the hoop-net in readiness for capture (Sea World photo).

From the pier at Punta Sara the collected dolphins were placed on cradles of thick (12cm) foam rubber, transferred to the bed of a pickup truck and driven 70km to Cabeza del Mar. During the transport they were kept moist with water sprayers. Their skin was protected from dehydration with a lanolin-based ointment.

Once at Cabeza del Mar the animals were released into an ocean pen approximately 20m in diameter and 1–2m deep. The pen was constructed of chain link fencing attached to small steel pilings driven into the bay floor (see Fig. 3). *Peccary*, a local fish similar to large smelt, were offered immediately. Some dolphins began feeding within a few hours. All were feeding well within a week and showed no apparent ill effects from collection activities during the

Fig. 3. Commerson's dolphins being fed in the holding pen at Cabeza del Mar (Sea World

Fig. 4. Closeup of a *tonina overa* awaiting transport. These handsome dolphins readily adapted to confinement (Sea World photo).

time at Cabeza del Mar. The dolphins each ate about 3kg of fish per day (Figs 3 and 4). Water temperature in the pens at Cabeza del Mar ranged from 7–15°C, varying primarily with available sunlight and tidal exchange.

Transport to the United States

For transport to the United States each dolphin was placed in a cotton-lined nylon stretcher, custom tailored to its body shape and equipped with open-cell

Fig. 5. The dolphins in stretchers and transporters on board a Chilean Air Force 707 *en route* Punta Arenas to San Diego (Sea World photo).

foam at points of contact with sensitive parts of the body (e.g., near the flippers and around chin and eyes). Stretchers were suspended in watertight fiberglass transport units with open tops (2m long, 1m high and 0.7m wide). The stretchers supported much of the animal's body weight; fresh water within the transport units provided additional support and cooling during transport. The animals were trucked to Punta Arenas airport and flown to San Diego aboard a Chilean Air Force Boeing 707 (Fig. 5). During the flight, air and water temperatures were maintained at 7°C. The animals were attended continuously during transport. After arrival at San Diego International Airport the dolphins were trucked the short distance to Sea World.

Acclimation

The dolphins were maintained for the first 6 months in an enclosure consisting of two 12 × 12 × 3m (453,600 l) filtered sea water pools joined by a 4 × 8 × 2.3m (64,000 l) examination pool, separated from both larger pools by gates. They were maintained alone or next to false killer whales, *Pseudorca crassidens*, and a beluga whale, *Delphinapterus leucas*. Ambient water temperature in the outdoor enclosure at Sea World varied between 14.5 and 24°C.

On 22 June 1984 the animals were transferred to a covered facility with a square concrete pool 12.8 × 12.8 × 3.9m (707,750 l) adjoined by a trapezoidal holding pool (49,900 l) to the main pool. They remain there at present, except for isolation of pregnant females near and after time of delivery.

Within a few days most dolphins had a daily intake of between 2.7 and 3.6kg of Atlantic herring, *Clupea harengus*. In subsequent weeks food intake gradually increased to 3–4kg of herring per animal per day.

Previously, others had fed Commerson's dolphins Atlantic herring, rainbow smelt, *Osmerus mordax*, and squid, *Loligo pealeii* (Spotte *et al.*, 1979). An average food intake of 3.6kg per day was considered normal for a 35kg animal. Caloric requirements have been estimated to be approximately 3,300 Kcal/day ($\bar{x}$ = 94 Kcal/kg body mass per day) (Spotte *et al.*, 1979). Gewalt (1979) and Shochi, Zbinden, Kraus, Gihr and Pilleri (1982) reported a daily food intake of 4kg/day for captive Commerson's dolphins. Gewalt (1979) considered this high for a species no larger than the harbor porpoise, *Phocoena phocoena*.

Growth and reproduction

Size data on the 12 dolphins are presented in Table 1. Lengths and weights ranged from 124.5–144cm ($\bar{x}$ = 136.3cm) and 33.8–40.4kg ($\bar{x}$ = 36.6), respectively, for males and 139.0–146.5cm ($\bar{x}$ = 143.2) and 35.4–44.5kg ($\bar{x}$ = 39.7) for females. Recent length to weight ratios averaged 3.51 (3.46 for males and 3.55 for females). The males appear consistently greater in girth. For example, on 4 May 1984 a 124.5cm male had a maximum girth of 86.5cm, whereas a 145cm female had a girth of 72cm. The seven animals for which two weights were available gained from 0.4–5.4kg ($\bar{x}$ = 2.33) in 36 days.

Copulation has been observed frequently since capture but has appeared to peak in frequency and intensity in January and early February each year. We assume higher probabilities of successful matings during such times and note reports that calves are born in austral summer, from November through February, with peak numbers of calves in late January (Gewalt, 1979, 1981; Goodall *et al.*, 1988; Mermoz, 1980). From these observations and from hormone studies we estimate that gestation is 11 to 12 months (Cornell and Leatherwood, 1986; Leatherwood and Cornell, 1985). Three calves had been born at Sea World by late 1986. The first birth is described in detail by Joseph, Antrim and Cornell (1987).

One male, 124.5cm, was sexually immature but another has produced motile sperm at 144cm. Females of 139 and 145cm were obviously sexually mature but ovaries of a 146.5cm female showed no signs of corpora on gross examination. Available data on reproduction in this species are reviewed by Goodall *et al.* (1988).

Husbandry

Shochi *et al.* (1982) reported that Commerson's dolphins can be kept successfully, provided that clean water (about 30ppt salinity and 8°C) is maintained. The dolphins at the Duisburg Zoo were reported to do well with a salt concentration of 3% and water temperatures below 10°C (Gewalt, 1981). Commerson's dolphins have been held in filtered ambient temperature (14.5–24°C) sea water at Sea World.

Hart (1935) speculated that Commerson's dolphins can be infested with diatoms on the skin like most cetaceans that seasonally remain in Antarctic waters. Commerson's dolphins at Duisburg suffered from some fungal and bacterial skin infections (Gewalt, 1981). Skin changes described as being like a 'cauliflower' were observed in which traces of *Candida albicans* (yeast) were detected (Gewalt, 1981). At Mystic Marine Life Aquarium a Commerson's dolphin was maintained in the same water system with other cetaceans which

were infected with *Candida albicans* but showed no evidence of candidiasis (Dunn, Buck and Spotte, 1982).

Although Goodall *et al.* (1988) have found stranded Commerson's dolphins to be remarkably parasite free, our experience indicates parasite infestations may represent a significant cause of mortality in wild populations. Lungworm (*Skrjabinalius* sp.) infections and pneumonia are reportedly main causes of death (Gewalt, 1979; Spotte *et al.*, 1979). To date several dolphins at Sea World have been noted to be infested with lungworm, roundworm and liver flukes. We have not yet identified these parasites. Spotte *et al.* (1979) reported positive effects from use of levamisole hydrochloride to treat lungworm (*Skrjabinalius* sp.) infestations in Commerson's dolphins at a dosage rate of 9mg/kg body mass injected subcutaneously. As is the case in some other species, it may be necessary to use the drug in combination with diazepam or an equivalent compound. One male in our program showed an adverse reaction when administered levamisole hydrochloride alone. Conversely, a female given both drugs simultaneously demonstrated no unusual behavior. We have successfully treated similar infestations in this species with Ivermectin (0.5mg/kg). The husbandry of the Commerson's dolphins at Sea World is based on a two-part preventative medicine program. The first aspect of this program is to provide a clean, disease-free environment. This is accomplished by using high-rate pressure sand filters to clean the natural seawater and then injecting either liquid or gas chlorine into the water before it enters the pool. A free chlorine level of approximately 0.5–1.0ppm is maintained.

The second aspect of the husbandry program is to maintain the animals on a diet of high nutritional quality. This includes liberal amounts of fresh frozen fish that have been properly thawed. The diet presently is supplemented daily with a multi-vitamin and iron. Disease prevention vaccination programs are utilized as indicated.

Hematology

Blood samples are routinely collected and analyzed as an integral part of our preventative medicine program. Such samples are important for establishing base-line parameters against which future samples can be interpreted. Substantial changes in successive blood samples from individual animals often indicate changes in an animal's health. Blood samples can also provide an insight into affinities of various species, including subspecies and populations and provide a 'window' into an individual's reproductive status.

Hematological data on blood parameters of Commerson's dolphins from the Strait of Magellan, Chile, are shown in Table 2. These values are similar to those of common dolphins, *Delphinus delphis*, and Pacific white-sided dolphins, *Lagenorhynchus obliquidens*, from the eastern North Pacific (Sea World, unpublished data).

Notes on behavior

Upon arrival at Sea World all dolphins were placed in a large pool. The next day they were separated into two groups, the more active in one pool, the more quiescent in another. A net gate permitted visual and acoustic contact.

Table 2
Values of hemotological and serum chemistry parameters of Commerson's dolphins.
n = sample size.

Parameter	n	Mean value	Range	
Hemoglobin (g/dl)	43	17.03	13.9	20.2
Hematocrit (%)	43	46.89	40.7	52.7
Red blood cells ($10^6/mm^3$)	43	4.98	4.19	5.73
Mean corpuscular volume fl.	43	94.14	90.0	100.0
Mean corpuscular hemoglobin pg.	42	34.43	32.0	38.0
Mean corpuscular hemoglobin concentration (g/dl)	42	36.33	34.0	39.0
Nucleated red blood cells/100 white blood cells	43	0.73	0	5.0
White blood cells ($10^3/mm^3$)	43	9.28	2.50	18.7
Bands (%)	43	0.09	0	2.0
Neutrophils(%)	43	47.47	20.0	38.0
Lymphocytes (%)	43	17.74	3.0	40.0
Monocytes (%)	43	2.44	0	9.0
Eosinophils (%)	43	32.28	1.0	59.0
Glucose (mg/dl)	41	134.83	95.0	199.0
Blood urea nitrogen (mg/dl)	43	34.05	14.0	55.0
Creatinine (mg/dl)	40	0.90	0.6	1.8
Bilirubin (total) (mg/dl)	40	0.18	0.1	0.4
Cholesterol (mg/dl)	41	199.76	75.0	361.0
Triglycerides (mg/dl)	41	123.56	42.0	329.0
Total protein (gm/dl)	41	6.20	4.8	7.3
Albumin (gm/dl)	41	3.82	2.7	4.4
Globulin (gm/dl)	41	2.38	1.5	3.9
Amylase (U/l)	37	15.84	5.0	36.0
Alkaline phosphatase (U/l)	41	111.27	3.0	306.0
Alanine aminotransferase (U/l)	40	110.88	23.0	1,018.9
Aspartate aminotransferase (U/l)	41	145.95	72.0	675.0
Creatine kinase (U/l)	40	95.77	29.0	222.0
Hydroxbutyrate dehydrogenase (U/l)	40	562.90	281.0	3,387.0
Lactate dehydrogenase (U/l)	41	316.32	145.0	1,755.0
Calcium (mg/dl)	40	9.10	7.4	10.6
Phosphorus (mg/dl)	40	5.48	2.9	7.9
Chloride (mEg./liter)	40	112.97	96.0	126.0
Iron (mg/dl)	36	146.69	57.0	261.0
Total iron binding capacity (mg/dl)	34	459.35	326.0	669.0
2,3-Diphosphoglyceric acid (μ mol/ml)	29	2.51	1.84	3.19

Most of the dolphins began to hand-feed shortly after arrival. They appeared less shy than some pelagic species (e.g. common dolphins, *Delphinus delphis*) and were easily approached. At present all are routinely fed by hand.

For much of the first week, animals spent considerable time bobbing at the surface, often in the 'pitch-pole' position in which the body is kept perpendicular to the water surface. In general, there was less active swimming and interaction than had been typical at Cabeza del Mar. By the end of the first week, however, the animals had become more active. 'Rest' periods, characterized by surface bobbing, continued to occur, particularly after feeding and at the hottest times of day. Such 'rest' or 'sleep' is reportedly polyphasic: typically, a sleeping dolphin lies motionless, close to the surface, with the melon and dorsal fin above the water for a few minutes (Shochi *et al.*, 1982).

During the second week most of the dolphins had become quite active. As noted by others they have proved to be fast swimmers, often swimming rapidly straight across the pool and turning suddenly at right angles without apparent reduction in speed (Shochi *et al.*, 1982). They are frequently observed swimming upside-down, often feeding in this posture, and apparently maneuvering as deftly as they do right-side up (Evans, Cornell and Yoon, 1985).

Dominance patterns appear complex. Males appear dominant, even over

larger females, and contest one another for dominance and mating access. As in breeding colonies of other species, such as bottlenosed dolphins, *Tursiops truncatus*, observed at Sea World, the colony is transiently dominated by one male. This dominant male is often challenged by subordinate males in bouts characterized by considerable agonistic behaviors. On at least one occasion a female Commerson's dolphin that had mated frequently seemed to tire of the attention and chased the courting male. During the majority of time the smaller holding pool is left open so the dolphins can come and go, which they do freely. The less aggressive males periodically use this pool, apparently as a refuge from harassment by more aggressive males. Vocalizations tend to be inaudible at poolside (Hackbarth, Awbrey and Evans, 1986). However, on occasion one can hear low-frequency, 'raspy' sounds. Once, a pair of Commerson's dolphins was heard producing a series of 'squeaks' apparently directed at the false killer whales in an adjoining pool as they were oriented towards one another with the gate between. Trails of bubbles can often be seen coming from the blowholes, presumably associated, as in other cetaceans, with whistle-like sounds. Vocalizations of Commerson's dolphins have been described by Leatherwood *et al.* (1988b). Sounds produced by this species are currently being compared with those produced by Dall's porpoises, *Phocoenoides dalli* (Awbrey and Evans, 1988).

Research – ongoing and planned

A healthy, accessible captive colony of Commerson's dolphins provides numerous opportunities for research under controlled circumstances not readily available with free-ranging dolphins. Accordingly, the following activities are underway or planned with the present animals: periodic measurements to determine growth rates (Table 1); periodic photographs to document ontogeny of color patterns; facilitation of captive breeding; examination of periodic blood samples for hormone levels as evidence of reproductive cycles; tetracycline marking of teeth and their subsequent removal and sectioning to determine age using growth layer groups; construction of ethograms on individuals and groups; continued documentation of sound production and correlated behavior; examination of echolocation abilities; and studies of visual acuity and possible color vision.

Comments on status

After three years at Sea World, seven Commerson's dolphins are alive, active and in apparent good health. They are handsome and compare favorably to Pacific white-sided dolphins in their ability to be trained. Our experience demonstrates that with proper care Commerson's dolphins can be collected, transported safely and acclimated to the captive environment. Populations of this species seem sufficiently large to support removals at the low levels of live-capture activities. Nevertheless, in view of apparent continued killing of these dolphins, we have decided not to acquire permits to collect additional Commerson's dolphins from Chile until additional information suggests the southern South American population is stable or increasing.

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Chilean dolphin
Cephalorhynchus eutropia

On the Chilean Dolphin, *Cephalorhynchus eutropia* (Gray, 1846)

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ABSTRACT

The Chilean dolphin, *Cephalorhynchus eutropia*, has been considered one of the least known cetaceans. A review of the literature and a study of unpublished records have clarified the taxonomic status of the species; *Delphinus lunatus* is considered a *nomen oblitum*, while *Phocaena albiventris*, *Tursio platyrrhinus* and *Phocaena obtusata* are junior synonyms. All known specimens and sightings, published and unpublished, are listed, along with tentative and doubtful records. The present distribution of the species is from Valparaíso (33°S) to southern Isla Navarino (55°14′S), just north of Cape Horn. External morphology and pigmentation are described, based on nine specimens. Maximum length (n = 13) is 167cm. Female specimens ranged from 136–165cm TL, males from 140–167cm. Counts of teeth ranged from 28–34 in the maxillary to 29–33 in the mandibular rows. Skull length (CBL) for 13 specimens ranged from 302–364mm (mean 341.1). The color pattern is basically gray above, with a darker beak and distinctive asymmetrical lunate marks running from behind the blowhole to behind the eye. On the ventral surface there is a wide white gular patch, a dark gray area between the flippers and a white axillary patch. The area from the flippers to the tail stock is white, with sexually distinctive gray genital patches and with lines running forward near the anus. Most sightings were coastal, in shallow waters. Groups were small, usually of two to five animals, although larger aggregations may form at times. The animals appear shy and often avoid vessels but sometimes ride the bow or waist. The Chilean dolphin is exploited moderately for bait in the northern part of its range and may be exploited but to an unknown extent for crab bait in the western Magellan region.

INTRODUCTION

The Chilean dolphin, *Cephalorhynchus eutropia* (Gray, 1846), is one of the least known species of cetaceans. Although common in the area in which it occurs, few scientists have studied it and only three photographs have been published (Norris and Dohl, 1980, p. 243; Leatherwood, Reeves and Foster, 1983, p. 258; Anon., 1984a).

In this paper we attempt a compilation and analysis of all that is known about this species. A review of the literature is included in order to summarize the available information and to clarify taxonomic problems. New information on additional specimens, the habitat and the behavior of the species is also included.

MATERIALS AND METHODS

The materials for this study were two fresh specimens collected by Norris, one nearly fresh specimen from San Antonio, a variety of skeletal specimens, a series of observations of the species at sea contributed to us by a number of trained observers and a series of observations and specimens collected by Oporto.

Specimens

Two complete specimens were obtained by Norris during a stay in Chile during 1968. The first, collected on 3 October 1968 at Bahía Corral (near Valdivia), was a physically mature adult male (KSN 68–55 SA, later USNM 395374) (Fig. 1). The second, collected near Playa Frailes, Golfo de Arauco (near Concepción) was a physically immature female (KSN 68–59 SA, later USNM 395375). Photographs and standard measurements were made of both animals. Data and photographs of an animal found on the beach near San Antonio, south of Santiago, on 28 June 1984 were contributed by J. Yañez, Curator of Mammals at the Museo Nacional de Historia Natural of Santiago, Chile. A skull (USNM 395625) was given to Norris by Dr Hugo Campos of the Universidad Austral, Valdivia, of an animal taken in December 1967 at Mehuin, north of Corral.

Oporto, as a student at the Universidad Austral at Valdivia, obtained measurements and sketches of six specimens captured by fishermen or beach-cast near Valdivia (Fig. 2).

All specimens known to us in North and South American museums have been measured and studied, first by Norris in 1968 and then by Cameron in 1978. Included were materials deposited at the Museo Nacional de Historia Natural in Santiago (MNHN-S); Instituto de Zoología of the Universidad Austral, Valdivia (IZUA); Instituto de la Patagonia, Punta Arenas, Chile (IPPA); United States National Museum (USNM); Museum of Vertebrate Zoology, University of California, Berkeley (MVZ). Additional skulls in the British Museum (Natural History) (BMNH) were measured by Cameron. Two skulls in the Naturhistoriska Riksmuseet, Stockholm (IWC, 1977, p. 476) were not examined. External measurements were made to the standardized system of Norris (1961), while cranial measurements were made following the methods of Perrin (1975) with modifications by Cameron.

Since no gonads were available for any specimens, physical maturity, based on vertebral epiphyseal fusion, was calculated as follows: immature, no epiphyseal fusion; subadult, some fusion near head and tail; adult, complete epiphyseal fusion. Tooth counts were read for the three US specimens by Cameron with the assistance of A. Myrick.

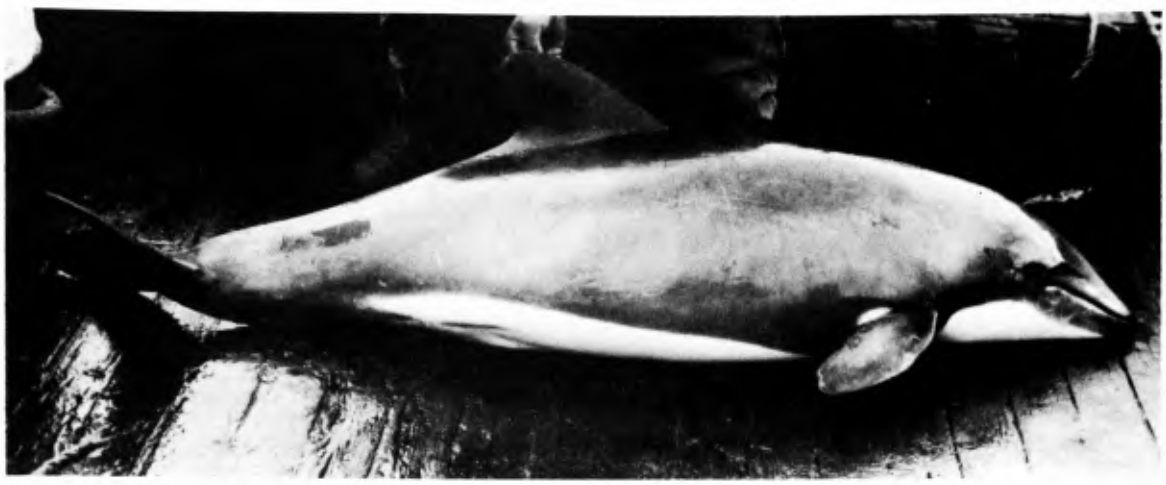


Fig. 1. The Chilean dolphin, *Cephalorhynchus eutropia*. An adult male captured at Corral, Chile. Field number KSN68-55SA. Photograph by K.S. Norris.

Fig. 2. A specimen of the Chilean dolphin, IZUA-MM 16, found at Playa Las Tres Niñas, Queule, Chile, in 1980. Photograph by J.A. Oporto.

Sightings

During October 1968, four sightings with attendant behavioral observations were made by Norris from fishing boats near Valdivia and at Playa Frailes. From 12 November to 10 December 1968, Norris was scientific leader aboard a voyage of R/V *Hero* for the study of cetaceans from Valparaíso through the Chilean and Fuegian channels to Cape Horn and back to Punta Arenas in the Strait of Magellan; six additional sightings were made.

As part of a sightings program organised by Goodall in the waters off southern South America, 10 additional sightings were obtained, mainly by the crew of the R/V *Hero* and by Judith Perkins of the Ocean Research and

Education Society. Ornithologist Sir Peter Scott provided four sightings made aboard the vessel *Navarino* on a trip through the channels. Some of these were summarized but not detailed in an unpublished work presented to the IWC (Goodall and Polkinghorn, 1979). Details of the sightings are given in the present paper.

Oporto was able to obtain a number of sightings near Valdivia, and Dr Roberto Schlatter of the Universidad Austral, Valdivia, kindly sent all his own sightings of this species. More recently, one detailed sighting was sent by Karen Pryor of North Bend, Washington. Stephen Leatherwood, Hubbs Marine Research Center, contributed various sightings by observers in southern Chile.

TAXONOMIC HISTORY

Although *Cephalorhynchus eutropia* is frequently mentioned in general references, only a few papers contain original observations of the animal or of museum materials. This paper will concentrate on such original data.

The Dickie skull

The type specimen of *Cephalorhynchus eutropia* is a skull collected by a Dr Dickie, RN, during a voyage in the Pacific. No specific locality data were provided. This skull is deposited as BMNH 1849.5.25.2 (936a), labelled as *Delphinus eutropia*.

The first published mention of the specimen was a drawing without any description by J.E. Gray (1846, pl. 34)[1]. Not until 1849 (p. 1) did he publish a description and measurements of the skull, the same year, apparently, that the skull was accessioned into the museum collections. A year later (Gray, 1850a, p. 48 and 1850b, p. 111) the description was repeated twice in identical form. In the latter publication, a location, 'Pacific Ocean, Chili', was added and the specimen was given a common name, the Eutropia.

In 1862 (p. 145), Gray reassigned his specimen to a new section of the genus *Delphinus*, which he named *Eutropia*. Then, 17 years after the original description (Gray, 1866a, p. 262), he again repeated the same description in identical form, under the new combination *Tursio eutropia*. That same year, he (Gray, 1866b, p. 215) raised *Eutropia* to generic status and included in it two species; *E. dickiei* and *E. heavisidii*, while mentioning that *D. cephalorhynchus* of F. Cuvier (1836) also appeared to belong to this genus. The latter is known to be a synonym of *C. heavisidii*. *Eutropia dickiei* seems to have been Gray's final choice. He used this combination in 1868 (p. 77, pl. 34), using the original 1846 plate, and used it again in 1871 (p. 75).

In his list of the cetaceans in museums of the world, Van Beneden (1868, p. 112) mentioned only that a cranium of *Tursio eutropia* was in the British Museum. Scott (1873, p. 78) returned to *Delphinus eutropia*, mentioning that

[1]We have been unable to find a given name for Dr Dickie (Watson, 1981, calls him George, Ellis, 1982, lists him as R.), nor the date or name of his voyage. All authorities agree that the date of publication of volume I of *The Zoology of the Voyage of* H.M.S. Erebus *and* Terror (whose title page says 1844–1875) was 1846. Nevertheless, Gray himself in 1850, p. 112; 1862, p. 145 and 1866a, p. 262, calls it 'ined.'. Flower (1885; p. 17) was the first to mention the plate of *C. eutropia* in Gray's 1846 publication, but at the same time said that the skull was purchased in 1849.

only one skull was known and giving a tooth count. The name *Cephalorhynchus* was first used by F. Cuvier (1836, p. 158) in a specific name (*D. cephalorhynchus* = *C. heavisidii*). It was designated a 'section' of the genus *Delphinus* by Gray (1850a, p. 106).

Dall (1874, p. 289) first used *Cephalorhynchus eutropia*, citing the Dickie skull, with the locality 'Coast of Chile, south Pacific Ocean' and adding: 'some one of the species described from drawings, and of which the skull is unknown may be identical to this'. This indeed has proved to be the case. Gervais (1880, p. 599) also put Gray's names for this skull into the genus *Cephalorhynchus*.

In 1881, Flower (1883, p. 477) received from T. Edmunds a second, smaller skull from Chile. Evidently unaware of Dall's publication, he also decided that these two skulls should be designated as *C. eutropia*. He (Flower, 1885, p. 17) included them in his list of the specimens in the British Museum, adding that, since the species was known only from skulls, it could only provisionally be assigned to *Cephalorhynchus*.

True (1889, p. 113) examined the skulls in the British Museum and purchased from Mr E. Gerrard a third skull (USNM 21167), also supposedly from the Coast of Chile. He compared measurements of the three crania and repeated Gray's figure of the Dickie cranium, under *C. eutropia*.

Flower and Lydekker (1891, p. 266), in defining the characteristics of the genus *Cephalorhynchus*, also provisionally included *C. eutropia*. Beddard (1900, p. 279) stated that *C. eutropia* was 'only known from a skull from the coast of Chili'.

A series of specimens, illustrations and descriptions followed these early works and have been referred to as *C. eutropia* by various authors. We will outline and analyse their relevance here.

Phocaena albiventris and *Tursio platyrrhinus*

The first description of the exterior form and color pattern of what was later recognised as *C. eutropia* was given by C. Pérez Canto (in Philippi, 1893a, p. 8, pl. 2), of an animal caught in the port of Valparaíso, Chile in 1882. He used the external description as the basis for the new species *Phocaena* (*Hyperoodon*?) *albiventris*. His illustration (see Fig. 3) became the basis for all succeeding drawings of the external form of this species, up until the publication of the first photograph (Norris and Dohl, 1980, p. 243). This description was repeated in German (Philippi, 1893b) and later in French (Pérez Canto, 1896, p. 227), accompanied by a line drawing of the animal.

In the fall of 1894, Philippi (1894, p. 4) received two skins and skulls of *P. albiventris* from Talcahuano, Chile, donated by Martin Bodecker and Jerman Rudolphi. Philippi, using Gray's 1849 description of *D. eutropia*, thought that his specimen was different.

In 1895 Philippi (p. 281) tried to classify 12 crania in his collection according to Gray's taxonomy, but was frustrated by the inadequate descriptions. He referred six of his crania, two with skins to *Tursio*? or *Phocaena albiventris*, two to a new species which he named *Tursio*? *platyrrhinus*, and one to another species, *Tursio panope*. He had difficulty allocating them to *Tursio* or *Phocaena*. He felt that although his colleague F. Lataste had classified several skulls in the

Santiago museum as *Tursio eutropia*, they could not be this form because they did not appear to agree with Gray's description.

The next year Philippi (1896, p. 12) once more translated Gray's papers, greatly lamenting the vague descriptions and the changing of genera. He summed up his frustration with a comment on Gray's description of *Eutropia dickiei*: '. . . which in the original has only twelve lines, one finds the word *rather* (a little, somewhat, quite a bit, more than) ten times'.

Philippi finally decided that his specimens belonged to Gray's genus *Tursio*. He then described and figured the crania of *T. albiventris*, *T. platyrrhinus* and *T. panope*. The first two illustrations are the first ventral views of the cranium of *C. eutropia*. As noted by True (1903, p. 142), the captions of the lateral views of these two were reversed.

Trouessart (1897, p. 1,041) put *T. albiventris* and *P. philippi* Canto Pérez (instead of Pérez Canto) provisionally in *Cephalorhynchus* along with *C. eutropia*, listing them all as from the 'South Pacific Ocean, Chili'. *Phocaena philippi* (a synonym of *P. spinipinnis*) was removed by the next edition (Trouessart, 1904, p. 768) of his work and ? *platyrrhinus* and ? *obtusata* were added as members of *Cephalorhynchus*.

True (1903, p. 135) reviewed Philippi's and Pérez Canto's works and tried to put the many species into synonymy with known species. He decided that both *T. albiventris* and *T. platyrrhinus* were synonymous with *C. eutropia*, and that the color pattern resembled that of other members of the genus *Cephalorhynchus*. Harmer (1922, p. 631) agreed with True (so do we), and compared the measurements of the type skull of *C. eutropia* with those of *C. commersonii* and *C. heavisidii*.

Phocaena obtusata

This species was described by Philippi (1893a, p. 12) on the basis of a poorly preserved skin without a skull. While thought to be a specimen of *Phocoena dioptrica* by some authors (for example Allen, 1925, p. 254 and Donoso-Barros, 1975, p. 52), both True (1903, p. 139) and Brownell (1975, p. 3) felt that it was from a species of *Cephalorhynchus*. Recent studies (Goodall and Cameron, 1979, p. 145; Goodall, Sobral, de Vinuesa and Cameron, 1988) show the skin in the Santiago museum to be most probably a specimen of *C. eutropia*. Philippi himself (1895, p. 283) wondered if his *P. obtusata* could be the same species as Gray's *D. eutropia*, but felt it unlikely.

Tursio panope

This species, based on a skull, was mentioned by Philippi in 1895 (p. 284) and described more fully and illustrated in 1896 (p. 14, pls 4–6). True (1903, p. 141) was unable to identify the specimen even to genus; he thought it resembled a *Lissodelphis*, but that it might be of a new genus. Trouessart (1904, p. 766) called it *Lissodelphis*? *panope*.

Harmer (1922, p. 631) believed that it might be referable to *Cephalorhynchus*. Miller (1928, p. 171), on the basis of photographs of the skull, considered Philippi's drawing of the lateral view incorrect and thought that *T. panope*

should be placed in *Cephalorhynchus*. Hershkovitz (1966, p. 74) listed it as a synonym of *C. eutropia*.

The specimen in the Museo Nacional de Historia Natural in Santiago was examined by Norris in 1968 and by Goodall and Cameron in 1978. While *T. panope* (now numbered MNHM-S 584) resembles *C. eutropia* in many ways, and has been classified by the museum staff as that species, it is larger and bears resemblances to *Lissodelphis*. The range of CBL (condylobasal length) of *C. eutropia* to date is 302–364mm (mean 341.3, n = 13) (Table 4c), while the CBL of *T. panope* is slightly over 379mm (the tip is broken). We prefer to leave its classification uncertain.

Tursio? chiloënsis

This species, described by Philippi (1900, p. 112; 1901, p. 276), was considered a synonym of *C. eutropia* by Harmer (1922, p. 631) and Cabrera (1961, p. 615), and the holotype specimen has been so classified by the staff of the Santiago Museum. This cranium (MNHN-S 586) has been shown to be a specimen of *Lagenorhynchus australis*; *T. chiloënsis* should be considered a junior synonym of that species (Goodall, 1986).

Delphinus lunatus

The earliest description of the Chilean dolphin seems to be a brief mention by Lesson (1826, p. 373), with a slightly longer version a year later (Lesson, 1827, p. 182), of a small dolphin, locally called *funenas*[2], seen abundantly in the Bahía de Concepción (Talcahuano), Chile, during Captain Duperrey's voyage aboard *La Coquille*. Although a specimen was not captured, a description of the color pattern and a sketch of the animal as seen at sea were given. Although the drawing was careless in many respects, it shows a chunky dolphin with a unique lunate pattern posterior to the blowhole (Fig. 3).

This description was repeated or modified by a series of authors of that time (Fischer, 1829, p. 509; Tilesius, 1835, p. 724; Cuvier, 1836, p. 228; Rapp, 1837, p. 34). Hamilton (1837, p. 250; 1856, p. 250) also repeated Lesson's text and copied Lesson's drawing, embellished with penguins and mountains.

Gay (1847, p. 175), while lamenting the erroneous use of the name *funenas*, said that the dolphin was well known in Chile and occurred in 'great multitudes' in the Bay of Valparaíso. He used the Lesson description. Murray (1866, p. 341) mentioned only '*D. lunatus* Less., Coast of Chili'.

Philippi (1893a, p. 11), in reviewing the then-known dolphins of southern South America, translated Lesson's text into Spanish and copied his drawing of *D. lunatus*, calling it *Phocaena lunata* (*Delphinus*) Lesson. On the basis of the

[2]We agree with Philippi (1893a, p. 11) who considered this common name to be a *lapsus calami* for the local Spanish word *tunina*, now more generally called *tonina* (= dolphin). In southern South America, three names are used for the smaller cetaceans: *marsopa*, which means porpoise, *tonina* and *delfín*. The last two can be used interchangeably, meaning dolphin, although a *delfín* may have a longer beak. In this paper we are using the English names 'dolphin' and 'porpoise' in the European sense: dolphin = small cetacean with conical teeth and porpoise = small cetacean with spade-shaped teeth, because it avoids confusion in Spanish.

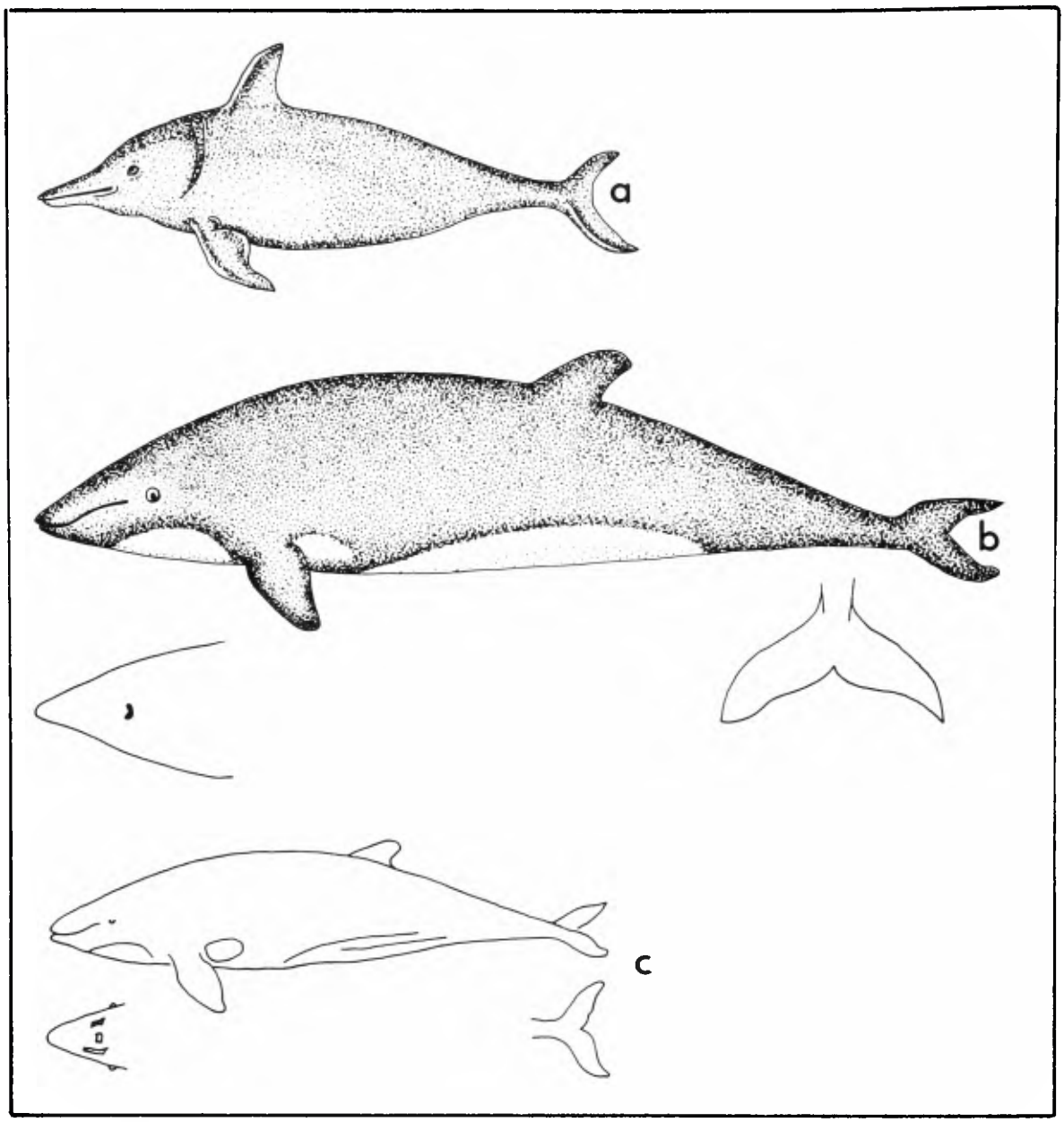


Fig. 3. Early published drawings of *Cephalorhynchus eutropia*: (a) sketch of *Delphinus lunatus*, from a sighting, after Lesson, 1827; (b) drawing of *Phocaena albiventris*, after Pérez Canto, *in*: Philippi (1893a); and (c) outline drawing of the same animal, Pérez Canto, 1896.

drawing and Lesson's color description (reddish brown), he considered it different from his own Chilean species. However, the line drawing of *P. albiventris* (Pérez Canto, 1896, p. 228) shows Lesson's lunate mark on each side of the blowhole.

True (1903, pp. 138, 143) did not believe that drawings of dolphins seen at distance had any validity. Since Lesson was 'unable to kill a single individual', he stated that the species had no status, as it was not based on a specimen. Trouessart (1904, p. 768) agreed with True, as did Norris and McFarland (1958, p. 32).

Reed (1904, p. 138) described two dolphins caught near Valparaíso in 1878 and one near Concepción in 1902, giving measurements of the latter. He wrote: 'That it is identical with the *Delphinus lunatus* of Lesson, and the work of Gay, tome 1, p. 175, there is no doubt . . . .' He did not mention the works of Gray,

Philippi or True, although he stated that, after Lesson 'a dozen authors have described species from fragments of crania, from badly preserved skins, or even from animals seen from a distance swimming in the sea'. He felt that his animal might be *D. peronii* except that it had a dorsal fin. However, his description is that of *C. eutropia*. Unfortunately, he did not publish an illustration.

Cabrera (1961, p. 619) wrote that Lesson's animal was perhaps a young individual, 'badly observed and worse drawn', of *Phocoena spinipinnis* Burmeister. Donoso-Barros (1975, p. 113), reviewing the cetaceans of Chile, copied Lesson's sketch (p. 123) and stated that this species did not correspond with those known from Chile. In general, *Delphinus lunatus* has been forgotten.

Even so, the specimens reported in this paper show that Lesson was describing *C. eutropia* when he named *D. lunatus*. We agree with True and recent authors that descriptions of animals seen at sea are not valid, but Lesson's description is accurate enough, we believe, to identify this species. The original description of *C. commersonii* (Lacépède 1804, p. 339), accepted as the type description although there was no specimen, is much more vague than that of Lesson. However, since the name *D. lunatus* has not yet been used in the last 130 years, and since there is no type specimen, it must be considered a *nomen oblitum*.

Recent literature

Cephalorhynchus eutropia has been mentioned or figured in a number of summary papers in the last 80 years, without any new data or specimens being added (Cabrera and Yepes, 1960, p. 114; Oliver Schneider, 1946, p. 80; Oliver, 1946, p. 4; Mann Fischer, 1957, p. 103; Yañez, 1948, p. 115; Fraser, 1937; 1948, p. 316; Harrison, 1965, p. 44; Scheffer and Rice, 1963, p. 5; Rice and Scheffer, 1968, p. 9; Matthews, 1968, p. 81; Marcuzzi and Pilleri, 1971, p. 130; Nishiwaki, 1972, p. 108; Ellis, 1982, p. 129; Leatherwood, Reeves and Foster, 1983, p. 257). Sonntag (1922, p. 641) studied the anatomy of the tongue, Ness (1967, p. 210) illustrated the cranium in his work on skull asymmetry and Kasuya (1973) studied the ear bones.

Mörzer Bruyns (1971, p. 43) added sea temperatures, weight, food, probable speed, breathing time and inshore habitat to his description, but it is unclear how these observations were made. The track chart of the travels from which his book was derived does not come near the known range for the species, his nearest visit being Buenos Aires on the opposite coast of South America. No visits are shown to either Tierra del Fuego or Chile.

The data obtained by Norris during work in southern Chile and aboard the R/V *Hero* are therefore the first on this animal, its behavior and its habitat since the early descriptions. This information has been reported in part by Aguayo (1975, p. 1,127) and is amplified here by more recent observations.

Recent investigations in southern Chile by the Hubbs Marine Research Institute have resulted in new sightings and information on exploitation (Leatherwood, Kastelein and Miller, 1984). Four additional sightings were made during a trip through the channels by Oporto (1984a, 1984b).

SYNONYMY

Cephalorhynchus eutropia (Gray, 1846)

Delphinus lunatus Lesson, 1826, p. 373
Lesson, 1827, p. 182, pl. 9, fig. 4
Murray, 1866, p. 341
Fischer, 1829, p. 509
Tilesius, 1835, p. 724
Cuvier, 1836, p. 228
Rapp, 1837, p. 34
Gay, 1847, p. 175
Reed, 1904, p. 140
Delphinus Lunatus Hamilton, 1837, p. 250, 1856, p. 250
Phocaena lunata (*Delphinus*) Philippi, 1893, p. 11
Delphinus Eutropia Gray, 1846, pl.34 (figure without text)
Gray, 1849, p. 1
Gray, 1850a, p. 48
Gray, 1850b, p. 111
Scott, 1873, p. 78
Delphinus eutropia Gray, 1862, p. 145
Philippi, 1895, p. 281
Tursio Eutropia Gray, 1866a, p. 262
Furcio [sic] *Eutropia* Philippi, 1895, p. 281
Tursio eutropia Van Beneden, 1868, p. 112
Philippi, 1895, p. 283
Eutropia Dickiei Gray, 1866b, p. 215
Gray, 1868, p. 7
Gray, 1871, p. 75
Eutropia dickiei Gray Philippi, 1896, p. 11
Cephalorhynchus Eutropia (Gray) Dall (*in*: Scammon 1874, p. 289)
Cephalorhynchus eutropia Dall, Gervais, 1880, p. 600
Cephalorhynchus eutropia Gray, Flower, 1883, p. 477
Flower and Lydekker, 1891, p. 266
True, 1889, p. 112
Trouessart, 1897, p. 1,041; 1904, p. 768
Beddard, 1900, p. 279
Hershkovitz, 1966, p. 74
Cephalorhynchus (?) *eutropia* Flower, 1885, p. 17
Cephalorhynchus eutropia (Gray) True, 1903, p. 143
Phocaena (*Hyperoodon*?) *albiventris* Pérez Canto, 1896, p. 227
Philippi, 1894, p. 4
Tursio? *albiventris*, *Phocaena albiventris Pérez* Philippi, 1895, p. 284
Tursio (*Phocaena*) *albiventris Pérez* Philippi, 1896, p. 15
Cephalorhynchus? *albiventris* Trouessart, 1897, p. 1,041; 1904, p. 768
Cephalorhynchus albiventris Fraser, 1937; 1948, p. 316
Harrison, 1965, p. 44
Tursio? *platyrrhinus* Philippi, 1895, p. 284

Tursio platyrrhinus Philippi, 1896, p. 16
Cephalorhynchus? *platyrhinus* (Philippi) Trouessart, 1904, p. 768
Phocaena obtusata Philippi, 1893a, p. 12
Cephalorhynchus? *obtusata* (Philippi) True, 1903, p. 143
Cephalorhynchus obtusata (Philippi) Trouessart, 1904, p. 768
[?] *Phocaena obtusata* Hershkovitz, 1966, p. 102
(as a synonym of *Phocoena dioptrica*: also under *C. eutropia*, p. 75).

COMMON NAMES

In only two of Gray's many papers was this species given a common name, the Eutropia (Gray, 1850b, p. 111; 1866a, p. 262). Other early authors, following Lesson, called it *Funenas*, *le dauphin Funenas* (Cuvier, 1836, p. 228), the *Funenas* of the Chileans (Hamilton, 1837; 1856, p. 250), or simply *tunina* (=tonina) (Gay, 1847, p. 175).

Philippi did not use a common name in his papers, but all his specimens in the MNHN-S are marked *delfín de vientre blanco* (the translation of albiventria) or *delfín negro de vientre blanco*.

Cabrera and Yepes (1940; 1960, p. 114) were followed by a number of authors in calling the species *delfín negro*, *tunina negro*, or black dolphin. In life the animal is colored with shades of gray or white, but like other dolphins when exposed to the sun for any extended period the dark pattern components tend to darken toward black, perhaps forming the basis for these common names.

In 1974 the IWC adopted an official list of scientific and common names to used as a standard in its publications, which was adopted by the US Marine Mammal Commission. Both list 'black dolphin' for *Cephalorhynchus eutropia* (Mitchell, 1975b; Anon., 1976).

Several authors followed Philippi, and later Fraser (1937; 1948, p. 316), in using white-bellied dolphin, or *tunina de vientre blanco*.

None of these names is much help in identification, especially since most dolphins are whitish below. Mörzer Bruyns (1971, p. 43) and Aguayo (1975, p. 1,127) suggested the name 'Chilean dolphin', or 'delfín chileno', which has been accepted by more recent authors (Rice, 1977, p. 9; Watson, 1981, p. 250).

J. Perkins (pers. comm.) reported that residents at Puerto Edén in the Chilean channels called this species *tunina* or *louel*; we have not heard the latter name at any other locality.

Since the species at present seems to be restricted to Chilean waters, we support the use of 'Chilean dolphin' as what can be called a 'book name' for the species. The IWC Scientific Committee used this name in the report of its meeting in 1984 (IWC, 1985).

MUSEUM MATERIALS

The confusion over the identity of museum materials, some 42 specimens, especially in Santiago, is so great that we believe it will be of help to future investigators to try to clarify the situation (Table 1).

Table 1

Known specimens, both published and unpublished, of *Cephalorhynchus eutropia*. The actual state of information of each specimen is given, followed by its probable or possible identity. Published total lengths (TL), in cm, taken over the body curve are given in parentheses, while those taken by us using standardized measurements are not. All condylobasal lengths (CBL) were taken (in mm) by Ian S. Cameron. 'Skull' means cranium with mandibles; 'cranium' means without mandibles.

Museum no.	Locality	Collection date	Specimen	Details and notes	CBL (mm)	References
BMNH 936a 1849.5.25.2	Coast of Chili, Pacific Ocean	Before 1846	Skull	Bought by BMNH from Dickie Collection Type of Delphinus eutropie Gray 1846.	364	Gray, 1846; 1849; True, 1899 :113; Flower, 1883:477; Harmer, 1922:632.
BMNH 936b 1881.8.17.1	Chili, Pacific Ocean	Before 1881	Skull	Bought by BMNH from T. Edmonds, 1881 'smaller, younger'.	326+	Flower, 183:477; True, 1889:113.
USNM 21167	Chili?	? 1883	Skull	F. True purchased from E. Gerrard, winter 1883-84. Originally determined as Lagenorhynchus obscurus by USNM.	342	True, 1889:113.
MNHN-S 597	Without data	-	Skin	Poorly mounted skin on pedestal, TL 127.5 (138) (measured by RNPG, ISC).	-	-
				a. Could be specimen coll. Port of Valparaiso in 1882, Type of Perez Canto's Phocaena albiventris, which was a skin 'sin sistema dentario' with a TL of (136) cm.		Perez Canto in Philippi, 1893a:8 tab.II, Fig. 3; Perez Canto, 1896:227.
				b. Or one col. by Martin Bodeker of Concepcion at Talcahuano in 1894, one of 'two skins and crania of Phocaena albiventris'.		
MNHN-S 604	Without data	-	Skin	TL 143 (149) (measured by RNP, ISC).	-	See note 1.
				a. Measurements coincide with Type of Phocaena obtusata TL (149) coll. Frederico Goday of Concepcion at Talcahuano, winter of 1888.		Philippi, 1893:12, Tab.III Fig. 3. See note 1. Goodall, Sobral et al., 1987

Museum no.	Locality	Collection date	Specimen	Details and notes	CBL (mm)	References
MNHN-S 598	Without data	-	Skin	TL 162.4 (169) (measured by RNP, ISC).	-	-
				a. Probably one of 'two skins with cranea of P. albiventris' coll. by Martin Bodeker at Talcohuano in 1894.		Philippi, 1894:4; Philippi, 1895:281.
MNHN-S 580	Talcahuano	1894	Skull	'albiventris' writted on R. mandible, C. eutropia and T. platyrrhinus written on card.	323+	Sielfeld, 1980.
				a. Probably is one of 'two specimens of P. albiventris from Talcahuano this this year' or,		Philippi, 1894:4; Philippi, 1895:16.
				b. 'animal stranded in winter of 1894 on beach at Talcahuano'.		
				c. Could belong to one of the skins above.		
MNHN-S 583	Talcahuano	-	Skull	'C. eutropia, P. albiventris Ph. 1893 and T. albiventris Ph. 1896' on card.	328+	Sielfeld, 1980.
				a. Probable identity same as MNHN-S 580, since these two were Philippi specimens.		
MNHN-S 582	Without data	-	Skull	'albiventris dibujado' written on skull. R. mandible has 'dentes 31'. L. mandible has the number '890'.	352	-
				a. Probably the skull illustrated in Philippi, 1896, since it is labelled 'dibujado'. But our photographs of this skull do not look much like the drawing.		Philippi, 1896, gave measurements of 330. Which skull?
				b. Philippi also had 'five skulls... of animals caught in the Rio Valdivia'.		

[*continued*]

Table 1 (*continued*)

Museum no.	Locality	Collection date	Specimen	Details and notes	CBL (mm)	References
MNHN-S 587	Without data	-	Skull	Type of Tursio platyrrhinus, 'platyrrhinus dibujado' on skull.	341+	Sielfeld, 1980.
				a. 'T. platyrrhimus... two skulls from Playa de San Vicente' (near Talcahuano). Could be this one and MNHN-S 580, the only other listed as platyrrhinus on the card? The card of 587 says 'Tipo Tursio platyrrhinus Philippi = C. eutropia (Gray)'. Neither of the skulls marked platyrrhinus give Philippi's CBL of 350mm.		Philippi, 1895:284; Philippi, 1896:16.
MNHN-S 581	Chiloe (on new card by J. Yanez)	-	Cranium	With MNHN-S 592 mandibles, but do not belong to this cranium. Teeth of cranium sharp and young. In catalogue (but not on bone) this is 'Philippi 896'; 'albiventris' written on cranium.	336	Sielfeld, 1980.
MNHN-S 592	Matuta (1)	-	Mandib.	'891 - Matuta' on mandibles in ink. They were with MNHN-S 581 but do not belong, very worn teeth.	-	-
MNHN-S 585	Without data	-	Skull	Card says albiventris 1893; 1895.	335+	Sielfeld, 1980.
MNHN-S 593	Without data	-	Skull, partial	Young animal, skeleton in poor condition, vertebral processes broken, skeleton no teeth, badly mounted.	-	-
				a. 'We have five skulls... two (with) whole skeletons, of animals caught in the Rio Valdivia'.		Philippi, 1893:14; Philippi, 1896:16.
MNHN-S 596	Without data	-	Skull	Skull on exhibitin in glass case, unable to examine.	-	-
MNHN-S 606	Without data	-	2 cerv., 1 thora. vertebrae	First two cervicals fused.	-	-

MNHN-S 594	Without data	-	Cranium	Found buried in a taxidermy section in 1978. Seems newer than other MNHN-S skulls. Perhaps collected in the 1970s?	341+	-
MNHN-S 605	Caleta Queule, Temuco 39 17'S,73 14'W	Oct 1972	Cranium	Cranium of animal killed by fishermen for congrio bait. Collected by Daniel Torres N.	326+	-
-	Valparaiso 33 02'S,71 37'W	1978	Not kept	Two specimens collected by Edwin C. Reed. One darker. Work load did not permit Reed to prepare them.	-	Reed, 1904:138.
Museo de Concepcion	Bahia de Concepcion 36 48'S,73 04'W	1903?	Kept?	Obtained from a fisherman by Reed. Pigmentation and external measurement described. TL (145)cm. No specimen in Museo de Concepcion at present.	-	Reed, 1904:140.
Naturhistoriska Riksmuseet, Stockholm.	-	-	2 skulls	Anelio Aguayo and Edward Mitchell studied two skulls of C. eutropia and two C. commersonii in Swedish Museum.	-	Brownell, 1977:475. Anelio Aguayo (pers.comm.).
USNM 395625	Bahia Mehuin 39 24'S,73 12'W	Dec 1977	Skull	Presented to K. Norris by Hugo Campos, Valdivia. KSN 68-53 SA.	310+	Kenneth Norris, Field Notes, 1968.
MVZ 11854	San Antonio, 30mi S. Valparaiso 33 37'S,71 38'W	15 Aug 1953	Skull	Beach cast specimen collected by C.B. Koford.	329	-
USNM 395374	Bahia Corral 39 50'S,73 25'W	5 Oct 1968	Complete skeleton	Collected by K. Norris, L. Hinton, J. Guzman. Physically adult male, TL 151.9cm. KSN 68-59 SA.	339	Kenneth Norris, Field Notes, 1968.
USNM 395375	Playa Frailes, Golfo de Arauco 37 12'S,75 30'W	11 Oct 1968	Complete skeleton	Collected by K. Norris, L. Hinton, K. Bloome. Physically immature female. TL 149.6cm. KSN 68-59 SA.	337	Kenneth Norris, Field Notes, 1968.
IZUA-MM 2	-	-	Cranium	Beach worn specimen.	342+	-
IZUA-MM 3	-	-	Cranium	Good condition.	340+	-
IZUA-MM 6	Mehuin 39 20'S,73 15'W	? Dec 1977	Skull	Caught by a fisherman. Good condition.	336	-

[*continued*]

Table 1 (*continued*)

Museum no.	Locality	Collection date	Specimen	Details and notes	CBL (mm)	References
IZUA-MM 9	-	-	37 vert. hyoids	Incomplete skeleton. May belong to IZUA-MM 6	-	Ian Cameron, Oct 1978, notes.
IZUA-MM 10	-	-	Cranium	Teeth glued in.	335+	Ian Cameron, Oct 1978, notes
IZUA-MM 11	Puerto Saavedra 38 39'S,73 24'W	12 Mar 1975	Skull	Enmeshed in net set at 84ft depth, female with fetus. TL 150. Collected by Alejandro Villagran.	339	-
IZUA-MM 12	-	-	Cranium	Worn	364	-
IZUA-MM 13	-	-	Mandib.	Was with cranium IZUA-MM 12, but jaws are too small.	-	-
IZUA-MM 15	Queule 39 19'S,73 14'W	24 Jan 1979	Skull, skeleton	Enmeshed in corvina nets, TL 136. Wt. 32.4kg, x-ray of flipper, measurements. Collected by Jorge Oporto.	-	-
IZUA-MM 16	Playa las Tres Ninas, near Queule 39 19'S,73 14'W	-	Skull	Almost complete beach cast, bird flensed, some measurements and tracings taken by Jorge Oporto. Skeleton lost.	-	-
IZUA-MM 17	Mehuin	-	Skull	No data. Teeth missing.	302	-
IZUA-MM _	Mehuin 39 20'S,73 13'W	19 Jan 1976	Saved?	Male, TL 167cm, testicle weight, measurements by Jorge Oporto.	-	-
IZUA-MM _	Mehuin 39 20'S,73 13'W	26 Apr 1979	No specimen	Male harpooned by fishermen, TL 155 cm, measurements by Jorge Oporto.	-	-
IZUA-MM _	Mehuin 39 20'S,73 13'W	26 Apr 1979	No specimen	Male harpooned by fishermen, TL 159 cm, measurements by Jorge Oporto.		
IPPA-CE-5 (CE-11)	No data, probably Strait of Magellan	-	Skull	No data	356	Sielfeld, 1980:277 W. Sielfeld, pers. comm.
MNHN-S 4003	San Antonio 33 38'S,71 42'W	28 Jun 1984	Complete	Incidental take in net. TL 165cm. 100kg, no wounds.	346	El Mercurio, 1984. J. Yanez, pers. comm.

Because there has been some transposition of museum numbers by various people who have examined these materials, we have listed the museum number as given in each reference alongside measurement data. To help in identifying the various specimens, the condylobasal length (CBL) is given. Confusion in the literature is also noted. For example, Flower (1885) gave the number of Gray's 1846 skull as 369z, while True (1889), Harmer (1922) and we (Cameron) found it to be 936a. True (1889) said that the second BMNH skull was larger than the first, but gave a smaller CBL for it.

The greatest confusion centers around the collection at MNHN-S. Although Philippi numbered some of his specimens, no references to these numbers are given in any of his publications[3].

In 1973, R.L. Brownell, Jr measured the skulls, noting his measurements on the accompanying identification card. Goodall and Cameron were able to match many of the specimens with their cards on the basis of these measurements. In Table 1 we note the state of the specimen, the existing data, and then its probable identity in Philippi's publications. Total lengths of the specimens are given when known.

There are three poorly mounted skins in the MNHN-S collection which we measured. Total lengths were taken over the dorsal curve (in parentheses) in order to correlate with Philippi's publications (Table 4).

Reed's (1904) two specimens taken at Valparaíso in 1878 are included but probably no longer exist[4]. There were no specimens of *Cephalorhynchus eutropia* at the Museo de Concepción when Cameron visited it in 1978 and there are none at present (Oporto). Sielfeld (1980, p. 277), in his list of marine mammal specimens in Chilean museums, lists no *C. eutropia* specimens from any museum at Concepción. He did not examine the material in MNHN-S himself; he includes only six of the twelve cranial specimens of *C. eutropia* in the museum and only one of the three skins. He mistakenly included under *C. eutropia* the type of *Tursio? panope* (MNHN-S 548) and MNHN-S 586, which is a specimen of *Lagenorhynchus australis* (see, Goodall, 1986).

DISTRIBUTION

All recorded sightings are summarized in Table 2 and plotted in Fig. 4. The first published sighting was that of Lesson (1826, p. 374), who saw the dolphin in 'la baie de la Conception, au Chili'.

[3]Rodolpho Amanndo Philippi (1808–1904), was born and educated in Germany, was director of the MNHN-S, at one time the most important museum in South America, from 1874 until his death. One of history's great students of nature, he described new species in many orders, tending to be a 'splitter' rather than a 'lumper'. In 1893, when he began to describe dolphins, he was 85 years old and nearly blind, relying on an assistant. Later, the museum gradually fell on hard times. From 1919 to 1976 there was no Curator of Mammals at MNHN-S, and practically no collecting was done. During that time some of the subsequent confusion must have been generated as specimens and labels were mixed. The present Curator of Mammals, José Yañez, started a new catalogue and numbering system, keeping the cards of the old, mostly unnumbered specimens, but giving them new numbers (used in Table 1).

[4]The original Museo de Historia Natural de Valparaíso was destroyed by earthquake and fire in 1906. It was started again, but did not soon find a permanent home. Its location, for example, was changed three times between 1974 and 1978. Although now being revitalized, there was very little cetacean material and none of *C. eutropia* at the time of our visit in 1978.

Table 2
Known sightings, both published and unpublished, of Chilean dolphin, *Cephalorhynchus eutropia*. Sightings marked * are only tentative for this species.

No	Date	Local time	Locality	Position	Numbers seen	Ship	Ref.
1	Ca. 1823	——	Bahia de Concepcion	36 42'S 77 03'W	Great numbers	La Coquille	A, B
2	Ca. 1866	——	Puerto de Valparaiso	32 02'S 71 37'W	Numerous schools	shore	C
3*	08 Dec 1964	1940	Off Chilean coast	35 20'S 73 32'W	15–20	Indus XIV	D
4*	09 Dec 1964	0930	Off Chilean coast	35 20'S 73 47'W	50–60	Indus XIV	D
5*	11 Dec 1964	1005	Off Chilean coast	36 22'S 74 13'W	20	Indus XIV	D
6*	11 Dec 1964	1010	Off Chilean coast	36 22'S 74 12'W	6	Indus XIV	D
7*	16 Dec 1964	1020	Off Chilean coast	33 59'S 73 07'W	20	Indus XIV	D
8*	04 Feb 1968	1800	N of Punta Arenas, Strait of Magellan	— — — —	2	Navarino	Ee F
9	22 Feb 1968	——	Channels S of Puerto Eden	— — — —	?	Navarino	E F
10	24 Feb 1968	——	Puerto Lagunas, channels S of Isla Chiloe	45 17'S 73 45'W	'some'	Navarino	E F
11	25 Feb 1968	——	Isla Chiloe	— — — —	'some'	Navarino	E, F
12	03 Oct 1968	0730	Bahia Corral, S of Rio Valdivia	39 50'S 73 45'W	2 schools of 10 each	Alejandro D	G
13	03 Oct 1968	——	Rio Valdivia to Nigue, N of Mehuin	39 15'S 73 16'W	8 schools of 1–18	Alejandro D	Gg
14	03 Oct 1968	dusk	Bahia Corral	39 50'S 73 25'W	'school' 1 captured	Alejandro D	G
15	06 Oct 1968	——	Queule	39 19'S 73 14'W	20	skiff	Gg
16	11 Oct 1968	1000	Playa Frailes, Golfo de Arauco	37 12'S 73 30'W	Several schools of 20–50. One captured	Lupita	G
17	16 Nov 1968	1440	Isla Butachauques, Golfo de Ancud	42 21'S 73 10'W	2	launch, R.V. Hero	Gg H
18	18 Nov 1968	1330	Estero Huildad, Isla Chiloe	43 04'S 73 31'W	4–5	launch, R.V. Hero	Gg H
19	19 Nov 1968	——	Puerto Tic Toc, Golfo de Corcovdo	43 37'S 73 00'W	2	shore	Gg
20	01 Dec 1968	1000	Wulaia, Isla Navarino	55 02'S 68 09'W	2	launch, R.V. Hero	Gg H
21	06 Dec 1968	1445	Seno Grandi, Isla Navarino	55 14'S 67 50'W	7,5,5	launch, R.V. Hero	Gg H
22	07 Dec 1968	1700	Wulaia, Isla Navarino	55 02'S 68 09'W	2	launch, R.V. Hero	Gg H
23	— Dec 1974	am	Bahia Corral	39 50'S 73 25'W	2	Caranco	I
24	17 Jan 1975	am	Mouth of Rio Valdivia	39 50'S 73 45'W	20–30 with young	Caranco	I
25	— Mar 1975	am	Bahia Corral	39 50'S 73 25'W	2	Caranco	I
26	— May 1975	am	Bahia Corral	39 50'S 73 25'W	30, in 4 groups	Caranco	I
27	— May 1975	am	Mouth of Rio Valdivia	39 50'S 73 45'W	4	Caranco	I
28	— Jul 1975	am	Bahia Corral	39 50'S 73 25'W	2,2	Caranco	I
29	— Nov 1975	am	Bahia Corral	39 50'S 73 25'W	2	Caranco	I
30	— Nov 1975	am	Mouth of Rio Valdivia	39 50'S 73 45'W	2	Caranco	I
31	— Dec 1975	am	Mouth of Rio Valdivia	39 50'S 73 45'W	2,3,2,3	Caranco	I
32	— Feb 1976	am	Bahia Corral	39 50'S 73 25'W	7	Caranco	I
33	— Jun 1976	am	Bahia Corral	39 50'S 73 25'W	3	Caranco	I
34	— Aug 1976	am	Bahia Corral	39 50'S 73 25'W	2	Caranco	I
35	— Oct 1976	am	Bahia Corral	39 50'S 73 25'W	15 approx.	Caranco	I
36	— Oct 1976	am	Mouth of Rio Valdivia	39 50'S 73 45'W	4	Caranco	I
37	— Dec 1976	am	Bahia Corral	39 50'S 73 25'W	9	Caranco	I
38*	03 Apr 1977	dusk	Bahia Playa Parda, Strait of Magellan	53 19'S 73 00'W	6–8	Yacht Tzu Hung	J, K F
39	27 May 1977	1700	Canal Canacus, Isla Hoste	55 12'S 68 20'W	6	zodiac, R.V. Hero	L F

Table 2 (*continued*)

No	Date	Local time	Locality	Position	Numbers seen	Ship	Ref.
40	01 Jun 1977	1600	Canal Canacus, Isla Hoste	55 12'S 68 20'W	6	zodiac, R.V. Hero	L F
41	05 Jun 1977	0900	Canal Canacus, Isla Hoste	55 12'S 68 20'W	6	zodiac, R.V. Hero	L F
42	07 Jul 1977	1240	Seno Cerrado, Brazo Noroeste Canal Beagle	54 49'S 69 46'W	20–30	zodiac R.V. Hero	Ll F
43	09 May 1978	1035	Entrance Seno Cerrado Brazo Noroeste Canal Beagle	54 49'S 69 46'W	10–12	zodiac R.V. Hero	M L
44	10 May 1978	1700	Entrance Seno Cerrado Brazo Noroeste Canal Beagle	54 49'S 69 46'W	10 approx.	zodiac R.V. Hero	N F
45	18 May 1978	1100	Seno Chair, Brazo Noroeste Canal Beagle	54 49'S 70 04'W	10–15	zodiac R.V. hero	O F
46	29 Jan 1979	1335	Puerto Eden	49 05'S 74 27'W	5–7	M.N. Isabella	P F
47	03 Feb 1979	2130	Canal between Dalcahue (Chiloe) and Isla Quinacho	42 20'S 73 47'W	3	M.N. Isabella	P F
48	— May 1979	——	Peninsula Staines Canal Sarmiento	51 28'S 73 45'W	6–7	R.V. Hero	Q
49	10 Oct 1979	——	Mehuin, N of Valdivia	39 20'S 73 13'W	10	shore	R
50	15 Mar 1980	1045	Estuary of Rio Valdivia	39 53'S 73 24'W	3	Yate D-14	S
51	16 Mar 1980	0900	Estuary of Rio Valdivia	39 53'S 73 24'W	3	Yate D-14	S
52	30 Mar 1980	0900	Estuary of Rio Valdivia	39 53'S 73 24'W	10	Yate D-14	R
53	15 May 1980	1500	Mehuin	39 20'S 73 13'W	21	shore	T
54	20 Sep 1980	0730	Mehuin	39 20'S 73 13'W	400	shore	T
55	14 Jan 1981	1300	Morro de Niebla, Bahia Corral	39 50'S 73 25'W	1	Yate D-14	S
56	21 Jan 1981	1940	Estuary de Rio Valdivia	39 53'S 73 24'W	6	Yate D-14	S
57	— Jan 1982	——	Seno Ultima Esperanza	— — — —	1	—— ——	U V
58	22 Mar 1983	1250	Mehuin	39 25'S 73 10'W	6–7	shore	R
59	31 Mar 1983	1325	Bahia Corral, Valdivia	39 50'S 73 25'W	3	lancha Meulen	R
60	16 Apr 1983	1015	Corral y Amargos, Valdivia	39 50'S 73 25'W	3,5,2	shore	R
61	16 Apr 1983	1410	Corral (Altos Hornos), Valdivia	39 50'S 73 25'W	1	shore	R
62	04 Aug 1983	0930	Los Molinos, Bahia Corral	39 50'S 73 25'W	2	shore	R
63	05 Aug 1983	1010	Fuerta Niebla, Bahia Corral	39 50'S 73 25'W	5,4	shore	R
64	09 Aug 1983	1430	Bahia Corral	39 50'S 73 25'W	2	Condor No. 40	W
65	20 Aug 1983	1555	Bahia Corral	39 50'S 73 25'W	2	Yate D-14	R
66	08 Nov 1983	1200	Yaldad	43 07'S 73 44'W	2	Totorore	X
67	03 Dec 1983	0650	Puerto Quellon	43 08'S 73 38'W	4	Totorore	X
68	24 Dec 1983	2035	Cerro Carrera del Cuchi	45 23'S 73 56'W	3	Totorore	X
69	26 Dec 1983	1645	Playa Quellon Viella, Isla Chiloe	43 26'S 73 48'W	7–10	shore	Y, Z
70	19 Jan 1984	1730	Puerto Morales	50 40'S 75 23'W	1	Totorore	X
71*	03 Feb 1984	——	Cabo San Isidro, Strait of Magellan	53 47'S 70 58'W	4	aircraft	AA BB
72	— Feb 1984	——	W of Isla Riesco (off Cordoba Peninsula)	— — — —	3–4	——	CC BB
73	24 Apr 1984	1800	Primera Angostura, Strait of Magellan	52 30'S 69 20'W	1	R.V. Hero	Q
74	24 Jul 1984	0910	Bahia Yaldad, Chiloe	43 07'S 73 44'W	7–9	rowboat	R
75	01 Oct 1984	0300	Cabo San Isidro, Strait of Magellan	53 55'S 71 10'W	2	——	DD
76	02 Oct 1984	1030	Canal Sea Shell, Isla Rice Trevor	53 25'S 71 10'W	2	——	DD
77	04 Oct 1984	0900	Paso Wakefield, Isla Santa Ines	53 55'S 73 25'W	6	——	DD

Table 2 (*continued*)

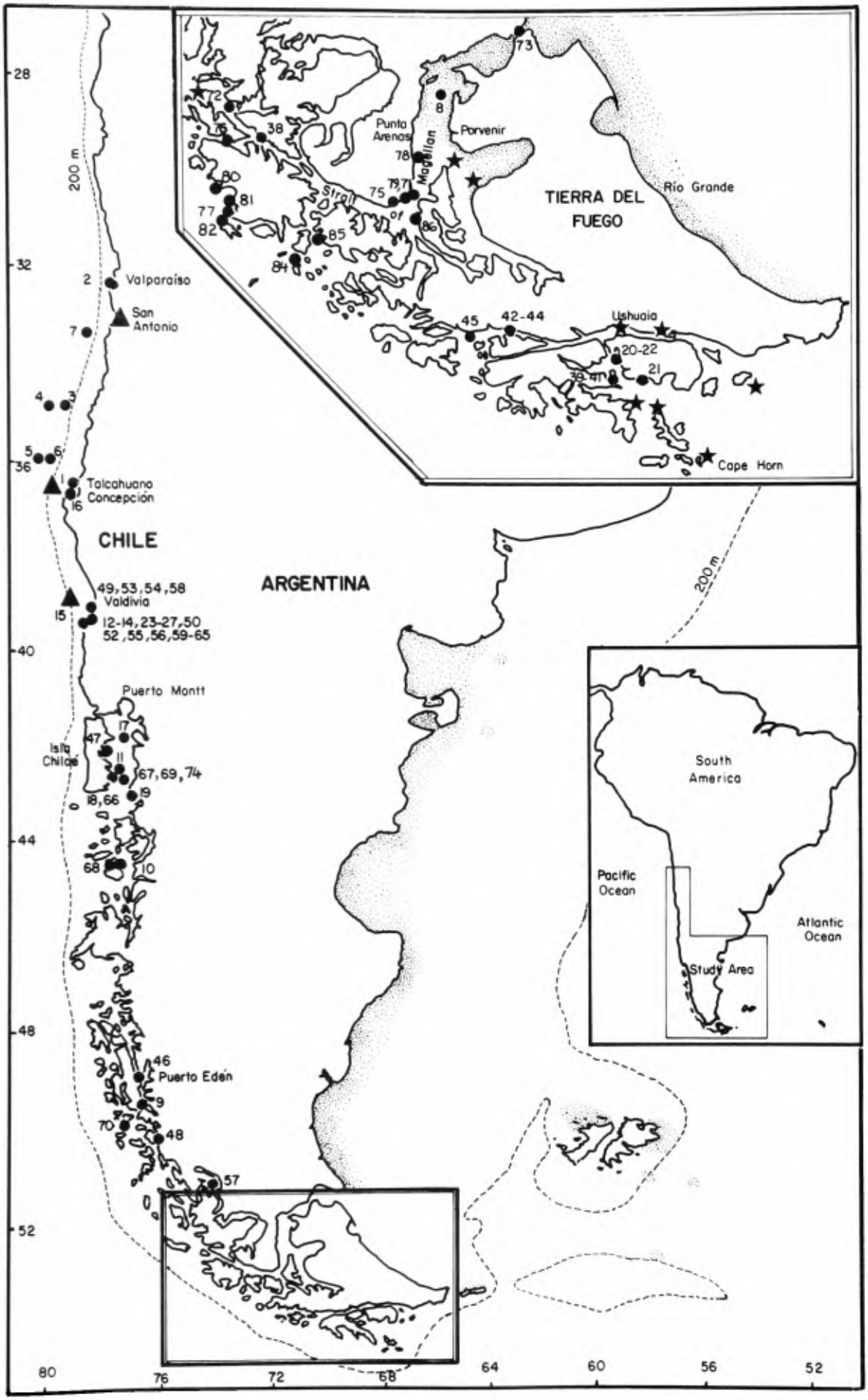
No	Date	Local time	Locality	Position	Numbers seen	Ship	Ref.
78	22 Jul 1984	——	Fuerte Bulnes, Strait of Magellan	53 32'S 70 55'W	3	——	EE
79	26 Jul 1984	——	B. San Nicolas, Paso del Hambre, Strait of Magellan	53 52'S 71 00'W	3	——	FF
80	18 Oct 1984	——	Seno Langford, Isla Santa Ines W.	53 47'S 73 20'W	9	——	CC
81	20 Oct 1984	——	B. Breaker, Isla Santa Ines W	53 52'S 73 22'W	2,2	——	CC
82	21 Oct 1984	——	B. Breaker, Isla Santa Ines	53 52'S 73 22'W	2,6,2	——	CC
83	25 Oct 1984	——	Islas Crafton, Pacific Ocean	54 07'S 72 49'W	3	——	CC
84	26 Oct 1984	——	Bahia Stokes, Pacific Ocean	54 09'S 72 49'W	3	——	CC
85	02 Nov 1984	——	Canal Barbara, Isla Guardian Brito W.	54 07'S 72 10'W	7,8	——	CC
86	04 Nov 1984	——	Punta Hillock, Isla Dawson W.	53 55'S 70 55'W	4	——	CC

The first three skulls are known from the coast of 'Chili, Pacific Ocean' (Gray, 1849; Flower, 1883; True, 1889). The first specimen for which external measurements and drawings were published (Philippi, 1893a, p. 8) was captured in the port of Valparaíso in 1882. The next year he (Philippi, 1894, p. 4) mentioned two specimens from Talcahuano, and in 1896 (p. 16) five specimens from the Río Valdivia, as well as one stranded on the beach at Talcahuano in 1894. Pérez Canto (1896, p. 227) wrote that these *tuninas* appeared frequently near the pier at Valparaíso in the 1880s, but later became more rare.

Some recent authors (Scheffer and Rice, 1963, p. 9; Marcuzzi and Pilleri, 1971, p. 108; Mörzer Bruyns and Baker, 1973, p. 128) listed the range as from 33°S to 40°S, in other words from Valdivia to Valparaíso. Oliver Schneider (1946, p. 80) called it occasional on the coast of Chile. Mörzer Bruyns (1971, p. 43), ignoring the published accounts to that time, said: 'it is very rare and probably does not range north of Chiloé Island'. Chiloé is at approximately 43°S latitude. Many authors (for example, Nishiwaki, 1972, p. 108; Coffey, 1978, p. 86) label its distribution as 'southern South America'. However, Brownell (1974, p. 16) noted that it has not yet been found on the Atlantic coast.

Aguayo (1975, p. 1127), quoting the 1968 *Hero* expedition data, extended the range south to the region of Cape Horn, or approximately 55°S latitude. He evidently felt the species was no longer found north of Concepción, since he lists the northern limit as 37°S. Mitchell (1975b, p. 935) and Rice (1977, p. 9) repeated this distribution. However, a 1953 specimen from 48km south of

Fig. 4. (right) The distribution of *Cephalorhynchus eutropia*. Dark circles are sightings; associated numbers refer to the sighting numbers in Table 2. Triangles represent sites of recent specimens. The range and areas of concentration of *C. commersonii* is shown in stipple and isolated sightings with stars (Goodall *et al.*, 1988).


Valparaiso
San Antonio
Talcahuano
Concepción
CHILE
ARGENTINA
Valdivia
Puerto Montt
Isla Chiloé
Puerto Edén
200 m
Punta Arenas
Porvenir
Strait of Magellan
TIERRA DEL FUEGO
Río Grande
Ushuaia
Cape Horn
South America
Pacific Ocean
Atlantic Ocean
Study Area

Valparaíso (MVZ 118854, Table 2) and possible sightings by Clarke, Aguayo and Basulto del Campo (1978, p. 152) show that it still inhabits waters north of Concepción. This is further confirmed by the June 1984 stranding of a specimen at San Antonio, only 65km south of Valparaíso. It is unclear if the present day scarcity of northern sightings represents (a) a decrease in numbers, perhaps due to increased human activity in harbors such as the port of Valparaíso, (b) a lack of sighting effort in that area (probably the case) or (c) the animal is migratory near its range limits.

Watson (1981, p. 250) included both northern and southern records when he gave the range as 33°S to 55°S. The most recent compilation, that of Leatherwood *et al.* (1983) again lists the range from approximately Concepción (37°S) to Isla Navarino (55°S).

In 1964, Clarke *et al.* (1978, p. 152) saw small dolphins or porpoises well offshore on five occasions in the area between Talcahuano and Valparaíso. After a review of possible species these authors decided that these animals were neither *Phocoena dioptrica* nor *Phocoena spinipinnis*. They concluded:

'on the other hand, our porpoises could have been, with regard to size and color pattern, the white-bellied dolphin *C. eutropia* as described by Pérez Canto; ... But again, our field notes say that the head and dorsal fin were typical of *Phocaena*'.

Discriminating between southern South American *Cephalorhynchus* spp. and phocoenids at sea can be very difficult (Goodall, Sobral *et al.*, 1988). Only the peculiar dorsal fin of *P. spinipinnis* allows its easy distinction, and the usual wariness of these animals makes prolonged close inspection difficult. Although we think that from the description the animals seen were probably *C. eutropia*, we include this sighting in Table 2 only tentatively. In fact, because of this difficulty, we believe that all sighting records that are unsubstantiated by either a photograph, a skeletal specimen or an entire animal from which a firm identification can be made, should be tentative, including our own.

One reason for our unwillingness to accept most sighting records outright is that mention of diagnostic characters is usually absent and many contain details that could refer to other species. In our sighting records from outside the range established by specimens, only the record from Wulaia (Sighting 20, Table 2) included note of the diagnostic lunate markings behind the blowhole.

Murphy (1925, p. 255) wrote that the 'handsome, black and white, beakless porpoises which played beneath the stem of the *Alcatraz* during the trip toward Huacho (Perú), probably belonged to the species called *Cephalorhynchus albifrons*'. Since *albifrons* (= *C. hectori*) is native to New Zealand, Clarke *et al.* (1978) thought the dolphins Murphy saw might have been *C. eutropia*. If this were true, it would double the known range since Huacho, Perú, is some 2,500km north of Valparaíso. Field work by Norris along the coast of northern Chile and Perú indicates that the record was probably of the dusky dolphin, *Lagenorhynchus obscurus*, which is very abundant in the area, and which typically plays at the bows of vessels.

Fourteen sightings of *C. eutropia* were mentioned by Goodall and Polkinghorn (1979) and Perrin (1980, p. 122) from the area between Isla Hoste (near Cape Horn) and Isla Chiloé, and are listed in detail in Table 2. These do not add to the known range but do show (Fig. 4) that the species is more or less continuously distributed throughout its range.

As discussed below, the Chilean dolphin's range comprises three general zones: (a) the northern, from Valparaíso to Puerto Montt on fairly open coast with some bays and river mouths, (b) the Chilean channels from Puerto Montt south to the Strait of Magellan and (c) the Fuegian channels to Cape Horn.

Many navigators and observers (P.J. Lenie, R. Nance, pers. comm.; Norris, 1968; and Oporto, 1984b) have found that from about Cabo Tres Montes, south to the Straits (Canal Gray), cetaceans are uncommon.

Davies (1963, p. 114) and Marcuzzi and Pilleri (1971, p. 131) suggested that *C. eutropia* and *C. commersonii* occur sympatrically in parts of their range and the latter showed *C. commersonii* all the way up to the Chilean coast. Brownell (1974, p. 16) correctly pointed out that although *C. commersonii* is known from the Beagle Channel and the Straits of Magellan, there are no records of this species from the Pacific coast of South America.

J. Polkinghorn, officer on the R/V *Hero*, later discovered a group of Commerson's dolphins at Puerto Churruca on Isla Desolación in the western Strait of Magellan (Goodall and Polkinghorn, 1979), the westernmost sighting yet known. Commerson's dolphins have also been seen south of Isla Navarino and north of the Islas Wollaston, and there are sightings and two specimens from the Beagle Channel east of Ushuaia (Aguayo, 1975, p. 1,124; Goodall, Galeazzi *et al.*, 1988). There are no sightings or specimens as yet of this species in the Beagle Channel west of Ushuaia and none of *C. eutropia* to the east (which does not necessarily mean they are not there).

Sir Peter Scott reported a sighting of what he felt were these species together in the western Strait of Magellan northeast of Punta Arenas, Chile (Sighting 8, Table 2); he illustrated them in a field sketch. His painting shows what he called 'white-bellied dolphin' browner than the many *C. commersonii* visible at the time and having a more defined beak than exist on *C. eutropia*; we believe that this record must be considered only tentative.

Recent sightings by Leatherwood's assistants confirm the presence of the Chilean dolphin in the western Strait of Magellan and surrounding channels. Captain P.J. Lenie, who has travelled the Fuegian Channels in the R.V. *Hero* for over 12 years, recently saw a specimen of *C. eutropia* in the eastern Strait of Magellan near the First Narrows, where Commerson's dolphin definitely occurs.

The two species evidently do overlap in the Strait of Magellan and Beagle Channel/Cape Horn region (Fig. 2), but these records seem to be at the edges of their ranges. Only intensified observations in the Tierra del Fuego region will clarify the situation.

In summary, the known distribution of *Cephalorhynchus eutropia* is approximately 30°S (Valparaíso) to 55°S. The southernmost sightings are from the 1968 *Hero* expedition at Seno Grandi, Isla Navarino, at 55°14′S latitude (Table 2). The species probably reaches Isla Hornos (Cape Horn) at nearly 56°S.

All recent records of *C. eutropia* are from Chilean waters. In our study of the stranded cetaceans of Tierra del Fuego, we have found no confirmed specimens of this species in Argentine territory. However, remains of this species were present in eastern Beagle Channel shell middens dated 6,000 years BC (Piana,

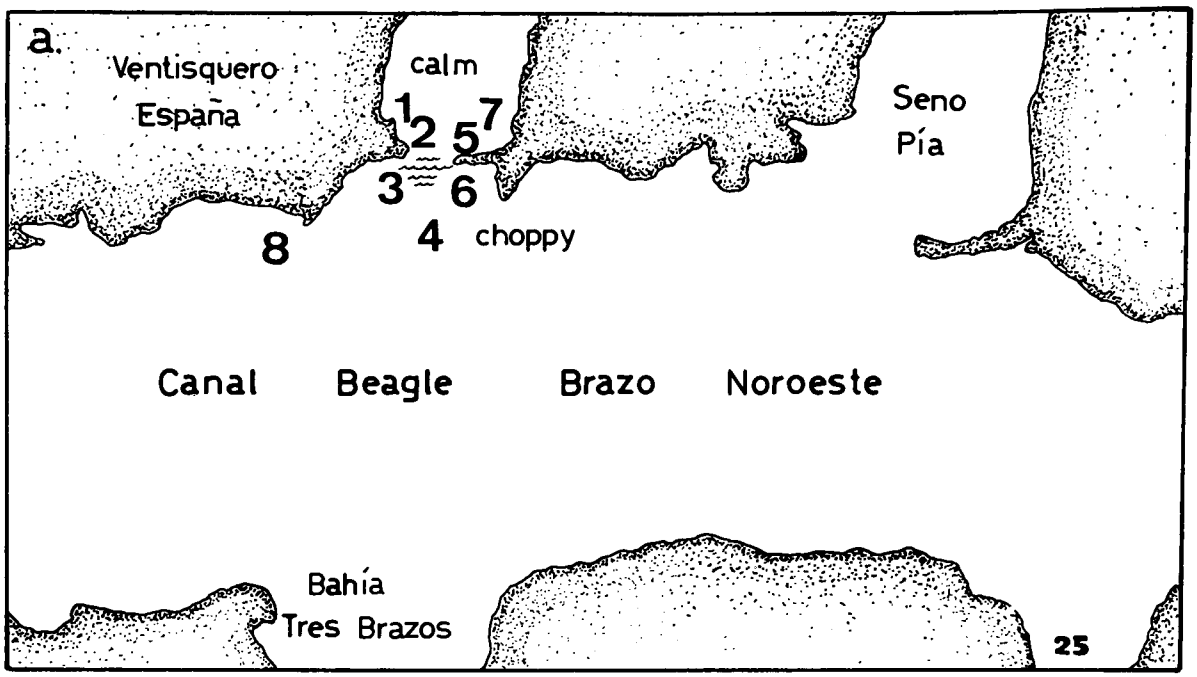


Fig. 5. Typical habitat and usual swimming or feeding pattern for the Chilean dolphin in the tide rips at the entrance to a fiord (Sighting 25). Numbers indicate successive positions of the dolphins.

Orquera, Galeazzi, Goodall and Sobral, 1985). Its present close proximity at Isla Navarino seems to predict future sightings in Argentinian waters.[5]

HABITAT

This dolphin is typically found along open coastlines in inland channels in areas of rapid tidal flow, especially in the tide rips at the entrance to fiords (Fig. 5). Most sightings have been near the shore; Oporto (1984b, p. 9), for example, found them in water depths of from 3 to 15m. However, if the Clarke *et al.* (1978) sightings were of this species, it also may occur some distance offshore.

The Chilean dolphin is known to enter rivers; Roberto Schlatter (pers. comm.) has seen them at least 5km upstream from the mouth of the Río Valdivia. Casual observations over a number of years indicate that a resident group occupies a stream, estuary and channel near a salmon hatchery on Isla Chiloé (K. Pryor, pers. comm.).

Evidently, overlap with *C. commersonii* is slight. One seeks answers for what appears to be competitive exclusion in features of the habitats or in resource partitioning. Brownell (1976, p. 16) wrote:

'There are two factors which may have prevented *C. commersonii* from invading the southern Pacific coast of Chile: (1) direct competition with other small cetaceans, possibly *C. eutropia* or (2) a restricted diet. The former is more plausible, since no known zoogeographic boundary occurs in the Strait of Magellan or Tierra del Fuego'.

[5]Fishermen and divers have repeatedly mentioned (to Goodall) a *delfín niño* (child-dolphin), which has been seen off the eastern mouth of the Beagle Channel in 'great numbers' (50–200). This small dolphin emits a sound like a child crying, which can be heard by divers or through the hull of a boat. Supposedly gray and white, we have not been able to obtain a good enough description to decide what species it might be, but *Cephalorhynchus eutropia* is a possibility. It might also be *Lagenorhynchus obscurus*, uncommon around Tierra del Fuego, or *Lissodelphis peronii*, which is black instead of gray, but which does strand there, and which has been heard to cry like a child (Galeazzi).

Although it has been shown above that the two species do overlap in the southern part of their ranges, this does not seem to be common.

Why do the two species live in such close proximity and yet seldom appear to mix? Both are neritic, living and feeding close to the shore (as far as we know) and both have been sighted along various kinds of coast, near river mouths and in the surf line.

The difference in average water temperature which exists between the east and west coasts is probably insignificant for these dolphins. West coast waters are slightly warmer than in the east, ranging from 7.4°C (at 20m below the surface) off the western part of the Strait of Magellan to 6.81°C at the eastern mouth. At comparable latitudes to the north on both coasts, water temperatures are quite similar: 12.18°C at Puerto Montt, Chile, and 11.5°C off Península Valdés (about 42°S), Argentina (Gordon and Goldberg, 1970).

The only water temperatures available during sightings are those of Oporto (1984b), who found temperatures of 11.0–14.6°C during four sightings.

The most evident habitat difference lies in physiography. The Atlantic coast is very flat and experiences large tidal changes (6.8m at Río Grande, 10.7m at San Sebastián, just south of the eastern entrance of the Strait of Magellan, and 12.3m at Río Gallegos) (Anon., 1978). Tidal ranges in the west are much less than in eastern Patagonia: 2.59m in southern Tierra del Fuego, 2.28m at Punta Arenas in the Strait of Magellan, 7.39m at Puerto Montt (at the head of a narrow gulf) and 1.95m at Valparaíso.

On the east side of the continent there are fewer rocky areas and the shallows are extensive. The shale substrate produces very fine sediments. Off the Argentine coast, the rich waters of the cool Malvinas current, largely composed of sub-Antarctic waters diverted northward from the West Wind Drift (Circumpolar Current), flow northward. The water is slightly more saline than that of the west coast.

Off southern Chile, waters from the southeast Pacific flow southward along the coast and round Cape Horn. It is warmer and not as nutrient-rich as Malvinas water. The Humboldt Current, originating in Antarctic waters and flowing northward offshore along the Chilean coast, does not hit the shore until about the latitude of Valparaíso (the northern limit, as far as presently known, of *C. eutropia*).

The channels of both the western Patagonian and Fuegian archipelagos are very different from the Atlantic coast. Along the Pacific, the land is mountainous throughout the range of *C. eutropia*. The relief deepens immediately offshore into one of the world's longest deep ocean trenches. The continental shelf is narrow, averaging only 50km in width. Steep profiles and rocky shores are the rule. Even against the shore the water usually deepens abruptly to 30m or more. In the Atlantic such a depth is reached at more than 2km from shore.

Shallow east coast waters where the fine sediments are easily stirred by water turbulence are often opaque near shore, although farther offshore deeper waters are clear and blue. Commerson's dolphins are found in both these areas. In marked contrast, the waters of the Chilean channels often appear tea or coffee colored, although clear; in deep channels the water may appear almost black.

The correspondence of the ranges of the two species to these habitat

differences is excellent. East of Punta Arenas in the Straits of Magellan one enters shallow, turbid waters and usually quickly encounters schools of *C. commersonii*, while travelling to the west into the Chilean channels they are all but absent, and scattered sightings of *C. eutropia* are to be made.

Few records are known for *C. eutropia* (see Feeding), but *C. commersonii* feeds on squid, small fish, mysid shrimp, isopods, tunicates and possibly other invertebrates (Goodall and Galeazzi, 1985; Bastida, Lichtschein and Goodall, 1988). These prey species also probably reflect the differences in habitat on opposite sides of the continent.

ABUNDANCE

Typically, *C. eutropia* is called a rare dolphin. We believe that it is considered rare because of its shy unobtrusive habits, its avoidance of ships, its dark coloring in the dark waters of the channels and, most of all, the lack of trained observers who have had experience with it in its often remote habitat. Few South American researchers have had the funds to carry out field observations where *C. eutropia* lives.

In the northern part of its range it can hardly be considered rare. Off Playa Frailes, at the western limb of Golfo de Arauco, it was found to be particularly abundant, with aggregations of 20–50 animals frequently encountered. Here they swam in relatively shallow water off a long open sandy beach. Within the channels of southern Chile, the schools Norris found were much smaller and very wary.

Nevertheless, the dolphins may fail to show themselves even to trained observers. R.L. Brownell Jr. (pers. comm.) saw none during a R/V *Hero* cruise from Punta Arenas to Talcahuano, 13–18 August 1969, and in several years of winter cruises in this area, officers of the *Hero* made only two sightings. Venegas and Sielfeld (1978, p. 174), residents of Punta Arenas, wrote that '... it is scarcer than the congeneric *C. commersonii* in Magellanic waters. To date, the authors have not observed specimens of this species in their extensive surveys of the southern channels'. A 1984 expedition from Punta Arenas to Isla Noir in the southwestern Fuegian archipelago encountered no Chilean dolphins (S. Leatherwood, pers. comm.).

The Chilean dolphin has been seen during all months of the year in the northern part of its range (Fig. 6) with most sightings in December, which is summer in Chile, and which likely reflects greater effort. Oporto found that more fishing trips are made in summer months (hence more sightings). The mid-part of its range (the Chilean Patagonian channels) is that with least sightings and also the area with least opportunities for observers. The dolphin appears to live year round even in the southern part of its range, as evidenced by sightings in winter (June, July).

It should be emphasized that nearly all sightings mentioned in this paper were opportunistic; the only planned sighting programs were those of Sielfeld and Venegas, of Norris in 1968, Brownell in 1969 and Oporto in 1983–84.

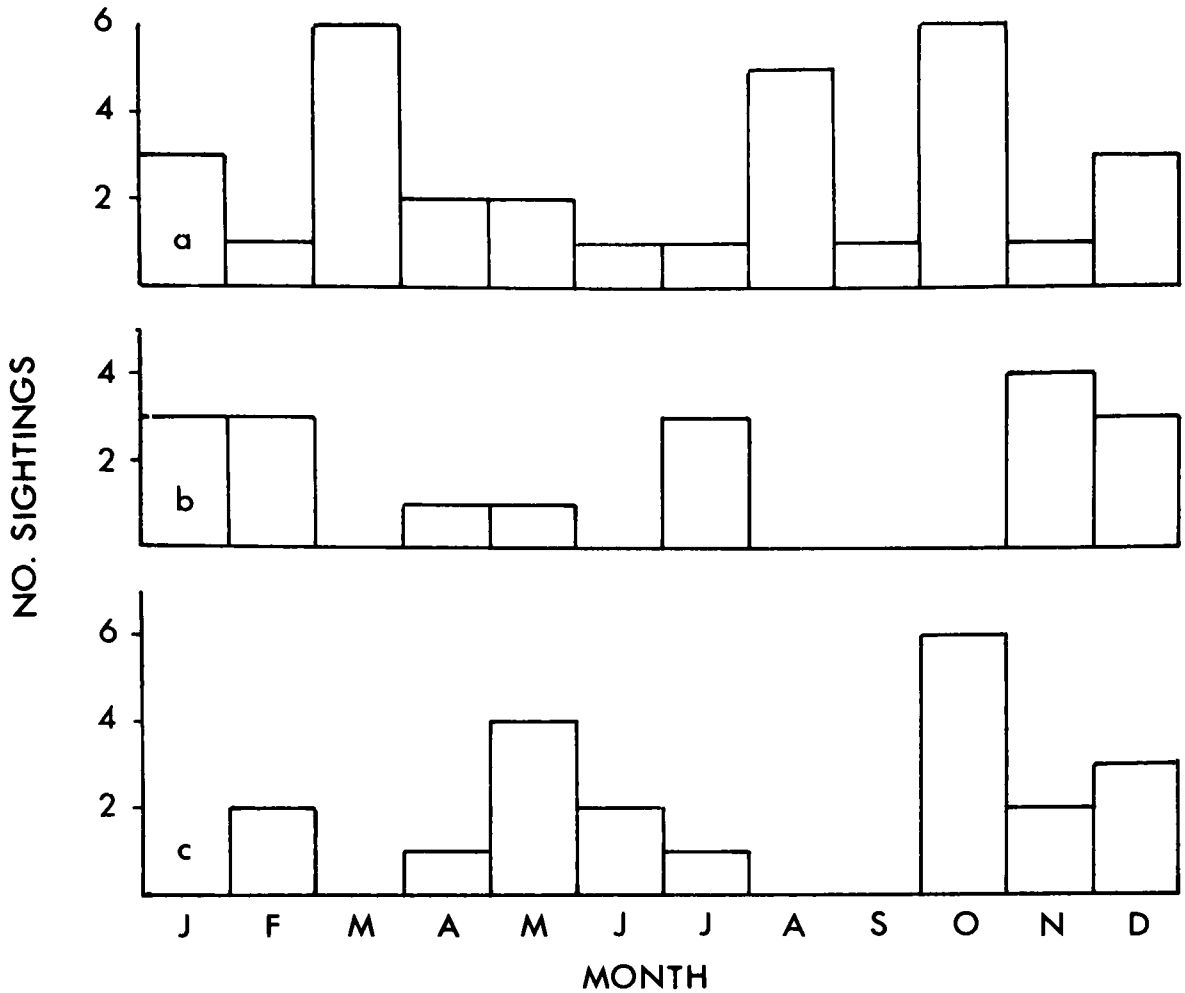


Fig. 6. Sightings of *C. eutropia* by area and month of occurrence: (a) Valparaíso to Puerto Montt; (b) Puerto Montt to the Strait of Magellan; and (c) Strait of Magellan to Cape Horn. The southern zones reflect less opportunities for sightings and less effort.

EXTERNAL MORPHOLOGY

The first description of the body form of the Chilean dolphin is that of Lesson (1826, p. 373; 1827, p. 182), who wrote that it is 'stocky in shape, at most three feet in length, with a tapering snout, and with a rounded dorsal fin on top of its back ...'. However, his drawing, based on an animal seen at sea, shows a dolphin with a long, pointed beak and a pointed (not rounded as described) dorsal fin situated far forward (Fig. 3). Nevertheless, it shows the characteristic lunate marks we will describe.

Pérez Canto (*in*: Philippi, 1893a, p. 8) gave a more precise description: head conical, with a pointed snout grading smoothly into the body contour, the pectoral fin with a rounded tip; the dorsal fin low, with a rounded tip and concave posterior border, set posterior to the center of the body; and concave flukes.

Reed (1904, p. 139), the only other person who had a specimen, described its color but not its shape.

Most other authors have copied Philippi's description. Although Watson (1981, p. 250) has apparently travelled waters inhabited by *C. eutropia* in his position as naturalist on the vessel *Lindblad Explorer*, his description makes us

insecure that he is describing this species. The very low backward leaning and triangular fin he describes is more like that of *P. spinipinnis* than *C. eutropia*. He says that they are darker black than *C. commersonii* (which in our experience is not true), and although he mentions that some individuals may have a pale blaze mark near the blowhole, he does not describe the very obvious lunate marks posterior to the blowhole.

Size

The four species of the genus *Cephalorhynchus* are usually described as small and chunky (Baker, 1978, p. 331; Watson, 1981, p. 250).

On the basis of the little that is known to date, in total length *C. eutropia* is the second largest of the four species in the genus. The maximum total length (TL) known for each species is: *C. heavisidii*, 174cm (Best, 1988); *C. eutropia*, 167cm, and *C. hectori*, 162.5cm (Baker, 1978, p. 331). Maximum total length for net-captured specimens of *C. commersonii* off Tierra del Fuego was 145.5cm (Goodall, Galeazzi *et al.*, 1988) but live captures reached 152cm (Leatherwood *et al.*, 1984; IWC, 1985), while animals off Kerguelen reached 174cm (Robineau and de Buffrénil, 1984). It thus appears that specimens of *C. commersonii* off South America are the smallest, followed by specimens of *C. eutropia* and *C. hectori*, while those of *C. heavisidii* and of *C. commersonii* from Kerguelen are of much the same size.

External measurements are available for nine recent specimens of *C. eutropia* (Table 3) as well as for the three mounted skins in the Santiago Museum (MNHN-S) remeasured by us using standardized methods. We also give the measurements reported by Reed (1904), even though we cannot be sure how he took them, except that his total length was over the curve of the body and not a standard projected measurement. Thus, the actual total length of his specimen would be somewhat less than he gives.

The 13 specimens range from 127.5cm (one of the skins) to 167cm TL: females 136–165cm, males 140–167cm. Eight recent specimens reported by Oporto (1985), not included in this paper, did not exceed these lengths.

A six year old female measuring 149.6cm had incomplete epiphyseal fusion (the posterior fusion was complete at CA 19), while another of 150cm TL had a fetus, indicating that at this size females can be sexually but not physically mature. The 165cm San Antonio specimen also had incomplete epiphyseal fusion.

The 7–9 year old Norris male had complete epiphyseal fusion at a TL of 152cm. The state of fusion of a 167cm male, the largest individual known to date, is unknown. True's specimen (USNM 21167) of unknown sex was 7–8 years of age.

On the basis of the few specimens measured to date, females are found to reach a larger size than males in *C. hectori* (Baker, 1978) and *C. commersonii* (Goodall, Galeazzi *et al.*, 1988). No mature females have yet been collected of *C. heavisidii* (Best, 1988). Since a 152cm male Chilean dolphin was found to be physically mature, while 150cm and 165cm females still had incomplete epiphyseal fusion, further specimens may show that females also grow to a larger size in this species.

Table 3a

External measurements (in mm) of nine recent specimens of *Cephalorhynchus eutropia*, of the three skins in MNHN-S and the measurements published by Reed (1904). Measurements by the authors except for MNHN-S 1003 (taken by J. Yañez) and those of Reed. Right side measurements used.

	IZUA-MM 15	USMN 395375	IZUA-MM 11	MNHN-S 1003	USMN 395374	JAO,26 iv 1979a	JAO,26 iv 1979b	JAO,19 i 1976	Reed 1904	IZUA-MM 16	MNHN-S 597	MNHN-S 604	MNHN-S 598
Sex	F	F	F	F	M	M	M	M	M	?	?	?	?
Physical maturity	-	2	-	2	3	-	-	-	-	-	skin	skin	skin
Sexual maturity	-	-	M	-	-	-	-	M	-	-	-	-	-
Age	-	6	-	-	7-9	-	-	-	-	-	-	-	-
Snout to													
deepest part of fluke notch	1,360	1,496	1,500	1,650	1,519	1,550	1,590	1,670	1,450	1,550	1,276	1,430	1,624
center of blowhole	225	222	-	210	197	220	240	245	240	-	160	-	185
angle of mouth	-	192	-	180	190	205	210	200	195	-	160	120	140
center of eye	-	230	-	200	217	230	240	240	-	-	195	170	185
ear	270	-	-	260	258	-	-	-	-	-	-	-	-
ant. insertion of flipper	-	380	-	400	367	380	400	390	355	-	330	315	370
ant. insertion of dorsal fin	700	-	-	770	-	725	970	-	740	-	615	660	760
posterior tip of dorsal fin	940	987	-	1,020	1,019	-	-	1,010	-	-	800	855	1,000
umbilicus	-	748	-	800	746	-	-	760	-	-	-	-	-
genital slit center	-	1,052	-	1,170	979	-	-	990	-	-	-	-	-
anus	960	1,094	-	1,220	1,135	1,080	1,110	1,170	-	-	-	-	-
Center of eye to													
angle of mouth	-	35	-	20	32	-	-	30	-	-	45	42	47
ear	50	52	-	60	50	-	-	-	-	-	-	-	-
Flipper													
anterior length	190	237	-	245	246	225	235	240	-	213	-	190	190
posterior length	120	181	-	185	182	175	165	180	-	162	-	-	140
maximum width	73	97	-	100	95	90	95	120	85	77	-	83	80
Dorsal fin													
length at base	250	261	-	270	281	225	290	320	205	-	230	200	280
height	110	145	-	155	158	25	120	150	120	122	80	90	114
Genital slit length	-	100	-	-	120	-	-	-	-	-	-	-	-
Flukes													
width, tip to tip	340	399	-	-	407	350	380	410	400	301	330	350	300
ant. margin to fluke notch	97	105	-	-	109	130	120	120	-	96	100	110	135
depth of notch	23	25	-	20	28	30	20	30	-	15	18	13	20
Girth													
at axilla	700	-	-	930	905	-	-	980	750	-	800	850	940
maximum	830	-	-	1,030	1,050	860	980	1,020	860	-	810	850	1,010
at anus	410	-	-	600	550	470	490	770	-	-	-	-	-

Table 3b

External mesurements of *C. eutropia* expressed as percentages of total length.

	IZUA-MM 15	USMN 395375	IZUA-MM 11	MNHN-S 1003	USMN 395374	JAO,26 iv 1979a	JAO,26 iv 1979b	JAO,19 i 1976	Reed 1904	IZUA-MM 16	MNHN-S 597	MNHN-S 604	MNHN-S 598
Snout to													
deepest part of fluke notch	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
center of blowhole	16.54	14.84	-	12.73	12.97	14.19	15.09	14.67	16.55	-	12.54	-	11.39
angle of mouth	-	12.83	-	10.91	12.51	13.23	13.21	11.98	13.45	-	12.54	8.39	8.62
center of eye	-	15.37	-	12.12	14.29	14.84	15.09	14.37	-	-	15.28	11.89	11.39
ear	19.85	-	-	15.76	16.98	-	-	-	-	-	-	-	-
ant. insertion of flipper	-	25.40	-	24.24	24.16	24.52	25.16	23.35	24.48	-	25.86	22.03	22.78
ant. insertion of dorsal fin	51.47	-	-	46.67	-	46.77	61.01	-	51.03	-	48.20	46.15	46.80
posterior tip of dorsal fin	69.12	65.98	-	61.82	67.08	-	-	60.48	-	-	62.70	59.79	61.58
umbilicus	-	50.00	-	48.48	49.11	-	-	45.51	-	-	-	-	-
genital slit center	-	70.32	-	70.91	64.45	-	-	59.28	-	-	-	-	-
to anus	70.59	73.13	-	73.94	74.72	69.68	69.81	70.06	-	-	-	-	-
Center of eye to													
angle of mouth	-	2.34	-	1.21	2.11	-	-	1.80	-	-	3.53	2.94	2.89
ear	3.68	3.48	-	3.64	3.29	-	-	-	-	-	-	-	-
Flipper													
anterior length	13.97	15.84	-	14.85	16.19	14.52	14.78	14.37	-	13.74	-	13.29	11.70
posterior length	8.82	12.10	-	11.21	11.98	11.29	10.38	10.78	-	10.45	-	-	8.62
maximum width	5.37	6.48	-	6.06	6.25	5.81	5.95	7.19	5.86	4.95	-	5.80	4.93
Dorsal fin													
length at base	18.38	17.45	-	16.36	18.50	14.52	18.24	19.16	14.14	-	18.03	13.99	17.24
height	8.09	9.69	-	9.39	10.40	8.06	7.55	8.98	8.28	7.87	6.27	6.29	7.02
Genital slit length	-	6.68	-	-	7.90	-	-	-	-	-	-	-	-
Flukes													
width, tip to tip	25.00	26.67	-	-	26.79	22.58	23.90	24.55	27.89	19.42	25.86	24.48	18.47
ant. margin to fluke notch	7.13	7.02	-	-	7.18	8.39	7.55	7.19	-	6.19	7.84	7.69	8.31
depth of notch	1.69	1.67	-	1.21	1.84	1.94	1.26	1.80	-	0.97	1.41	0.91	1.23
Girth													
at axilla	51.47	-	-	56.36	59.58	-	-	58.68	51.72	-	62.70	59.44	57.88
maximum	61.03	-	-	62.42	69.12	55.48	55.97	61.08	59.31	-	63.48	59.44	62.19
at anus	30.15	-	-	36.36	36.21	30.32	30.82	46.11	-	-	-	-	-

Table 3c
Range and mean of external measurements.

Measurement	N	Mean	Range	Variance	Standard deviation	Standard error
Snout to						
deepest part of fluke notch	13	1,512.7	1,360–1,670	1,294.5	113.8	31.6
center of blowhole	10	214.4	160–245	73.3	7.1	8.6
angle of mouth	10	179.2	120–210	88.8	29.8	9.4
center of eye	9	211.9	170–240	64.6	25.4	8.5
ear	3	262.7	258–270	4.1	6.4	3.7
ant. insertion of flipper	10	368.7	330–400	80.5	28.4	8.9
ant. insertion of dorsal fin	8	742.5	615–970	1,114.3	105.6	37.3
posterior tip of dorsal fin	8	953.9	800–1,020	694.8	83.4	29.5
umbilicus	4	763.5	746–800	63.0	25.1	12.6
genital slit center	4	1,047.8	979–1,170	767.5	87.6	43.8
to anus	7	1,109.9	960–1,220	666.3	81.6	30.9
Center of eye to						
angle of mouth	7	35.9	20–47	9.1	9.5	3.6
ear	4	53.0	50–60	2.3	4.8	2.4
Flipper						
anterior length	10	221.1	190–246	55.3	23.5	7.4
posterior length	9	165.6	120–185	49.1	22.2	7.4
maximum width	11	90.4	73–120	17.3	13.1	4.0
Dorsal fin						
length at base	11	255.6	200–290	140.8	37.5	11.3
height	12	124.1	80–158	60.5	24.6	7.1
Genital slit length	2	110.0	100–120	20.0	11.4	10.0
Flukes						
width, tip to tip	11	360.6	300–410	168.1	41.0	12.4
ant. margin to fluke notch	10	112.2	96–135	18.5	13.6	4.3
depth of notch	11	22.0	13–30	3.3	5.8	1.7
Girth						
at axilla	8	856.9	700–980	986.4	99.3	35.1
maximum	10	921.0	810–1,050	892.1	94.5	29.9
at anus	6	548.3	410–770	1,609.7	126.9	51.8

The maximum girth is 55–69% of the TL (n=6). Baker (1978) found the maximum girth in *C. hectori* to be 59–68%, while the average girth for *C. heavisidii* is 62.5% TL (Best, 1988). Girths for specimens of *C. commersonii* collected off Tierra del Fuego averaged 67% (Goodall, Galeazzi *et al.*, 1988).

We report weights for two specimens. The 136cm female (IZUA-MM 15) (the smallest animal for which we have accurate measurements) weighed 32.5kg. The 151.9cm male captured by Norris at Bahía Corral weighed 62kg. Oporto (1985) reported weights of 33.5 to 63kg for seven recent specimens. Watson (1981, p. 250) and Mörzer Bruyns (1971, p. 43) gave unsubstantiated weight estimates. A weight of 100kg for the 1984 San Antonio specimen, reported in a newspaper (Anon., 1984a) is also unproven.

The head

Cephalorhynchus eutropia does not have a well-defined melon, or beak, as, for example, does the bottlenose dolphin *Tursiops truncatus*, but the head can hardly be called 'broad and flat' (Watson, 1981, p. 250). It is conical, with a smooth curve from the dorsal fin to the tip of the upper jaw. The word 'broad' is further misleading, because when seen from the front, these dolphins do not have a 'broad flat look' but an evenly curved cone-shaped head (Fig. 7).

Fig. 7. Anterior body of two specimens of the Chilean dolphin. (a,b) the adult male from Corral; (c,d) the younger female from Playa Frailes. Photographs by K.S. Norris.

Goodall, Sobral *et al.* (1988) have pointed out that none of the far southern coastal dolphins have a marked beak. *C. eutropia* has a slightly more pointed face than does *C. commersonii*, with a slight groove on either side. Of the three fresh specimens for which photographs are available, that from San Antonio has the largest beak (Anon., 1984a).

The dorsal fin

Descriptions of the dorsal fin varied from 'dolphins with blunt dorsals' (Sighting 10, Table 2), 'peculiar' (Sighting 12), 'peculiar low dorsal fin, very rounded posteriorly' (Sighting 18), 'rounded' (Sighting 44), to 'roundish' (Sighting 46). None of the observers described a low triangle dorsal fin such as is illustrated by Watson (1981).

Fig. 8 shows a tracing (taken from photographs) of the dorsal fin of the male captured by Norris and a tracing of the very dried dorsal fin of a stranded beach specimen (IZUA-MM 16). Tracings of the dorsal fins of the mounted skins in MNHN-S are presented in Goodall, Sobral *et al.* (1988). Only tracings or photographs will resolve the variability of description for sighted animals.

As seen in Figs 8 and 9, the dorsal fin of *C. eutropia* is smoothly rounded, rising from mid-body and with an undercut, S-shaped posterior margin. It is

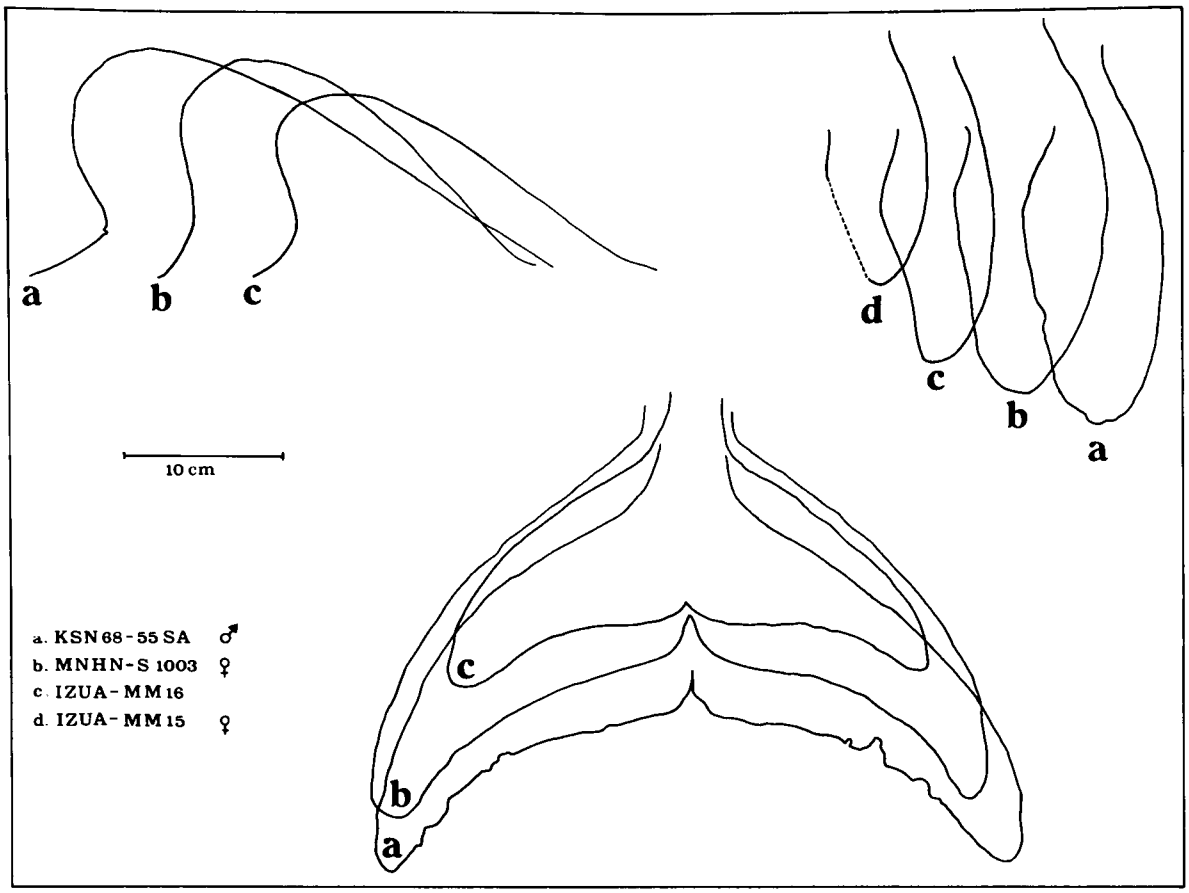


Fig. 8. Tracings of appendages of *Cephalorhynchus eutropia*: (a) adult male USNM 395374, from slides enlarged to scale; (b) MNHN-S 1003, a fresh female; (c) IZUA-MM 16, a dried, bird-flensed skeleton of 155cm (appendages therefore not of original size); (d) IZUA-MM 15, a 136cm animal that had been buried and was partially decomposed.

very similar in shape to that of *C. commersonii*, although larger, and to some specimens of *Australophocoena dioptrica* (Goodall, Sobral *et al.*, 1988). It would be very difficult to separate these three species at sea on the basis of dorsal fin shape alone.

Flippers

The flippers have generally been described as short with a rounded tip. Those of the two specimens taken by Norris were moderate in size and well rounded (Fig. 8). All specimens we saw confirmed the flipper shape described by Pérez Canto (*in*: Philippi, 1893a, p. 8).

Flukes

The flukes have a deeply concave posterior border. This characteristic is only occasionally useful for field identification, since apparently the dolphin rather seldom leaps or throws its flukes. However, jumps were seen in several sightings, and Oporto (Sighting 64) saw one animal jump continuously for about 8mins. He also mentions jumps in other sightings (Oporto, 1984b).

Our specimens show the flukes to be large for the size of the animals and deeply lunate along the posterior border (Fig. 8). The fluke shape is similar to that of *C. commersonii* (Goodall, Sobral *et al.*, 1988).

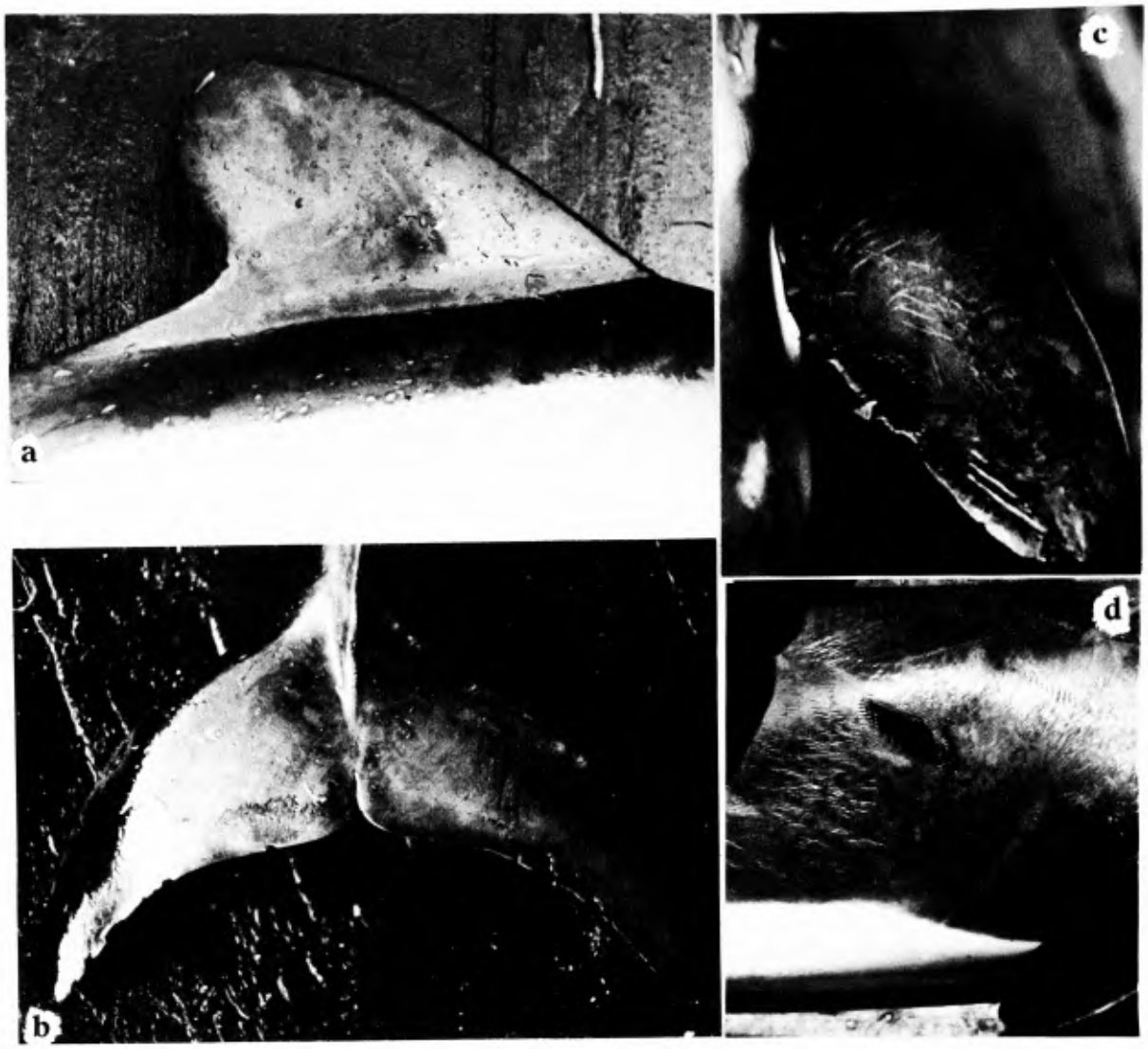


Fig. 9. Appendages and scars of *Cephalorhynchus eutropia*: (a) dorsal fin; (b) flukes; and (c) pectoral fin, all of the adult male from Corral; (d) tooth rakes on the lateral body of the immature female from Playa Frailes. Photographs by K.S. Norris.

PIGMENTATION

Lesson (1827, p. 183) wrote that the dolphins he saw at Concepción were of a light fawn brown on the back, which merged imperceptibly with the ventral white. He called them *D. lunatus* for the darker brown, crescent or half-moon shaped mark 'on the back, next to the pectoral fins and in front of the dorsal one'.

The next description of pigmentation, taken from a 136cm specimen by Pérez Canto (*in*: Philippi, 1893a, p. 8), was somewhat more explicit:

'Head, back, sides and fins of a very dark greenish-black color; region under the neck with a large oval patch; another white patch behind the posterior insertion of the pectoral fin; belly with an elongated white patch, which widens posteriorly, with a dark line on both sides which runs from front backwards'.

He noted that the dark line could not be seen in his illustration, but the figure does show a gray area on the belly. The dark line is shown more clearly in a later illustration (Pérez Canto, 1896, p. 228). He does not mention the lunate marks but, since his animal was dead, it probably had darkened and they had

disappeared. However, in the latter publication, the illustration shows lines on the head.

Philippi (1893a, p. 12) described two specimens from Valdivia as simply 'black above and white below'.

Reed (1904, p. 139) described two specimens from Valparaíso, taken in 1878, and a male obtained later near Concepción:

'The two specimens ... presented differences in color, not of form and structure ... One was entirely of a slate blackish color; the other was white below, dark above. Whether this difference in color is the effect of sex, age or another cause, I do not know ... The specimen I now have under study, still in the flesh, is of a slate-blackish color above, white below, except for a transverse band from the origin of the pectoral fins ... and around the anus. Behind the pectoral fins there is on each side a white spot six centimeters long by three wide, at the base of the fins'.

Later authors repeated these descriptions in various ways, but no new specimens were described. Cabrera and Yepes (1960, p. 115) said that the white spot behind the pectoral fin was sometimes absent, though the source of this information is unclear. The species was described as 'dark, black or greenish black'.

Donoso-Barros (1975, p. 33) called its dorsal color:

'grayish with greenish tints, the belly is white and very frequently there is a spot behind the flippers. Some variations exist within this general design. In the specimen described by Pérez Canto as *Phocaena albiventris* the coloration is typical enough; nevertheless, around the lips a clear, somewhat rose color appears'.

Being from Concepción, Donoso-Barros may have had occasion to see this dolphin, but he does not mention if he had seen this lip color himself, or where he got his information.

The next sightings, possibly of this species, were those of Clarke *et al.* (1978, p. 153). Their animals, seen far at sea, were:

'colored lead-brown above and white beneath. The white of the ventral surface extended to the flanks where it merged with the dorsal lead-brown in an area of dirty white. The flukes are darkly pigmented ... Pérez Canto's dark line on the side could have been the dirty white area on the flanks of our porpoises where dark and white merged ...'.

Again, without stating the basis for his description, Watson (1981, p. 250) wrote:

'The coloring is pure black, darker than the back of the Piebald Dolphin (*C. commersonii*). On the belly are three patches of white: one on the throat, one behind the flippers, and a third in the anal area. The last two may be either very much reduced, or large enough to overlap. There is a pale and very thin white line around the lips on both jaws. In a few individuals there may be a pale blaze mark around the blowhole'.

It seems likely that this description is *Phocoena spinipinnis* and not *C. eutropia*, especially considering Watson's illustration, which shows a dorsal fin more like that of *P. spinipinnis*. Norris has photographed such a white border on the lips of specimens of *P. spinipinnis* caught in Perú, but we have not yet seen them on specimens of *C. eutropia*. It seems impossible that the prominent lunate marks of *C. eutropia*, from blowhole to beak, were not seen by Watson if he described from a specimen. His 'pale blaze mark' hardly seems a description of the lunate marks.

In view of Goodall's eight years of study of Commerson's dolphin off Tierra del Fuego (Goodall, Galeazzi *et al.*, 1988), we say with assurance that the black

areas in *C. commersonii* are very black, while in the photographs of recently caught specimens of *C. eutropia* the back is gray.

The disagreement over color found in past sightings and specimens of *C. eutropia* may stem from three causes, just as similar color descriptions for other dolphin species often fail to match the true color of the living animal seen out of water.

The first common problem is that soon after death, especially if the animal is in the sun, dolphins darken, and those that are already of dark pattern may become nearly black. Markings, such as those noted by Donoso-Barros (1975) around the lips, may become rosy with coagulated blood in the skin, even though they may have been white in life.

The second cause is that a grayish animal will tend to assume a color dependent on the color of the water around it. A gray dolphin swimming in clear shallow water over white sand will appear tan or brown, while the water will be greenish. The reflected light and backscattered light are both made greenish by their path through water and the relatively dark animal reflects as brown or tan. This is a common observation for other gray dolphins such as *Tursiops truncatus* or *Stenella coeruleoalba* swimming in relatively well lighted transparent water (e.g. see the two color 'forms' of *S. coeruleoalba* in Watson, 1981).

In darker water, such as the almost black water sometimes encountered in Chilean fiords, a gray animal is scarcely illuminated at all from within the water, and may appear nearly black. Even when a dolphin breaks the surface, the color of the adjacent water will affect its apparent color.

In the case of *C. eutropia*, the Norris observations near Talcahuano were over a well-lighted and shallow sandy bottom and the animals appeared tan or brown, just as they have been described by others in that same or similar areas (such as Lesson). But, once on deck the true coloration of different shades of gray and white (from nearly black to pure white) was revealed. In the sightings we received (Table 2), observers called the animals brownish, lead-colored, bluish-gray, lead-black, dark gray or just gray.

A more exact description of the pigmentation pattern of *C. eutropia* can now be made on the basis of the two specimens obtained by Norris in 1968, photographed soon after being brought on deck, and the specimen from San Antonio.

In the field, if the entire animal is available to an observer, the rounded dorsal fin, chunky body and bold sharply demarcated dark and light pattern allow confusion only with *Australophocoena dioptrica* and perhaps *Cephalorhynchus commersonii* (in which the placement of the white is very different). *Cephalorhynchus eutropia* may be distinguished from either of these by three aspects of its pigmentation: (a) the dark moderately asymmetrical semilunar mark just posterior to the blowhole, (b) the ovoid white patch in the axilla and (c) a pair of longitudinal dark lines running lateral to the vent and genital slits at the edge of the white belly field (Fig. 10).

Inspection of the teeth will also allow the observer to discriminate *A. dioptrica* (spade-shape) from either species of *Cephalorhynchus* (conical). Except as a small calf, *A. dioptrica* is also much larger. But, as we discussed earlier in this

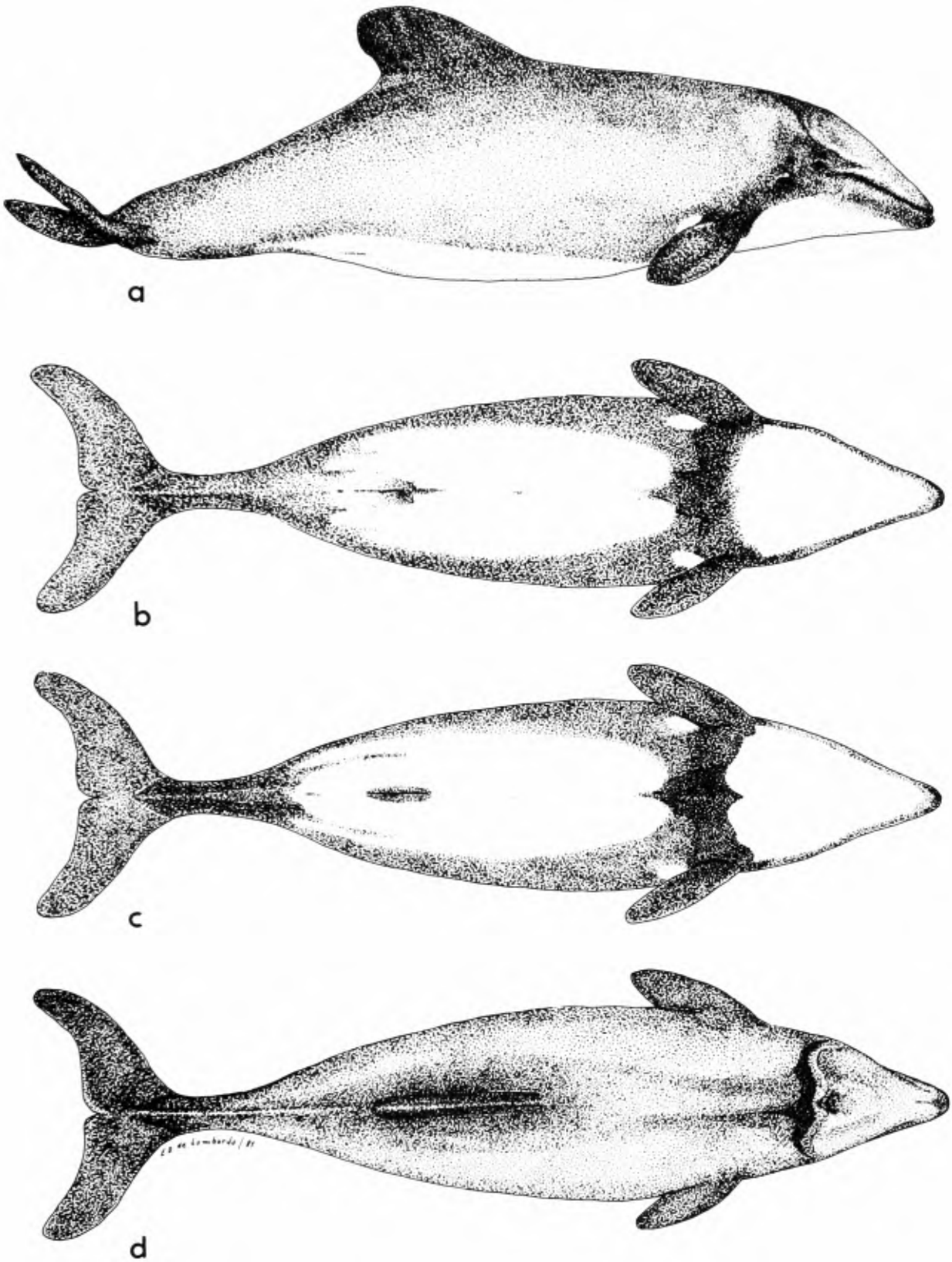


Fig. 10. Pigmentation pattern of the Chilean dolphin. (a,c,d) the adult male from Corral (USNM 395374); (b) the female from Playa Frailes (USNM 395375).

paper, if the glimpse of the animals is fleeting and from a distance, the three can easily be confused. The bright white back in front of the dorsal fin identifies *C. commersonii* immediately.

The head

The dark semilunar pattern consists of a coalescence just posterior to the blowhole (where it is broadest) and curving, narrowing patterns on both sides of the head that extend forward above the eye and onto the rostrum about 2cm above the lip margin. The lunate mark on the animal's right side extends farther posterior than the one on the left. If a field observer is close to an animal, these marks are quite obvious but if the animal has been dead for any length of time the pattern may disappear in the general darkening of the skin. The pattern is illustrated in Figs 7, 10 and 11.

The melon and beak merge imperceptibly into one another dorsally, although there is a groove between the posterior melon and the angle of the gape, anterior to the eye. The melon is generally light gray except at the jaw tip, where it is dark gray with a central triangle of darker pigment extending posteriorly onto the melon.

The eye is surrounded by an indistinctly bordered eye-patch of dark gray that merges with the anterior limbs of the lunate pattern. Surrounding the eye-patch is a slightly lighter patch which itself rings the eye. It merges above and below the angle of the gape with darker gray. A small white tear-drop shaped spot marks the external ear opening (Figs 7 and 11). It is interesting to note that in over 80 fresh specimens of *C. commersonii*, only once was this small white tear-drop spot present (Goodall, Galeazzi *et al.*, 1988). None of the specimens known to date showed the narrow white margin of the lips mentioned by Donoso-Barros (1975) and Watson (1981).

Appendages

The flippers are generally dark gray but suffused with lighter gray along their leading edges. There is a patch of lighter gray at mid-length of the fin near the posterior edge.

There is an ovoid white patch in axilla, under and behind the flipper. When the flipper is pressed against the body it entirely covers this mark, which is also seen in *C. hectorii* (Baker, 1978) and in *C. heavisidii* (Best, 1988). This area in *C. commersonii* is represented by a black lobe against the white flank. Norris and Dohl (1980, p. 242) felt that these marks might serve as signals of swimming maneuvers to adjacent schoolmates as similar markings do in birds, and illustrated this discussion with a photograph of *C. eutropia*. The mark, they postulate, allows a schoolmate to perceive the exact attitude and position of the flippers, which regulate the direction of movement. This axillary spot is also present in *Lagenorhynchus australis* and other delphinids, such as *Stenella longirostris* and *L. obliquidens*, and in some species of *Mesoplodon*. Could this 'maneuver-flash' or 'advertisement pattern' (Mitchell, 1970) be more important in species which tend to live in dark waters?

The dorsal fin is dark gray, as are the flukes on both surfaces.

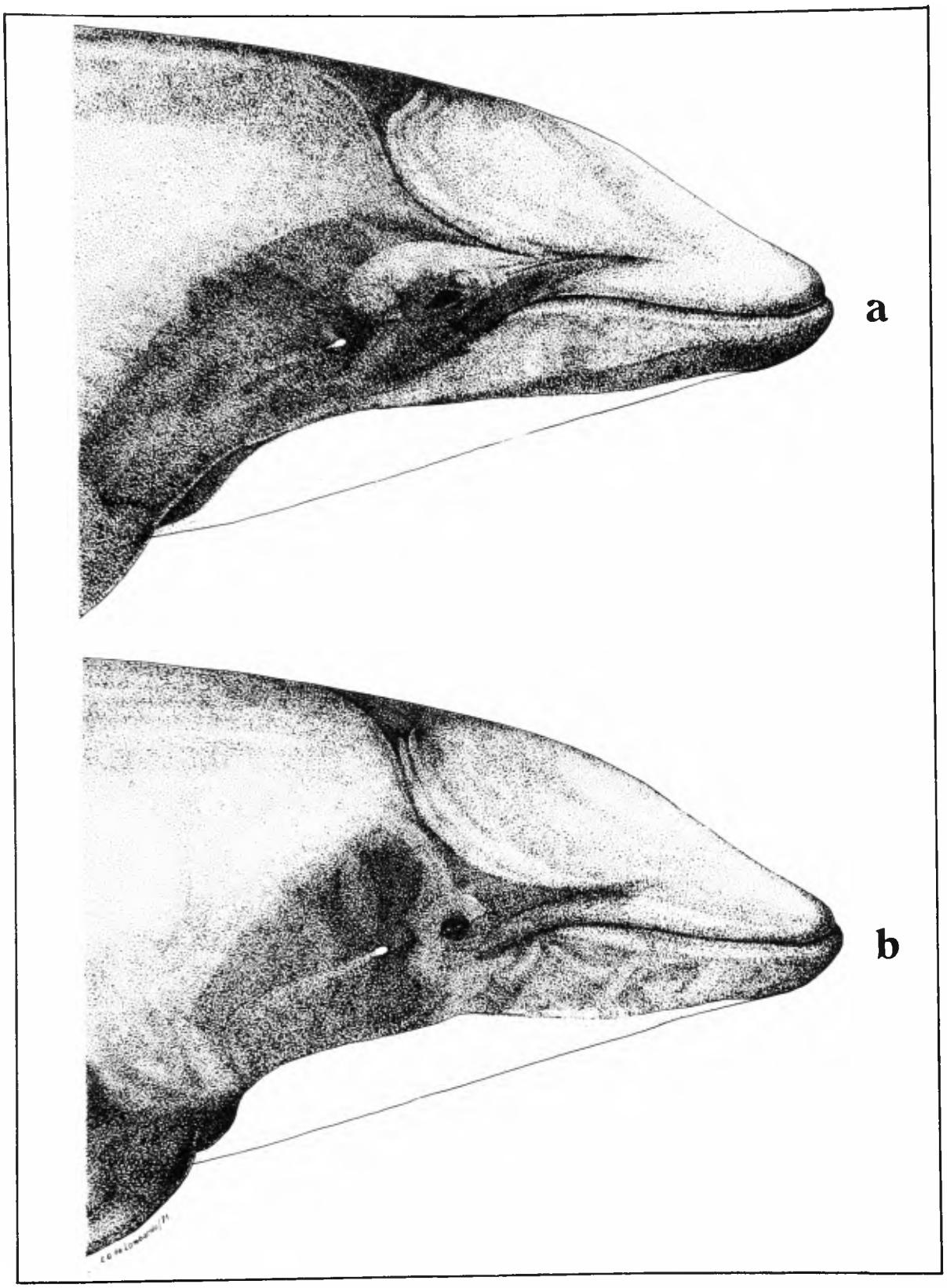


Fig. 11. Detail of the pigmentation of the anterior body of two specimens of the Chilean dolphin: (a) subadult female (USNM 395375); (b) adult male (USNM 395374).

The dorsal surface

Posterior to the lunate marks there is a dark cape extending posteriorly making a relatively narrow mid-dorsal dark band that widens around the dorsal fin base and extends onto the anterior tail stock, finally fading into lighter gray just anterior to the insertion of the flukes.

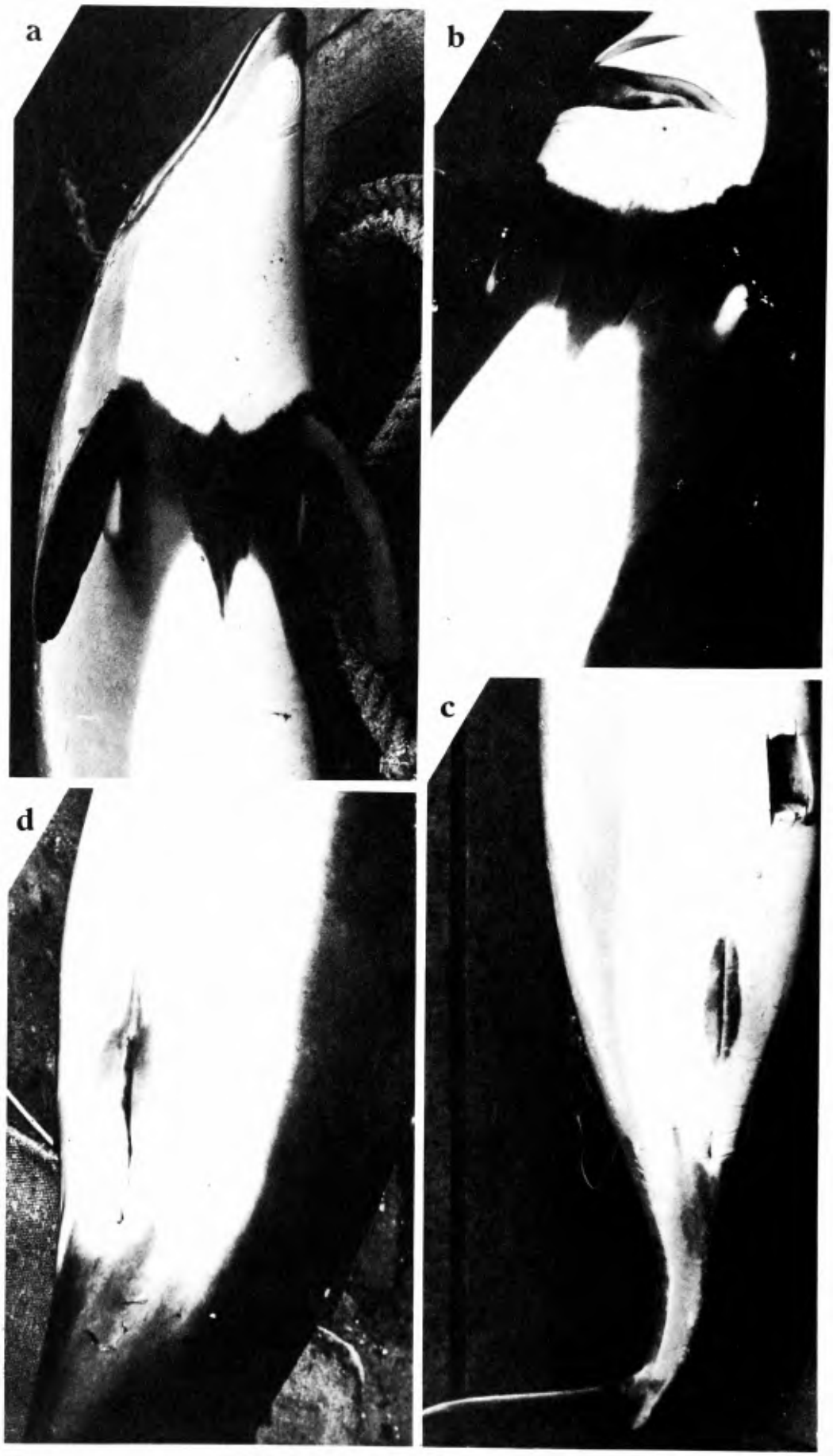


Fig. 12. Ventral patterns of the Chilean dolphin: (a) thoracic and gular pattern of the female from Playa Frailes and (b) of the male from Corral; (c) genital and abdominal pattern of the male and (d) of the female. Photographs by K.S. Norris.

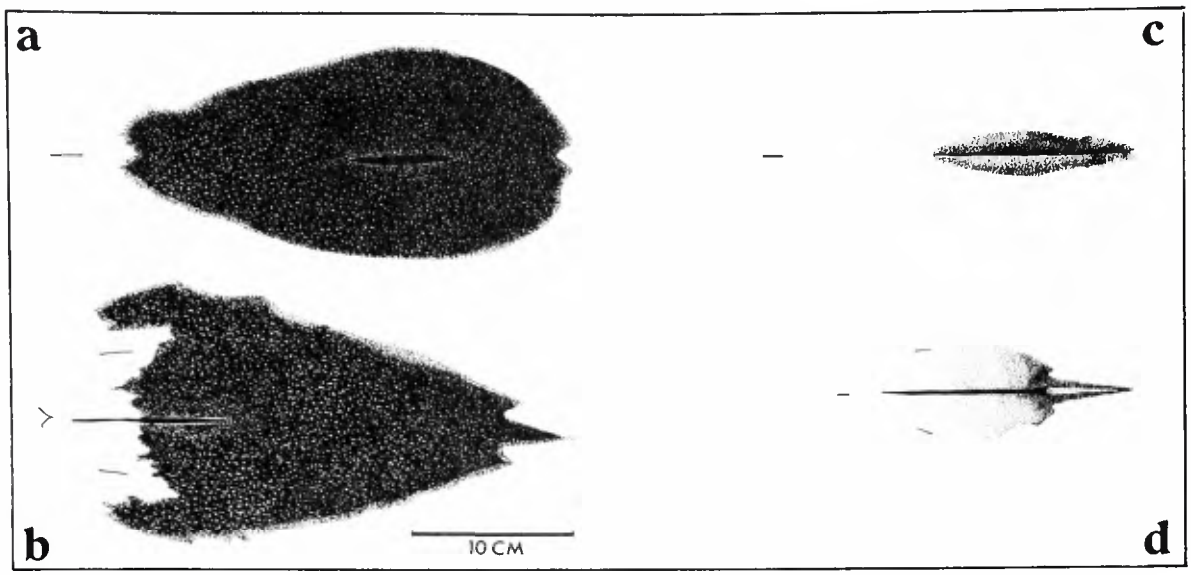


Fig. 13. Drawing of the genital patches of the Chilean dolphin: (a) male (USNM 395374); (b) female (USNM 395375) compared to those of Commerson's dolphin: (c) male RNP 595 and (d) female RNP 634. All drawings to scale.

The lateral surface

Below the dorsal cape the lateral surfaces are a somewhat lighter gray, darkening slightly above the white belly (Figs 1 and 10). The border between the belly and the lateral field is sharp. An indistinctly bordered broad dark gray flipper band extends diagonally forward and upward from the anterior insertion of the flipper to almost merge into the darker lunate marking above the eye and the gape.

The ventral surface

The lower lips and chin are dark gray and are sharply demarcated from the immaculate white gular area. This white patch widens to just in front of the anterior insertion of the pectorals and curves between them. It is much larger and wider than the corresponding pear-shaped area in *C. commersonii*.

Between the flippers the white gular and abdominal patches are separated by a transverse black shield, slightly wider than the base of the flippers. In the mid-ventral center of this shield, triangular points of black extend anteriorly into the gular white and posteriorly into the abdominal white. This shield varies in outline in different specimens (Fig. 12a, b).

The whole abdominal area from the thoracic shield to just behind the anus is a long zone of white, while the caudal peduncle is dark.

In both the male and female specimens the vent and mammary slits were white and unaccented from the surrounding white field. In the male the genital slit was completely surrounded by an anteroposteriorly oriented lozenge of dark gray. Only the anterior half of the genital slit of the female was colored gray. The female genital patch was roughly triangular with a long mid-ventral point extending forward (Fig. 12c, d). This sexual dimorphism resembles that of *C. commersonii*, where the sexual pattern difference is even more marked and the genital patches are much larger, even though the Commerson's dolphin is a smaller animal (Fig. 13).

In both specimens the dark color of the caudal peduncle extends forward as a pair of dark lines on either side of the vent to about the middle of the genital slit in the white abdominal field. In the female an additional pair of dark lines run forward into the abdominal white on both sides of the anus.

Pigmentation of the young

Pigmentation changes with growth are of common occurrence in dolphins, but clear descriptions of such differences do not yet exist for *C. eutropia*. Cameron, while seeking information about the species from fishermen at Mehuín, Chile, was shown an eviscerated, dried fetus. Although most of the ventral region was gone, some white of the abdominal field could still be seen, as well as the gray stripes adjacent to the anus. Oporto and others could distinguish young from adults on the basis of size, but gave no description of color pattern. No fresh juvenile specimens have been examined.

Scars and marks

On both of the Norris specimens, numerous rake marks were found. These were spaced at intervals approximately the same as the distance between teeth in adults and presumably were produced by schoolmates. The male had parallel rake marks on the head, dorsal fin, flippers and anterior upper body and between the flippers (Fig. 7). The female had deep rake marks on the side of the body behind her flipper (Fig. 8) and a subcircular set of irregular concentric rings about 1.5cm in diameter, possibly from a skin fungus, on the melon anterior to and to the right of the blowhole (Fig. 7). Neither specimen has any marks in the genital aperture area.

Abnormal markings were mentioned in two of the sightings. In Sighting 51 three black marks, which could have been scars, were seen on the left side of the body just above the flipper. Another animal (Sighting 56) had a wide coffee-colored mark on the left surface of the otherwise gray dorsal fin.

SKELETAL FEATURES

The skull characteristics of *C. eutropia* were described by Gray (1849 and thereafter), Flower (1883) and True (1889) and were compared with those of *C. commersonii* and *C. heavisidii* by Harmer (1922, p. 633), while all four species (including *C. hectori*) were compared by Best (1977).

The maximum CBL is 364mm (BMNH 1849.5.25.2, the type specimen; and IZUA-MM 12), while the range, based on 13 individuals, was 302–364mm. A typical skull is illustrated in Fig. 14.

The teeth range from 29 to 33 for each side of the lower jaw and 28 to 34 for the upper, the average being 31/31 lower and 32/31 upper. Largest tooth diameter (taken from front to back at the gum line) was 2.7–4.2mm (n = 8).

The skeletons collected by Norris are the only complete ones available at this time. There is only one incomplete skeleton in MNHN-S. Material available to Oporto will be presented separately.

[*Text continues on p.* 242]

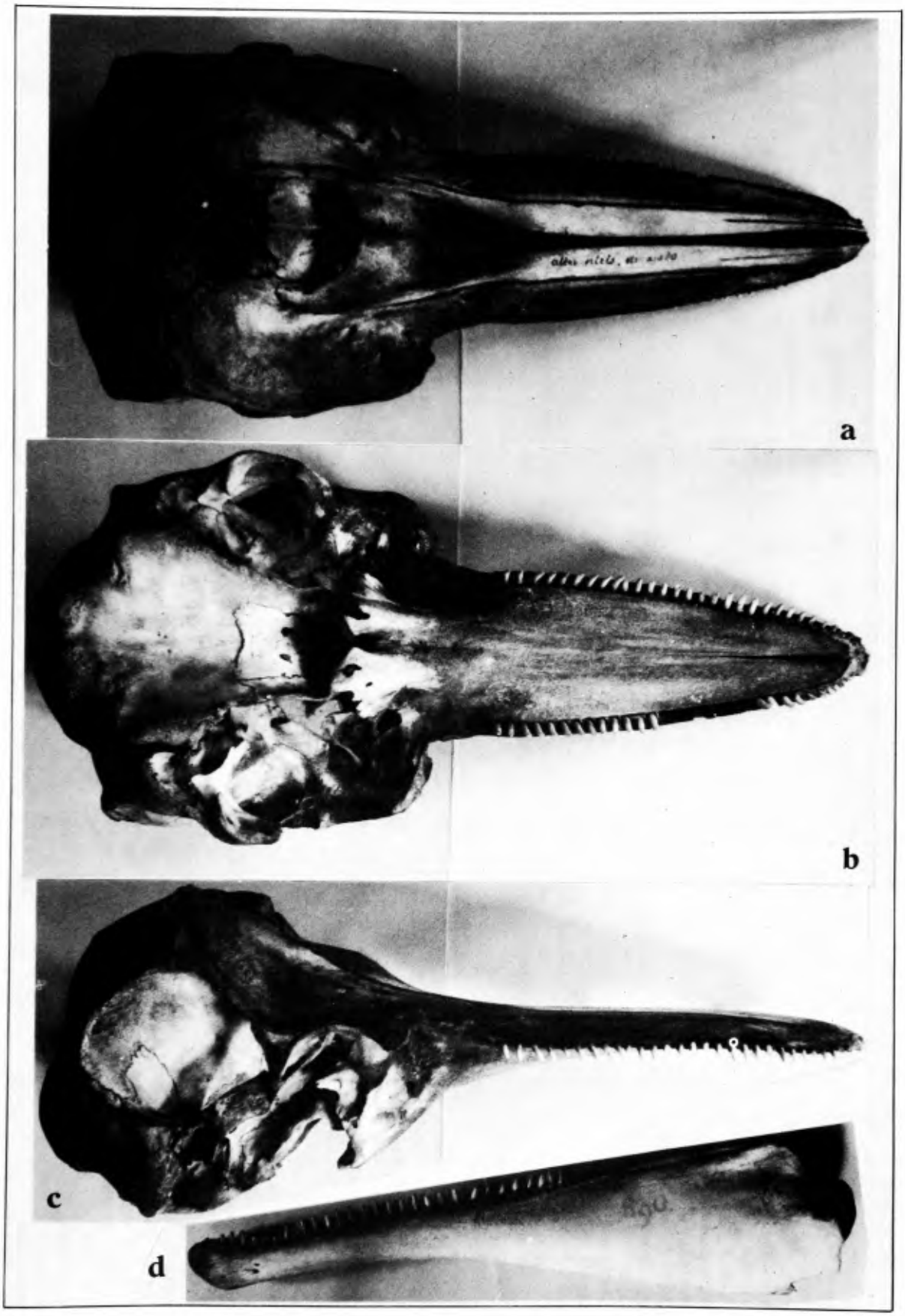


Fig. 14. Photographs of the skull of *Cephalorhynchus eutropia*, specimen NHMN-S 582, part of the R.A. Philippi collection: (a) dorsal view; (b) ventral view; (c) lateral aspect; (d) mandible. Photographs by I.S. Cameron.

Table 4a

Skull measurements (in mm) of *C. eutropia*, taken by I.S. Cameron except for IPPA-CE 5 taken by S. Leatherwood.

Description	UC-MVZ 118854	BMNH 1849 5.25.2	BMNH 1881 8.17.1	USNM 395375	USNM 395374	MNHN-S 580	MNHN-S 587	MNHN-S 605	MNHN-S 581	MNHN-S 594	MNHN-S 583	MNHN-S 585	IZUA-MM 6
Condylo-basal length	329	364	326+	337	339	323+	341+	326+	336	341+	328+	335+	336
Rostrum length	179	197	171+	182	182	173+	183+	173+	180	186+	168+	178+	177
Rostrum width at base	76	91	76	89	83	79	81	70	79	85	80	82	82
Rostrum width at midlength	55	69	57	59	58	54	–	52	57	–	–	57	59
Premax. width at midlength	23	32	27	28	24	25	–	24	23	–	–	29	28
Rostrum width at 3/4 length	41	51	38	45	43	–	–	–	41	–	–	–	44
Rostrum tip to external nares	207	229	200	216	209	201+	209+	201	208	215+	188+	199	207
Rostrum tip to internal nares	–	213	188	195	192	186	199	194	195	197	184	195	190
Preorbital width	130	150+	127	143	137	130	134	–	–	139	134	137	136
Orbital width	134	154	131	144	141	134	138	–	137	143	138	140	144
Postorbital width	146	167	142	159	154	–	151	–	–	155	153	155	154
External nares width	38	46	40	40	41	39	43	40	41	42	42	42	42
Zygomatic width	136	146	138	138	150	135	139	139	141	142	143	142	145
Greatest width of premaxillae	49	67	53	60	56	54	58	53	56	60	59	54	62
Braincase height	105	121	104	107	112	103	106	101	108	104	107	110	113
Braincase length	107	117	104	110	111	–	–	–	–	–	–	–	–
Left postemporal fossa length	68	70	63	64	74	65	62	–	–	69	68	65	72
Right postemporal fossa length	69	72	–	–	76	–	66	–	69	68	67	68	74
Left postemporal fossa width	49	59	52	49	53	48	51	–	–	53	49	53	54
Right postemporal fossa width	50	60	–	47	56	50	57	55	52	55	52	56	58
Left orbit length	41	48	41	41	41	43	45	–	–	44	44	46	45
Right orbit length	40	48	–	41	41	–	45	–	–	44	45	46	46
Internal nares width	43	46	40	45	44	42	43	–	40	42	42	44	45
Left pterigoid length	49	–	50	52	51	52	–	–	53	47	50	52	54
Right pterigoid length	49	–	51	51	52	54	–	–	–	47	50	50	52
Upper tooth row length right	155	174	148	161	159	151+	162+	150	160	162+	147+	159	157
Upper tooth row length left	157	172	149	161	161	151+	160+	153	160	164+	148+	159	158
Number of teeth upper left	32	30	30	34	32	28+	30	29+	34	33+	29+	33	31
Number of teeth upper right	32?	31	31	33	32	28+	29	–	34	33+	31+	31+	28+
Number of teeth lower left	31	31	31	31	31	30	32	28+	–	–	32	29	33
Number of teeth lower right	25+	31	30	29	30	29+	32	–	–	–	28+	31	31+
Lower tooth row length right	–	173	153	154	157	158	162	–	–	–	154	155	153
Lower tooth row length left	157	172	158	156	158	157	160	–	–	–	154	153	159
Left ramus length	269	301	262	272	273	276	274	–	–	–	269	267	274
Right ramus length	–	302	265	273	273	277	274	–	–	–	269	270	276
Left ramus height	56	65	54	57	58	59	59	–	–	–	–	57	59
Right ramus height	–	67	54	57	58	60	59	–	–	–	–	57	59
Tooth width (to 1/10mm)	2.7	4.2	3	3.2	2.9	–	–	–	–	–	–	–	–

Table 4a (*continued*)

Description	IZUA-MM 2	MNHN-S 582	IZUA-MM 3	IPPA CE-5	USNM 21167	USNM 395625	MNHN-S 592	IZUA-MM 10	IZUA-MM 11	IZUA-MM 12	IZUA-MM 13	IZUA-MM 17	MNHN-S -
Condylo-basal length	342+	352	340+	356	342	310+	-	335+	339	364	-	302	346
Rostrum length	183	190	181	175	185	159+	-	-	-	-	-	-	-
Rostrum width at base	86	83	84	81	79	80	-	-	-	-	-	-	-
Rostrum width at midlength	-	62	59	62	61	54	-	-	-	-	-	-	-
Premax. width at midlength	-	29	27	32	26	26	-	-	-	-	-	-	-
Rostrum width at 3/4 length	-	44	43	45	43	40	-	-	-	-	-	-	-
Rostrum tip to external nares	214+	218	210	204	219	193+	-	-	-	-	-	-	-
Rostrum tip to internal nares	197	208	195	-	204	170+	-	-	-	-	-	-	-
Preorbital width	146	140	138	150	138	130	-	-	-	-	-	-	-
Orbital width	148	145	142	-	140	132+	-	-	-	-	-	-	-
Postorbital width	161	-	155	167	154	142	-	-	-	-	-	-	-
External nares width	42	43	43	33	40	39	-	-	-	-	-	-	-
Zygomatic width	146	147	148	167	138	131	-	-	-	-	-	-	-
Greatest width of premaxillae	57	60	57	62	56	55	-	-	-	-	-	-	-
Braincase height	111	112	114	119	103	102	-	-	-	-	-	-	-
Braincase length	-	-	-	111	106	104	-	-	-	-	-	-	-
Left postemporal fossa length	70	-	66	63*	68	59	-	-	-	-	-	-	-
Right postemporal fossa length	69	76	66		70	64	-	-	-	-	-	-	-
Left postemporal fossa width	57	56	62	45*	51	46	-	-	-	-	-	-	-
Right postemporal fossa width	60	57	58		52	50	-	-	-	-	-	-	-
Left orbit length	41	-	45	47*	45	39	-	-	-	-	-	-	-
Right orbit length	41	48	45		43	38	-	-	-	-	-	-	-
Internal nares width	45	44	44	36	42	41	-	-	-	-	-	-	-
Left pterigoid length	51	52	51	-	52	52	-	-	-	-	-	-	-
Right pterigoid length	52	-	52	-	52	-	-	-	-	-	-	-	-
Upper tooth row length right	163	169	160	162*	160	138+	-	-	-	-	-	-	-
Upper tooth row length left	164	168	159		157	136+	-	-	-	-	-	-	-
Number of teeth upper left	30+	33	33?	31	30	29+	-	30+	32+	28+	-	-	29
Number of teeth upper right	32+	30	33?	29	32	28+	-	30+	32+	28+	-	-	29
Number of teeth lower left	-	31	-	29	30	29	34?	30+	32	31?	31?	-	30
Number of teeth lower right	-	32	-	31	29	30	32?	31+	32	31+	31?	-	30
Lower tooth row length right	-	170	-	161*	159	147+	-	-	-	-	-	-	-
Lower tooth row length left	-	170	-		159	146+	-	-	-	-	-	-	-
Left ramus length	-	290	-	276*	278	253+	-	-	-	-	-	-	-
Right ramus length	-	289	-		282	253+	-	-	-	-	-	-	-
Left ramus height	-	-	-	57*	56	50	-	-	-	-	-	-	-
Right ramus height	-	-	-		57	52	-	-	-	-	-	-	-
Tooth width (to 1/10mm)	-	-	-	3.8	2.9	3.1	-	-	-	-	-	-	-

Table 4b

Skull measurements expressed as percentages of condylobasal length (CBL). Specimens with inexact CBL's were not used in calculations.

Description	UC-MVZ 118854	1849 5.25.2	USNM 395375	USNM 395374	MNHN-S 581	IZUA-MM 6	MNHN-S 582	IPPA CE-5	USNM 21167
Condylo-basal length	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Rostrum length	54.41	54.12	54.01	53.69	53.57	52.68	53.98	49.16	54.09
Rostrum width at base	23.10	25.00	26.41	24.48	23.51	24.40	23.58	22.75	23.10
Rostrum width at midlength	16.72	18.96	17.51	17.11	16.96	17.56	17.61	17.42	17.84
Premax. width at midlength	6.99	8.79	8.31	7.08	6.85	8.33	8.24	8.99	7.60
Rostrum width at 3/4 length	12.46	14.01	13.35	12.68	12.20	13.10	12.50	12.64	12.57
Rostrum tip to external nares	62.92	62.91	64.09	61.65	61.90	61.61	61.93	57.30	64.04
Rostrum tip to internal nares	-	58.52	57.86	56.64	58.04	56.55	59.09	-	59.65
Preorbital width	39.51	41.21	42.43	40.41	-	40.48	39.77	42.13	40.35
Orbital width	40.73	42.31	42.73	41.59	40.77	42.86	41.19	-	40.94
Postorbital width	44.38	45.88	47.18	45.43	-	45.83	-	46.91	45.03
External nares width	11.55	12.64	11.87	12.09	12.20	12.50	12.22	9.27	11.70
Zygomatic width	41.34	40.11	40.95	44.25	41.96	43.15	41.76	46.91	45.03
Greatest width of premaxillae	14.89	18.41	17.80	16.52	16.67	18.45	17.05	17.42	16.37
Braincase height	31.91	33.24	31.75	33.04	32.14	33.63	31.82	33.43	30.12
Braincase length	32.52	32.14	32.64	32.74	-	-	-	31.18	30.99
Left postemporal fossa length	20.67	19.23	18.99	21.83	-	21.43	-	17.70	19.88
Right postemporal fossa length	20.97	19.78	-	22.42	20.54	22.02	21.59	-	20.47
Left postemporal fossa width	14.89	16.21	14.54	15.63	-	16.07	15.91	12.64	14.91
Right postemporal fossa width	15.20	16.48	13.95	16.52	15.48	17.26	16.19	-	15.20
Left orbit length	12.46	13.19	12.17	12.09	-	13.39	-	13.20	13.16
Right orbit length	12.16	13.19	12.17	12.09	-	13.69	13.64	-	12.57
Internal nares width	13.07	12.64	13.35	12.98	11.90	13.39	12.50	10.11	12.28
Left pterigoid length	14.89	-	15.43	15.04	15.77	16.07	14.77	-	15.20
Right pterigoid length	14.89	-	15.13	15.34	-	15.48	-	-	15.20
Upper tooth row length right	47.11	47.80	47.77	46.90	47.62	46.73	48.01	45.51	46.78
Upper tooth row length left	47.72	47.25	47.77	47.49	47.62	47.02	47.73	-	45.91
Lower tooth row length right	-	47.53	45.70	46.31	-	-	-	-	-
Lower tooth row length left	47.72	47.25	46.29	46.61	-	-	-	-	-
Left ramus length	81.76	82.69	80.71	80.53	-	-	-	-	-
Right ramus length	-	82.97	81.01	80.53	-	-	-	-	-
Left ramus height	17.02	17.86	16.91	17.11	-	-	-	-	-
Right ramus height	-	18.41	16.91	17.11	-	-	-	-	-
Tooth width (to 1/10mm)	0.82	1.15	0.95	0.86	-	-	-	-	-

Specimen USNM 395374 has 63 vertebrae, with the last 2–3 caudals missing (7 cervical, 13 thoracic, 15 lumbar and 28+ caudals). Specimen USNM 395375 has 7 cervical, 13 thoracic, 15 lumbar and 30 (one or more missing?) caudals, giving a total vertebral count of 65–66 for the two specimens. The first two cervicals are fused (three individuals) and both USNM specimens have seven pairs of sternal ribs.

The tympano-periotic bones of specimen USNM 21167 (True's specimen purchased in 1883) were included in a study of earbones by Kasuya (1973), who concluded that these bones in *Cephalorhynchus* greatly resembled those of the genera *Sotalia* and *Sousa*; he included *Cephalorhynchus* in his subfamily Sotaliinae.

Since we have examined only two skeletal specimens for which the sex was known, one adult male and one physically immature (sub-adult) female, we can say nothing about possible sexual dimorphisms in skeletal characteristics, except for the pelvic bones, as in other cetaceans.

Donoso-Barros (1975, p. 34), on the other hand, said: 'The cranium shows sexual and growth variations which gave distinct names such as *panope*,

Table 4c
Range and mean in skull measurements.

	N	Mean	Range	Variance	Standard deviation
Condylo-basal length	13	341.4	302–364	261.9	16.2
Rostrum length	11	182.8	175–197	38.0	6.2
Rostrum width at base	19	81.4	70–91	22.6	4.8
Rostrum width at midlength	12	59.3	54–69	15.5	3.9
Premax. width at midlength	12	27.1	23–32	9.0	3.0
Rostrum width at 3/4 length	12	43.2	40–51	10.5	3.2
Rostrum tip to external nares	13	209.8	199–229	75.2	8.7
Rostrum tip to internal nares	16	195.8	184–213	58.3	7.6
Preorbital width	16	136.8	127–150	37.8	6.1
Orbital width	16	140.8	131–154	32.7	5.7
Postorbital width	14	155.2	142–167	47.1	6.9
External nares width	19	40.8	33–46	7.0	2.7
Zygomatic width	19	142.7	131–167	58.7	7.7
Greatest width of premaxillae	19	57.3	49–67	16.8	4.1
Braincase height	19	108.5	101–121	31.8	5.6
Braincase length	8	108.8	104–117	19.4	4.4
Left postemporal fossa length	16	66.6	59–74	15.7	4.0
Right postemporal fossa length	14	69.6	64–76	13.6	3.7
Left postemporal fossa width	17	51.6	46–59	14.0	3.7
Right postemporal fossa width	17	54.4	47–60	14.9	3.9
Left orbit length	16	43.5	39–48	6.7	2.6
Right orbit length	14	43.6	38–48	9.3	3.1
Internal nares width	18	42.7	36–46	5.8	2.4
Left pterigoid length	15	51.2	47–54	2.9	1.7
Right pterigoid length	12	51.0	47–54	3.3	1.8
Upper tooth row length right	13	159.6	148–174	47.1	6.9
Upper tooth row length left	13	159.8	149–172	31.7	2.4
Number of teeth upper left	13	31.5	29–34	2.8	1.7
Number of teeth upper right	10	30.9	28–34	3.7	1.9
Number of teeth lower left	16	30.8	29–33	1.4	1.2
Number of teeth lower right	12	30.6	29–32	1.2	1.1
Lower tooth row length right	12	159.1	153–173	43.0	6.6
Lower tooth row length left	12	159.4	153–172	33.5	5.8
Left ramus length	12	275.4	262–301	111.7	10.6
Right ramus length	11	277.3	265–302	109.2	10.5
Left ramus height	11	57.3	50–65	13.6	3.7
Right ramus height	10	58.0	52–67	15.8	4.0
Tooth width (to 1/10mm)	8	3.2	2.7–4.2	0.3	0.5

platyrrhinus and *albiventris*'. We suspect this is speculation, since the sex is unknown for specimens in the Chilean Museums, except for those captured after his death.

INTERNAL ANATOMY

The only discussion of internal anatomical features for the species appears to be in the work of Sonntag (1922, p. 641, fig. 25) on cetacean tongues. He found that the tongue of *C. eutropia* is plain and pointed, with a thick fold surrounding it below the apex. Many small elevations with minute orifices were found, as was a slight frenum, and five V-form fissures located at the back of the tongue. The source of his specimen is not discussed. Later, Arvy and Pilleri (1970, p. 75) performed another comparative study of cetacean tongues, mentioning *C. eutropia*, presumably on the basis of Sonntag's data.

There seem to be no other published accounts of this animal's anatomy.

Unfortunately, the recent specimen from San Antonio had been eviscerated when it reached the museum.

No parasites are yet known.

REPRODUCTION

In our observer records the presence of young in schools is frequently mentioned. Young were seen with adults in October, January, March and April near Valdivia (Table 5) and in December at Islas Chiloé and Navarino. Only one sighting (Sighting 69, December at Chiloé) mentioned a calf. Two December sightings were of 'half grown animals' in the central and southern zones, while all the others mentioned only 'young'. Without more details or length data it is impossible to define a breeding or calving season.

Oporto examined a 150cm female caught on 12 March 1975 at Puerto Saavedra, which contained a fetus of unrecorded length. He also examined a 167cm male with enlarged testes caught on 19 January 1976.

Table 5

Sightings of *C. eutropia* with young, by zones.

Sighting no.	Date	Locality	Notes
Zone I. Valparaiso to Puerto Montt			
12	3 October 1968	Corral	2 groups of 10 with young
13	3 October 1968	Nigue	Larger schools with young
24	17 January 1975	Valdivia	20–30 with young
52	30 March 1980	Valdivia	3–4 adults in group of 10
58	22 March 1983	Mehuin	6 or 7 with young
59	31 March 1983	Corral	3 young animals
60	16 April 1983	Corral	2 adults, one young, two more groups of adults
Zone II. Puerto Montt to the Strait of Magellan			
69	26 December 1983	S. Chiloe	7–10 animals, at least one calf and one half grown
Zone III. Strait of Magellan to Cape Horn			
21	6 December 1968	Seno Grandi	7 animals including 1 young
22	7 December 1968	Wulaia	One adult, one half grown

BEHAVIOR

Nearly all observations of the Chilean dolphin have been made very near the shoreline. Along the coast from Valparaíso to Valdivia, where the species has been most frequently seen, it occurs in bays, along sandy beaches, and along the exposed rocky shores. To the south, in the fiords and inland channels of southern Chile, it has been sighted most frequently in situations where tidal currents are swift, such as the entrances to embayments, but some sightings have been made deep in very calm enclosed bays (Fig. 5).

Along open coasts the dolphin seems remarkably adept at swimming in turbulent waters. In Bahía Corral, near Valdivia, Norris watched a small school of these dolphins fleeing from a pursuing boat. The animals travelled underwater through the breaker line and appeared in the apron of waters between these waves and the shore.

On another occasion Norris observed a school very close to a rocky shore south of Queule. The day was windy and ocean swells surged and rose around rocky stacks on their way to crash on shore. A school of these dolphins was seen as it was lifted by the translucent water welling around such a stack. The observers, in a small skiff, watched as the school and the water that supported it rose above the level of their heads and then subsided. Some of the animals were within a meter or two of the rocky stack at times.

Karen Pryor and Jon Lindbergh watched 7–10 dolphins off the southernmost beach of Isla Chiloé. The animals moved to within 15m of the shore, circling irregularly and rolling occasionally, usually one at a time.

Capt. P.J. Lenie (Sighting 48) found Chilean dolphins in a long, mountainous fiord, patrolling a short sandy beach at the far end. They could hardly have found a more protected spot.

However, in spite of these coast-hugging habits, the distance they range from the coast is not known. As far as we know, no aerial cetacean surveys have been made in this region and most ships ply the channels rather than offshore waters.

Field characteristics

It requires much care to be sure that dolphins sighted at sea are of this species. First, the observer may watch for the low rounded dorsal fin (Fig. 15a). Second, if the animals are small and swim close to the shore, the sighting may be of *C. eutropia*. Third, if the animals are in small groups and wary and make evasive maneuvers, especially underwater, they may be of this species. Finally, if they come close to the observer, as they sometimes do, especially when in fairly large groups, one may see the obvious and diagnostic lunate marks behind the blowhole. The latter characteristic separates them from all other South American species.

Typically, these dolphins arch their backs when surfacing (J. Perkins, pers. comm.). They occasionally jump clear of the water, entering head first or falling to one side (Oporto, 1984b) (Fig. 15b).

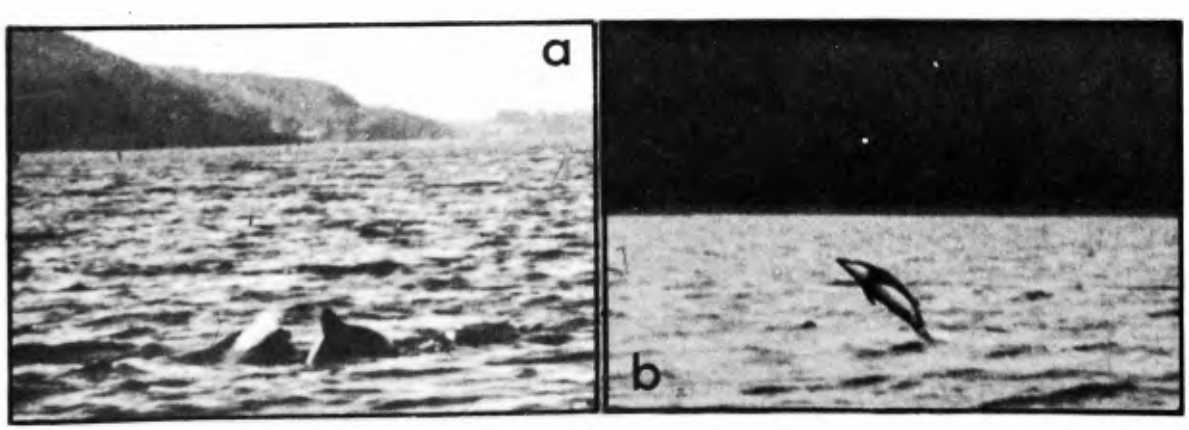


Fig. 15. Views of the Chilean dolphin at sea: (a) Sighting 52 in the Río Valdivia on 30 March 1980; (b) Sighting 66 at Yaldad on 8 November 1983. Photographs by J.A. Oporto.

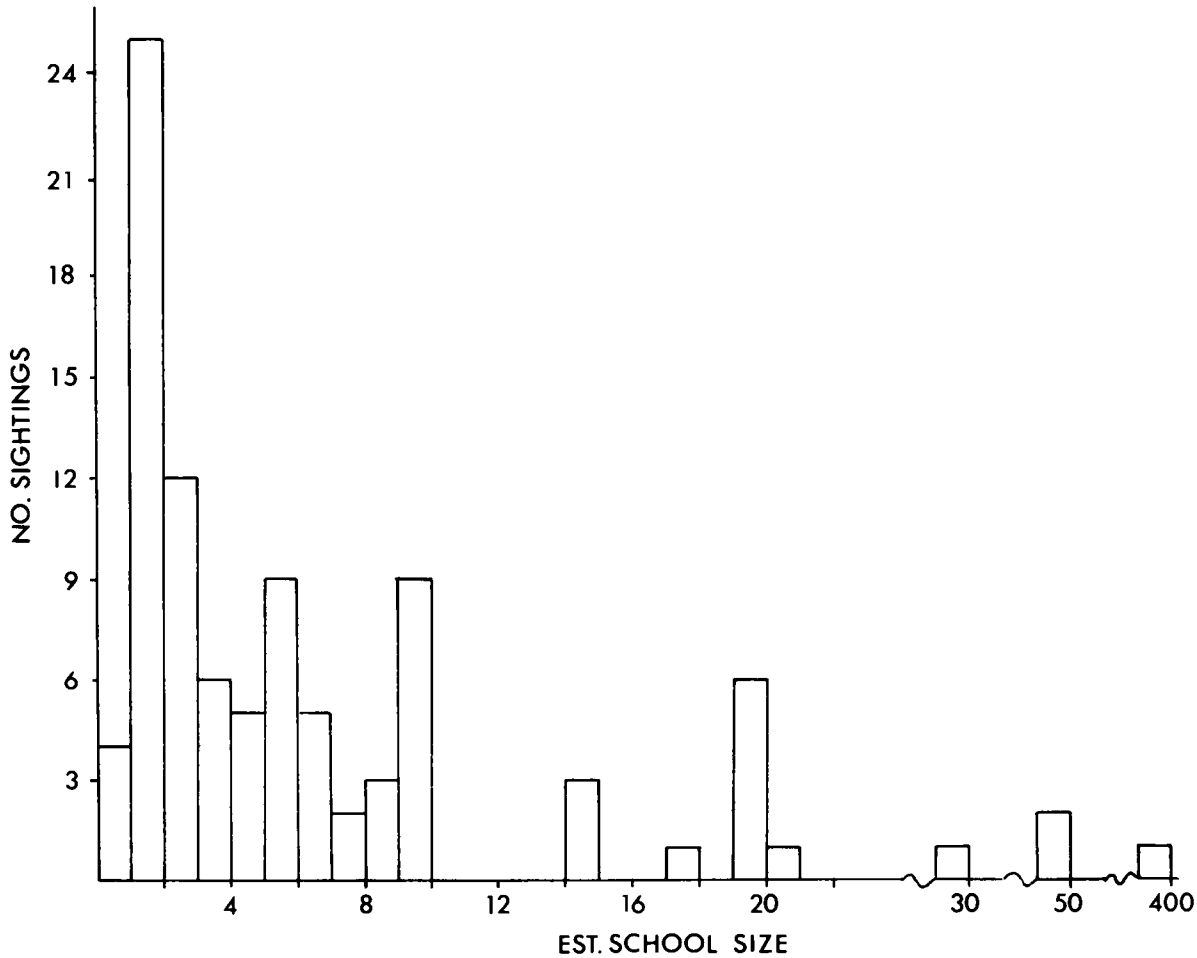


Fig. 16. School size of the Chilean dolphin. Lowest estimates used. When the sighting mentioned schools such as 'four groups of 1–18', both 1 and 18 were plotted, but nothing else.

School size

The largest aggregations of Chilean dolphins have been seen on the open coast near the northern limits of its range. Lesson (1826; 1827) and Pérez Canto (1896) wrote of 'great numbers' and 'numerous schools'. Estimated numbers ranged from about 20 to as high as 400 animals. The latter figure, observed by P. Castro, a research technician from IZUA, refers to the total number of several smaller groups in a large, northward moving, feeding aggregation with associated bird flocks.

In the complex inland waterways of southern Chile, large aggregations have yet to be seen and school sizes range from two to about 15 individuals (Table 2, Fig. 16).

Best (1984) found group size small for *C. heavisidii* although he felt that 'amalgamation into larger groups may occur occasionally'. The same seems to be true of *C. commersonii* (Goodall, Galeazzi *et al.*, 1988).

Interaction with boats

The usual reaction of schools of Chilean dolphins to boats is avoidance, but occasionally they may crowd in at the bows of vessels or ride the waist in typical delphinid fashion. Study of observer records shows that these two tendencies can be subdivided geographically. All records of bow riding were obtained in

the northern part of the species' range, along the open coast and wide bays from Valdivia to Valparaíso (Sightings 14, 51 and 52).

Parenthetically, for fishermen to harpoon Chilean dolphins for bait, as we describe later, the dolphins must ride the bow.

Yet, in the intricate and restricted waters of southernmost Chile, these dolphins are sometimes wary indeed. The observer usually must search hard for a few glimpses of dorsal fins and backs many meters away. Approach usually produces avoidance, as the dolphins dive and reappear some distance away, often moving in a direction different to their previous travel.

A similar phenomenon was noted by Norris *et al.* (1985) in the Hawaiian spinner dolphin, *Stenella longirostris*. In that case, small schools (less than about 10 animals) were notably more wary of boats than larger schools. In the larger schools some subgroups could usually be enticed to ride along with a vessel, while in smaller groups avoidance was the rule.

It may be that the same phenomenon is at work in the behavior of the Chilean dolphin, since our observations of large schools have been made in the northern part of the species' range, while southern observations (to date) were of much smaller aggregations.

While it is difficult to establish, this difference in wariness might be due to the protective function of the school being better served by more animals. Small schools may need to be more alert and wary because fewer sensory inputs to the school as a whole exist. Or wariness may be a learned reaction to fishermen who pursue this species for bait. There may also be differences in the types of boats used, and it might depend upon what the dolphins are doing at time of sighting.

Some groups seemed to mind their own business and pay no attention at all to boats, if not pursued. One observer was told that these dolphins sometimes rubbed against a dinghy.

Epimeletic behavior

Norris observed a subadult female as it was shot from the deck of a small fishing vessel near Concepción (No. 16, Table 2). The animal, shot through the heart and aorta, died almost instantly, turning over with scarcely a tail beat. It could not have uttered more than a sound or two but it was accompanied continuously by two to four schoolmates during the time it was brought aboard, circling the boat even after the animal was on board. The accompanying school then fled, plunging away rapidly.

An adult male shot near Corral (Sighting 14, Table 2) was immediately abandoned.

Feeding

The only stomach contents known for this species were reported by Oporto (1985). They included crustaceans (*Munida subrugosa*), cephalopods (*Loligo gahi*) and fish. Chilean dolphins have been seen in association with fish schools (Lesson, 1827). Dolphins near a fish hatchery on Isla Chiloé played with salmon and other fish and probably fed on recently released young salmon (K. Pryor,

pers. comm.). Pryor also felt that animals she saw may have been feeding on the bottom. The common occurrence of Chilean dolphins in tide rips and the entrances to inland waterways suggests that these features may concentrate food (see Habitat). Since most coastal delphinid species have been found to be opportunistic feeders, taking advantage of a number of prey forms (Wells, Irvine and Scott, 1980, p. 279), this species may do likewise.

Associated species

Chilean dolphins have been seen in association with Peale's dolphin (*delfín austral* or *llampa*, *Lagenorhynchus australis*). On 19 November 1968, Norris watched a school of *llampa* from the shore of Bahía Tic Toc, in the Golfo de Corcovado, and made the following notes:

'There were perhaps eight *llampas* and they cruised within 25–30 feet of the beach, often coming to the surface in unison. I was able to make out an additional two animals, swimming inshore of the others as all cruised along a calm, sandy beach – two *Cephalorhynchus*. It was interesting to see these two genera form an essentially mixed school. They must nearly have touched one another and they clearly moved together'.

Similar, but less intimate associations between these two species have been noted by Norris at Corral and at Seno Grandi, Isla Navarino.

Cephalorhynchus eutropia and *Phocoena spinipinnis* are both captured off Valdivia and other parts of Chile, but there are as yet no observations of these being closely associated.

One sighting (No. 8), which we consider tentative, was made of two animals thought to be Chilean dolphins, which joined a very large, scattered group of *Cephalorhynchus commersonii* for a few minutes in the Strait of Magellan. Since in this area and further south the ranges of these two merge, further observation may confirm their occasional occurrence together (see Distribution).

Sounds

On the 1968 *Hero* expedition, W.E. Schevill and W.A. Watkins attempted to record the sounds of *C. eutropia* on three occasions. Even though listening conditions were excellent, and in one case, the animals were quite close to the hydrophone, no sounds were detected at first. Later, on closer listening to tapes made at Wulaia and Seno Grandi, very low level sounds were heard. These were described as 'a series of rapid pulses, up to 500 per second, produced in a somewhat stereotyped sequence. The sound varied in duration from 0.4–2.0 seconds'. Similar cries have been recorded from *C. commersonii* and *C. hectori* (Watkins, Schevill and Best, 1977).

The recording equipment used by Watkins and Schevill had an upper frequency limit of near 30kHz and it had been slowly emerging that the peak frequencies of *Cephalorhynchus* sounds are much higher than this gear could adequately record since they are narrow band signals of 124–130kHz (Kamminga and Wiersma, 1982; Shochi, Zbinden, Kraus, Gihr and Pilleri, 1982). These authors recorded and analysed the sound of two captive *C. commersonii* held in the Duisberg Zoo, West Germany, and found the animals to be very noisy at this very high frequency. The signals were very brief (about

70 microseconds duration) signals arranged in brief burst or trains. No whistles were detected.

Evans, Awbrey and Hackbarth (1988) have compared the sounds of *Cephalorhynchus* with those of the Dall's porpoise (*Phocoenoides dalli*). Their work confirms the unique structure of phocoenid clicks and their similarity to the clicks of *Cephalorhynchus*.

SIMILARITIES BETWEEN *CEPHALORHYNCHUS* SPP. AND THE PHOCOENIDS

As early as 1900, Beddard (1900, p. 277) wrote that the external appearance of the genus *Cephalorhynchus* 'is suggestive of that of the porpoises, and the form of the pterygoids is much like what I found in the genus *Phocaena*, as also the elevations upon the premaxillae. They have not a beak well marked off the rest of the head . . . '.

Watkins *et al.* (1977), writing at a time when only the very low level low frequencies sounds of *Cephalorhynchus* and *Phocoena* had been heard, said:

'This similarity in the sounds produced by *Phocoena* and *Cephalorhynchus* is accompanied by similarities in body shape, habitat and behavior. Both genera have short snouts without a definitive beak, small rounded flippers and a low dorsal fin. Both have essentially coastal habitats and are often shy and difficult to approach . . . Though they are considered distinct phyletically . . . the similarities . . . appear to be a response to the equivalent ecological niches that they occupy . . . Their similar vocalizations, therefore, invite speculation on how such low level, pulsed sounds . . . might be especially suited for the ecological circumstances under which these animals live'.

We concur with the view from the behavioral standpoint that *C. eutropia* is remarkably similar to the various phocoenids especially *P. phocoena*. *Phocoena* spp. are even more shy of vessels than the Chilean dolphin, but both show similar escape behavior that is different from most delphinids; that is they typically change directions under water and may surface in any direction from a pursuing vessel, they both often frequent murky or swift water, and both surface almost surreptitiously at times.

There are also similarities in external form that may or may not be ecotypic. Large rounded dorsal fins are found in some species of both *Cephalorhynchus* and phocoenids and both are close to being beakless.

The females and young males of *Australophocoena dioptrica* have dorsal fins which are quite similar in size and shape to both of the South American *Cephalorhynchus* (Goodall, Galeazzi *et al.*, 1988). However, the adult male of *A. dioptrica* has a greatly enlarged dorsal fin (as does *C. hectori* of New Zealand), exceeding those of South American *Cephalorhynchus*. Although difficult to distinguish at a distance, *A. dioptrica* fins are less undercut on the posterior margin. The flippers and flukes of the two genera are quite different.

It is typical of nearshore odontocete genera that the beak is either stout (*Tursiops*) or very reduced, except in the relictual platanistoids. Such reduction may provide protection against damage in a complex environment, and hence be ecotypic.

Most slow-moving dolphins show enlarged control surfaces compared to the swifter, more open water species, and hence some part of dorsal fin enlargement might be due to this factor, although it would not explain dimorphism.

While the rounded dorsal fin of *Cephalorhynchus* and *A. dioptrica* might also be explained as being a response to a complex environment (sharp surfaces might be more easily subject to damage than rounded ones), *Lagenorhynchus australis*, which frequents the same waters, even showing a predilection for tide rips and the entrances to inland waterways, has a very different, though large, falcate dorsal fin.

Both *C. eutropia* and *L. australis* have a rostral groove which is only hinted at in the phocoenids.

Although there are similarities in the skull and skeletal anatomy, there are also important differences. The Northern Hemisphere *Phocoena phocoena* is probably more similar to *Cephalorhynchus* than are any of the Southern Hemisphere phocoenids.

The difference in teeth is commonly cited by those who would separate the genera *Cephalorhynchus* and *Phocoena* into separate higher taxa: phocoenids usually have tricuspid teeth, while *Cephalorhynchus* possesses typical delphinid conical teeth. But this argument loses some of its force when one examines fossil phocoenids, the earliest of which (*Loxolithax stocktoni*) had conical teeth or one with a light restriction below the crown. Only a single tooth with a possible cusp was found (Wilson, 1973).

Even the striking similarity between the sound of *Cephalorhynchus* and phocoenids and their difference from the usual dolphin clicks may be ecotypic. Both genera comprise small dolphins frequenting inshore waters where visibility is poor. Because a wide head width at the source of sound generation may be crucial to formation of a sharply focussed echolocation beam where broad band clicks are used, these small dolphins may have to resort to using very high frequencies (hence short wave lengths) to accomplish the same thing. The narrow band width that results is probably less useful than a broad band click in scanning the environment (Evans *et al.*, 1988) and for this reason these species may usually frequent murky waters where a simple short-range system will suffice.

EXPLOITATION

This species has probably been exploited in a modest way for thousands of years. Although they were not one of their main food items, the Alacalufs and Yahgans, canoe Indians of the channels, harpooned dolphins when possible, especially as these animals travelled among the kelp forest near shore (Bridges, 1948, p. 97; Emperaire, 1963, p. 181). These authors do not specify the exploited species, but the coast-hugging *C. eutropia* was probably one of them. That this was true has been borne out by recent excavations along the Beagle's Channel, where remains of this species, as well as others, have been found in shell middens dating to 4,000 BC (Piana *et al.*, 1985)

There has been some fishing for the Chilean dolphin in modern times in its northern range. The first whole specimen known to science was 'fished in the neighborhood of the port' of Valparaíso in 1882 (Pérez Canto *in*: Philippi, 1893a, p. 8). Later Pérez Canto (1896, p. 227), seemingly contradicting himself, wrote:

'About ten years ago the cetaceans called *tuninas* used to appear quite frequently in the neighboring waters of the quay of Valparaíso, and the fishermen often filled their leisure time by fishing them,

usually with a line. But since those days the animals have become so rare that one hardly hears those same workers talking about them.

They have doubtless emigrated although we ignore the cause of that voyage; given that in Valparaíso man has never pursued them cruelly.

In those days the fishermen brought many specimens of *tuninas* to the city museum, where only two were used'.

Aguayo (1975, p. 1,127) quoting D. Torres, stated that fishermen of Queule, near Valdivia, used this species for bait and perhaps human food. On this basis Mitchell (1975a, p. 91; 1975b, p. 935) said that *C. eutropia* may be caught in small numbers by net fisheries, or occasionally taken by fishermen in south Chile.

Goodall and Cameron (1980, p. 448) noted that near Valdivia *C. eutropia* and *P. spinipinnis* are taken incidentally in surface gillnets and then used for bait, but rarely for human consumption, although some could be taken to a nearby fish meal plant.

In 1968, fishermen at Corral told Norris that *toninas* avoided nets but that they were sometimes taken for *Congrio* (*Genypterus spp.*) bait. At Queule, to the north, fishermen reported catching three kinds of dolphins (almost certainly *Phocoena spinipinnis*, *Cephalorhynchus eutropia* and *Lagenorhynchus australis*) 'in *corvina* nets', and Norris was led to a specimen of *P. spinipinnis* which had been caught in this fashion four days earlier.

Fishermen at Tubul, on the Golfo de Arauco south of Concepción, told Norris of a local summer fishery for three dolphins which they called *tonina* (which we believe are the above three species). The dolphins were encircled with a long net and the animals used for oil. The *pope* (assumed to be *Phocoena spinipinnis*) was described as producing much less oil than the other species. Due to prohibitive legislation this fishery probably no longer exists.

Residents at Puerto Eden (Sighting 46) and Chiloé (47) told J. Perkins that *toninas* are caught in their nets but that no one eats them.

Oporto spent some time with fishermen while a graduate student at the Universidad Austral at Valdivia, and found that *toninas* were both taken incidentally in nets and harpooned for bait. Some are caught in nets set for *jurel* (*Trachurus picturatus*) and *róbalo* (*Eleginops maclovinus*). Meshes are 8 to 10cm square; the nets are about 50cm long and anchored overnight in about 30m of water.

Bait, expensive for fishermen in this area, is required for three kinds of fishing. *Róbalo* are caught on long-lines of about 150 hooks each; *pez espanda*, or broadbill swordfish (*Xiphius gladius*) is fished with individual hooks, and a crab called *jaivas* (*Cancer* sp.) is caught in ring nets baited in the center. Dolphins, sometimes harpooned for the purpose, can be used in all these kinds of fishing. Torres and Aguayo (1979, p. 221) mention that a 'butterfly' harpoon is sometimes used to hunt these dolphins.

Chilean dolphins are also taken incidentally. The 1984 San Antonio specimen was found in a *red cerquera*, a net hauled out in a circle from a ship or from two vessels (J. Yañez, pers. comm.). A newspaper report (Anon., 1984b) claimed the fishermen had 'hatcheted' it, but this is not borne out in the photographs.

Leatherwood *et al.* (1984), in recent investigations in the Strait of Magellan, found that fishermen of one cannery were taking about two Chilean dolphins

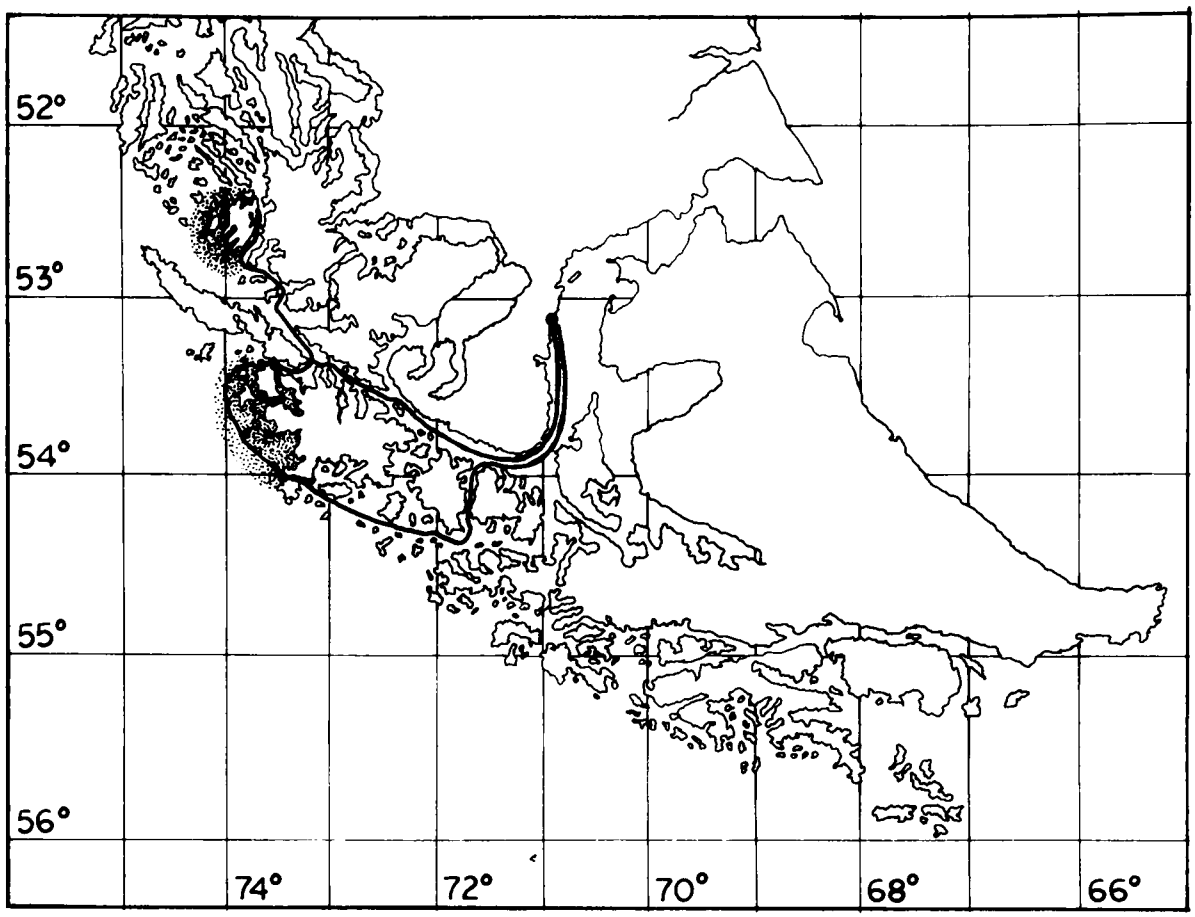


Fig. 17. Map showing the route of a Punta Arenas cannery boat in retrieving the catch of *centolla* and *centollon*. Hatched areas are those where Chilean dolphins are harpooned for bait. (R.A. Kastelein, via S. Leatherwood).

per boat per week for the bait in the western strait and surrounding islands, which could mean as many as 1,300 to 1,500 per year. This has come about because of the scarcity of the over fished *centolla*, *Lithodes antarcticus*, forcing fishermen to move into the western channels in search of the smaller *centollón*, *Paralomis granulosa*. The area where this capture is carried out is illustrated in Fig. 17.

Goodall and Jordan (1986) questioned authorities and factory owners in July 1985, who said fishing is no longer carried out in the area illustrated in Fig. 17, but further to the north and south. Although all admitted that dolphins are being taken, it was felt that *Lagenorhynchus australis* was the more likely species. The quantity of dolphins captured, either incidentally or deliberately, is unknown. Any deliberate captures have been clandestine since 1977, when a law prohibiting the killing of dolphins in Chilean waters was enacted (Sielfeld, Venegas and Atalah, 1977). Exploitation in the Magellan region is under investigation.

As far as we know, no Chilean dolphins have been captured live for display.

Obviously, more research is needed in all aspects of this species' biology, behavior and exploitation.

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On *Phocaena obtusata*, with a Comparison of Certain Diagnostic Characters in South American Phocoenids and the genus *Cephalorhynchus*

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ABSTRACT

Phocaena obtusata, described by R.A. Philippi in 1893, has been thought by some authors to be *Phocoena dioptrica* (now *Australophocaena dioptrica* – Barnes, 1985) and others to be *Cephalorhynchus* sp. An examination of the poorly preserved specimen in Santiago, a comparison of size and external shape and the structure of the flipper proves that the specimen is not a phocoenid. On the basis of known distribution of the species involved, we feel the holotype to be a specimen of *Cephalorhynchus eutropia*, a common but little known dolphin of the Chilean coast.

The external morphology and x-rays of this specimen were compared with *Cephalorhynchus commersonii*, *C. eutropia*, *Australophocaena dioptrica* and *Phocoena spinipinnis*. The phocoenids can be distinguished from genus *Cephalorhynchus* in that: the length of gape is shorter in relation to length of snout to eye and to total length; the angle formed by the scaphoid with the bones above and below it (flipper angle) is less; the number of carpals is less; the second metacarpal is always longer than the third; and the phalanges of digits II and III are less than half the length of the corresponding metacarpal.

INTRODUCTION

In 1893, R.A. Philippi described a new dolphin (*tunina*), under the name *Phocaena obtusata*, of which only a poorly preserved skin remains in the Museo Nacional de Historia Natural in Santiago (MNHN-S), Chile. Over the years, debate arose as to the identity of this specimen, a result of Philippi's illustration (1893, fig. 1) of a dolphin with a strange pigmentation pattern consisting of five vertical white bars extending into the black dorsal field (Fig. 1). This paper is an attempt to clarify the situation and to provide a comparison of some of the characteristics of these two genera from southern South America.

A full translation of the type description (Philippi, 1893) follows (italics ours):

'Near the end of the winter of 1888 I received, thanks to the work of Mr D. Federico Godoy, of Concepción, a skin of a *tunina* caught in the Bay of Talcahuano and which evidently constitutes a new species, which I call *Phocaena obtusata*.

The body is very fusiform; the dorsal and ventral lines have almost the same curvature, the ventral one being a little more convex. The forehead is very inclined and a little convex. The eye is found in a prolongation of the line of the mouth, and the third part of the height of the head. The anterior part of the head, seen from above, shows the form of an equilateral triangle with a rounded point. The caudal part of the body is keeled as always, and the dorsal line shows a marked angle at the beginning of this keel. The dorsal fin has a very obtuse and rounded point, and the posterior border is very little cut out. The pectoral fins are even more obtuse, and almost the same width throughout their lengths; they are situated very low, which is shown, apart from the drawing, by the short distance there is between them.

The coloration is very unique: the lower half of the body is of a handsome silvered white, the superior of a very dark black, and from the white part five short bands of the same color are directed upwards. The flippers are black. I cannot guarantee the width, etc, of these bands; the skin, which I received, *had lost its epidermis in various parts, so that it was necessary to paint the embalmed animal*. But even omitting the color, the form of the head and that of the appendages would alone be sufficient to distinguish this species'.

In Fig. 1 we show Philippi's *P. obtusata* drawn to scale with published illustrations of *A. dioptrica* and drawings of specimens of *C. eutropia*, *C. commersonii* and *P. spinipinnis*, the four species of these two genera known off southern South America.

Most of the authors discussing this species had not seen the type specimen, but were working only from Philippi's description and figures. True (1903) believed that it resembled *Cephalorhynchus* and called it *C.? obtusata* (Philippi), as did Trouessart (1904). Philippi himself (1895) mentioned that his specimen might be the same as Gray's *Delphinus eutropia* (*C. eutropia*) but, since he had no skulls and Gray was ignorant of the exterior form, he thought it doubtful.

Lahille (1912) in describing the new species *Phocaena dioptrica*, reviewed Philippi's 1893 paper but did not consider that *P. obtusata* was similar. Allen (1925), however, was certain that *P. obtusata* was a female *P. dioptrica* and that the name *obtusata* had preference.

Aguayo (1975), Yañez (1948), Mann (1957) and Torres (1977) did not mention *P. dioptrica* in their list of marine vertebrates of Chile. Sielfeld, Venegas and Atalah (1977) included *P. dioptrica* (indicating that the name *obtusata* had priority) in the species of southern Chile, probably on the basis of Philippi's specimen, but without providing additional documentation. Specimens of *P.* (*Australophocaena*) *dioptrica* were found in extreme southern Chile only recently (Goodall and Cameron, 1979). Nevertheless, Donoso-Barros (1975) who said he had examined the Santiago specimen as well as the two models of *P. dioptrica* in the Museo de La Plata, considered them to be conspecific and gave priority to the name *P. obtusata*.

The name *obtusata* was included under both *Phocoena dioptrica* (p. 102) and *Cephalorhynchus* (p. 75) by Hershkovitz (1966). Fraser (1968) and Praderi (1971) considered the species doubtful until further specimens could be found.

Brownell (1975) stated that he had examined the holotype of *P. obtusata* which was 'on public display in the Museo Nacional de Historia Natural in Santiago, Chile'. He considered that it was a 'delphinid of the genus

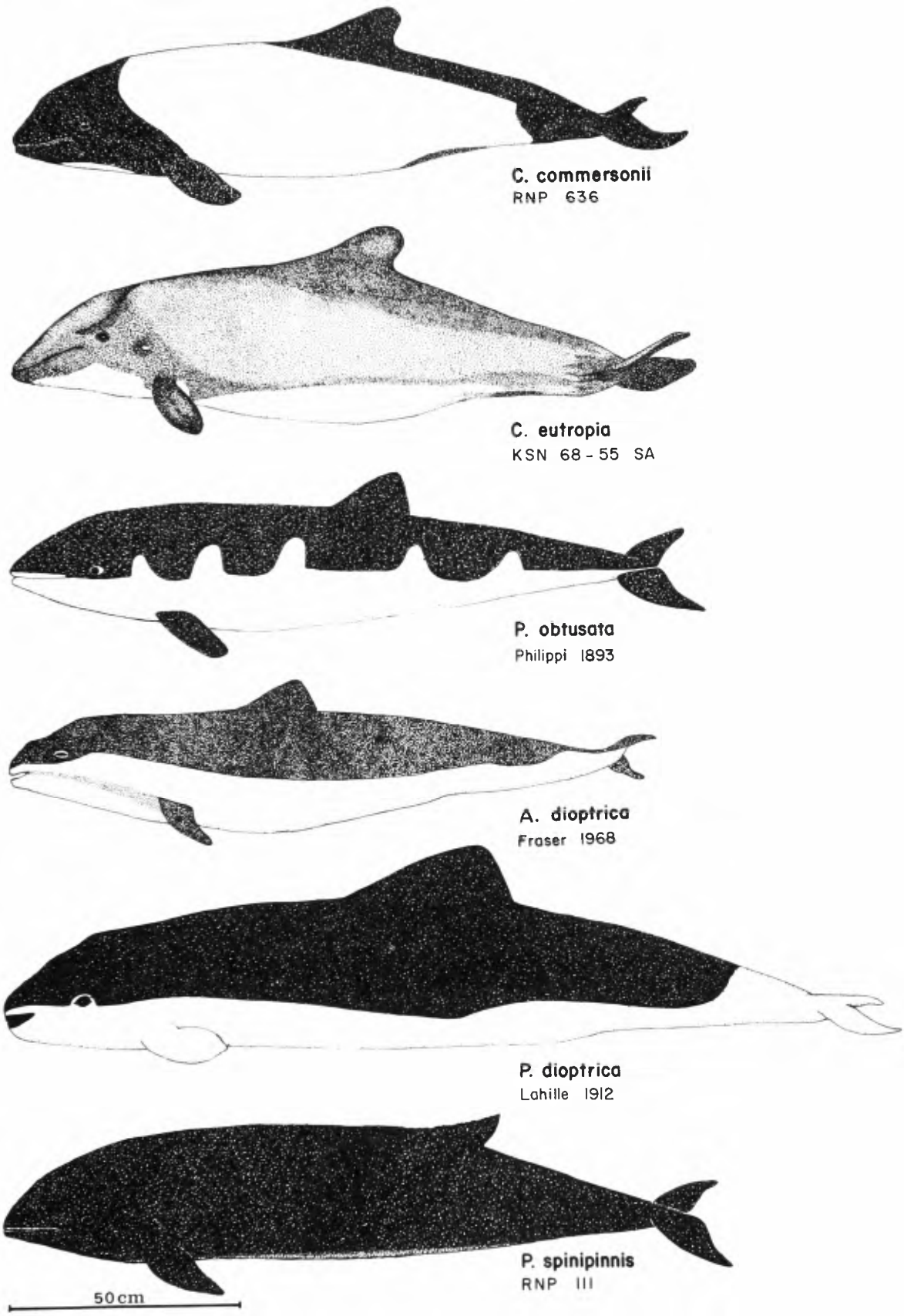

Fig. 1. External shape and pigmentation in *Phocaena obtusata* and South American species of *Cephalorhynchus*, *Australophocaena* and *Phocaena*. All animals drawn to scale.

Table 1

Measurements given by Philippi (1893: 12) of his *Phocaena obtusata* compared to three mounted skins of *C. eutropia* in the Museo Nacional de Historia Natural in Santiago, Chile. Measurements taken over the body curve are given in parenthesis. Measurements are only approximate due to the deteriorated state of the skins. Standard measurements by Goodall and Cameron, rounded to nearest cm. Note that several measurements have been eliminated due to the state of the specimens. Philippi stated that his total length was taken over the curve, but does not clarify how the others were taken.

Measurement	P. obtusata by Philippi 1893	MNHN-S 604	MNHN-S 597	MNHN-S 598
Total length	(149)	143 (149)	128 (138)	162 (169)
Snout/center eye	18	17 (20)	20	20
Snout/angle mouth	15	12 (16)	16	14
Snout/anterior insertion of flipper	31	32 (37)	33	34
Snout/anterior insertion of dorsal fin	69	66 (70)	62	76
Fin notch/posterior insertion of dorsal fin	60	57 (60)	43	59
Maximum girth	85	85	81	101
Dorsal fin height	9	9	8	11
Dorsal fin base, length	20	20	23	28
Fluke depth	11	11	10	13
Fluke width	35	35	-	-

Cephalorhynchus as True stated and not *P. dioptrica*' because the dorsal fin was more rounded than figured by Philippi and the flippers were not like those of *P. dioptrica*. Clarke, Aguayo and Basulto (1978) on the basis of available literature, felt that *P. obtusata* and *P. dioptrica* must be identical, but in view of Brownell's statement (1975) accepted that the identity of Philippi's animal still remained in doubt.

Thus Allen (1925), Donoso-Barros (1975), Sielfeld *et al.* (1977) and Clarke *et al.* (1978) believed that *P. obtusata* was a specimen of *P. dioptrica*, True (1903) and Brownell (1975) considered it to be a specimen of *Cephalorhynchus*, while Fraser (1968) and Praderi (1971) withheld comment.

MATERIALS AND METHODS

In October 1978, Goodall and Cameron visited MNHN-S, Chile. The specimen of *Phocaena obtusata* was *not* on public display, although a similar, slightly longer stuffed skin was. Only after three days of searching was an unnumbered specimen, later designated as MNHN-S 604, found hidden in the back of a cabinet and identified by comparing the measurements of three skins in the museum (labelled *Cephalorhynchus eutropia* by the museum staff) with those given by Philippi (Table 1). Specimen 604 was x-rayed to determine the amount of osteological material remaining within the skin.

Apart from the other two skins of *C. eutropia* in MNHN-S, comparative materials were available in the literature and in the Goodall collection in Tierra del Fuego. The latter included specimens of *Phocoena* (*Australophocoena*) *dioptrica* (11), *P. spinipinnis* (3) and *C. commersonii* (87) (Goodall, Galeazzi, Leatherwood, Miller, Cameron, Kastelein and Sobral, 1988) for which there were standard measurements (Norris, 1961), appendage tracings, flipper x-rays and osteological materials. Information on known specimens of *C. eutropia* was

taken from Goodall, Norris, Galeazzi, Oporto and Cameron (1988); flipper tracings and x-rays were contributed by J.A. Oporto. The available material on flippers, therefore, included a number of x-rays, cleaned and dried bones in our collection (especially of *C. commersonii*) and a drawing (by R.N.P. Goodall) of the flippers of two specimens of *C. eutropia* in the US National Museum (USNM).

Since reproductive data was unavailable for most specimens, physical maturity was based on fusion of the vertebral epiphyses: class 0, fetus and neonates; 1, juveniles with no epiphyseal fusion; 2, subadults with some epiphyseal fusion; 3, adults, all epiphyses fused to the centra.

The flippers were studied in detail. Measurements were available for both flippers of most specimens; an average of measurements of the left and right flippers of each individual was used for calculations. Little difference has been found between left and right measurements in *Globicephala* (Kendrick and Ogden, 1982).

The humerus, radius and ulna of these species were not compared because they are indistinct in the x-ray of *P. obtusata*. Phalanx number was not considered because both flippers of specimen 604 were broken; furthermore, these bones are susceptible to ontogenic changes (Perrin, 1975). Other bones of the flippers were carefully compared in the four species.

Measurements (taken directly from bones except for the x-rays of *P. obtusata*) were made of the metacarpals and first phalanges (or first and second phalanges in terminology which includes metacarpals with phalanges [Yablokov, Bel'kovitch and Borisov, 1972; Perrin, 1975]) of digits 2 and 3 with 0.1mm precision calipers by measuring the length of the bone in mid-line from proximal to distal suture on the external face of the flipper, without including the epiphyses. This methodology was adopted in order to unify the sample, in which the epiphyses fuse very early in phocoenids but are still quite visible in old specimens of *Cephalorhynchus* (de Buffrénil and Robineau, 1984; Robineau and de Buffrénil, 1985).

RESULTS

Specimen MNHN-S 604 measured 149cm over the dorsal curve, the measurement given by Philippi (143cm by standard methods). The other two skins measured 138cm (MNHN-S 597) and 169cm (MNHN-S 598, the one on public display). All three skins (Fig. 2), as well as another of *Phocoena spinipinnis*, were dried, badly mounted and sewn, but the measurements of MNHN-S 604 coincided enough with those of Philippi to convince us that we had found his specimen.

Most of the body of MNHN-S 604 is covered with a thick (1cm or more) coating of burlap and plaster. From this sheath – which completely surrounds the body and covers the skin – the snout, dorsal fin, flippers and flukes protrude. None of the skin on the underside of the body nor the genital or anal apertures is visible due to the circular encasement. The snout is deformed, the mouth lumpily sewn together with a double thickness of twine. The tips of the flippers are missing and the flukes are badly dried and twisted. Only the dorsal

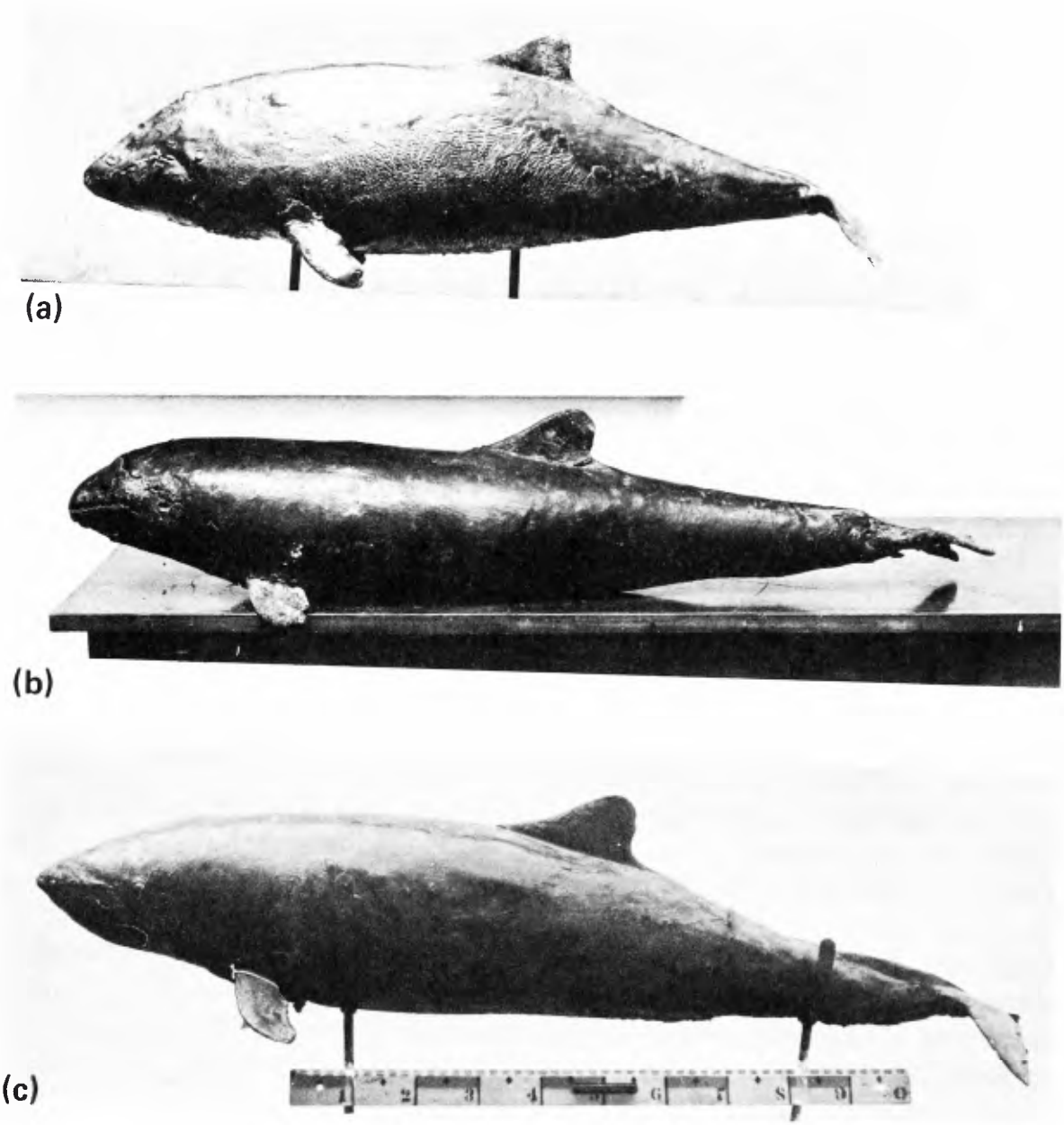

Fig. 2. *Phocaena obtusata* (b), specimen MNHN-S 604 compared to the two specimens of *C. eutropia* in the museum: (a) MNHN-S 597 and (c) MNHN-S 598. Photographs to scale.

fin retains some of its original shape, although also dried; it is not pointed as in Philippi's drawing (Figs 1, 2 and 6).

Evidently the plaster layer covering the body was originally painted black and white below, as described by Philippi, but, according to museum attendants, over the years varnish was applied at intervals to all mounted skins so that now the general color is a dark golden brown, without even the white of the lower body being visible. The visible skin of the head is black, without a suggestion of the white on the side of the face which is typical of *A. dioptrica*. Below the chin there is, just barely visible in front of the plaster, a slightly lighter area which might be a chin spot such as in *C. eutropia* or *C. commersonii*.

The only osteological materials left in the skin as shown by the x-rays are the last 14 caudal vertebrae (Fig. 4) and the remains of the broken flippers (Figs 3 and 7). A wooden stick runs longitudinally within the plaster, skin and straw filling, and there is a metal rod in the caudal region. Putrefaction, as well as the

(a)

(b)

(c)

(d)

(e)

Fig. 3. *Phocaena obtusata*, MNHN-S 604. (a) right lateral view; (b) flukes; (c) right flipper; (d) left flipper; and (e) view of the head.

Fig. 4. Caudal vertebrae within the dried skin of *P. obtusata*.

layers of covering and the angle at which they had to be taken, prevented clear x-rays of the flippers. The flippers themselves could not be removed because they were wired together within the plaster sheath.

The external shape of MNHN-S 604 is very similar to the two specimens of *Cephalorhynchus eutropia* in the Santiago Museum (shown to scale in Fig. 2).

Total length (TL)

Known total lengths at physical maturity (on the basis of fusion of the vertebral epiphyses) of the four southern species and *P. obtusata* are compared in Table

Table 2

Certain morphometric differences between the genera and species of phocoenids and *Cephalorhynchus* off southern South America.

Key: A = Total length of subadults of known physical maturity (cm). B = Total length of physically adult animals (cm). C = Length of gape as percent of total length. D = Fluke width as percent of total length. E = Number of carpals. [1] Brownell and Praderi, 1983. [2] Measurement by Philippi, left and right sides by the authors.

	A. dioptrica			P. spinipinnis			C. eutropia			C. commersonii			P. obtusata		
	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N
A	186.7	180–204	7	162.3	134–185	4	157.3	150–165	2	127.0	114–142	23	143.0	–	1
B	207.7	196–224	3	–	180–200[1]		152.0	–	1	132.2	127–146	26			
C	5.6	5–8	8	6.3	5–8	8	12.6	11–14	7	10.4	9–12	59	9.3	8–11	3[2]
D	20.5	16–23	6	21.9	22–22	3	24.5	19–28	7	22.7	18–29	22	24.0	–	1
E	4.8	4–5	4	3.0	–	4	6.7	6–7	3	6.4	6–8	34	7.0	–	2

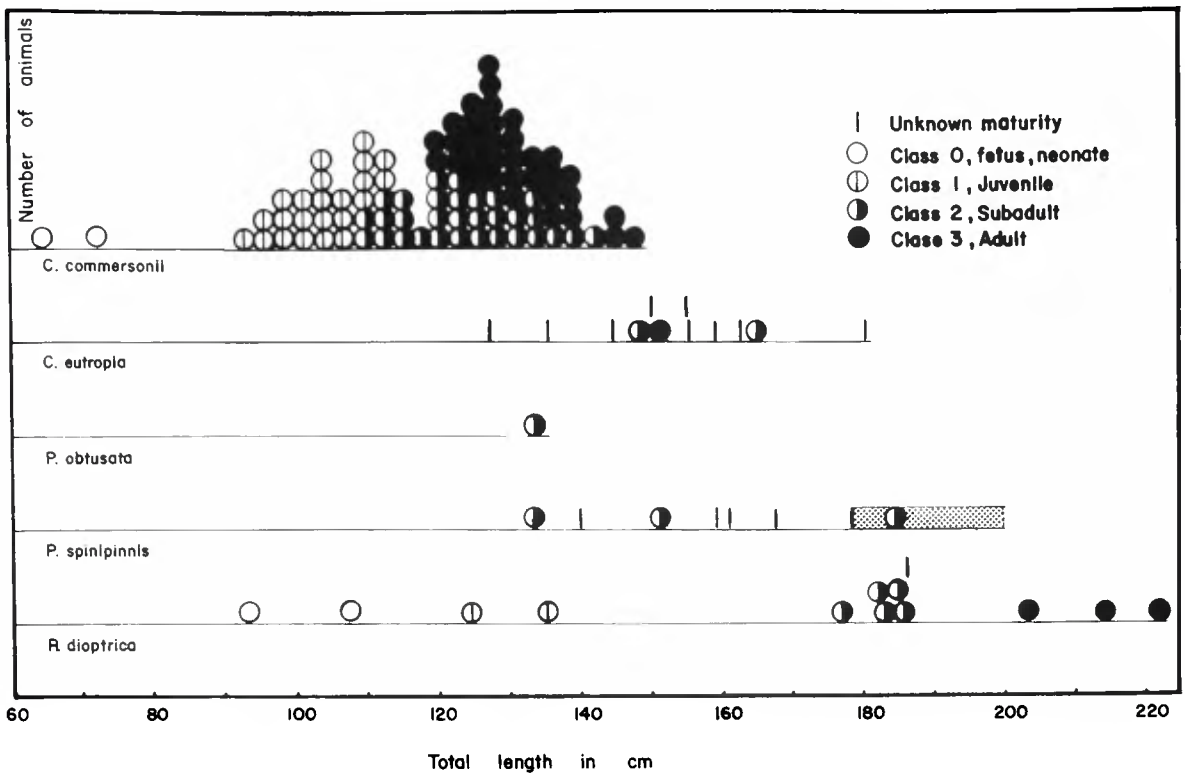

Fig. 5. Comparison of total length at physical maturity for specimens (examined by the authors) of the four species of phocoenids and *Cephalorhynchus* off southern South America, compared to *P. obtusata*. The shaded area shows 'adult' sizes of *P. spinipinnis* as indicated by Brownell and Praderi (1983).

2 and Fig. 5. *Phocaena obtusata*, either a subadult or adult (the last 14 caudal vertebrae have fused epiphyses) with a standard TL of 143, would be most unlikely to be an adult or subadult of *A. dioptrica*, in which a very young specimen with unerupted teeth measured 135.8cm (Fraser, 1968).

Dorsal fin shape

The dorsal fin in Philippi's drawing is very similar to that of a young male or female of *A. dioptrica* (the adult male of this species has a much enlarged dorsal fin). Philippi illustrated a pointed fin but described the fin as rounded; that of MNHN-S 604 fits the description and is like those of the two specimens of *C. eutropia* in the Santiago Museum (Fig. 2). Scale tracings of dorsal fins of the four southern species are compared with the fin of MNHN-S 604 in Fig. 6. There is a good deal of variation in shape within a species; the female spectacled porpoise could be confused at sea with the two species of *Cephalorhynchus* if shape alone were the criterion. Therefore, dorsal fin shape is fairly undiagnostic except for *P. spinipinnis* and the adult male of *A. dioptrica*.

Flipper shape

Brownell (1975) found that the flippers of the Santiago specimen he thought was *P. obtusata* were not like those of *A. dioptrica*; neither is Philippi's description like the flippers of *dioptrica* (as illustrated by Fraser, 1968 or Lahille, 1912). The flippers of *A. dioptrica* are smaller than those of *Cephalorhynchus*, wider in

[*Text continues on p.* 270]

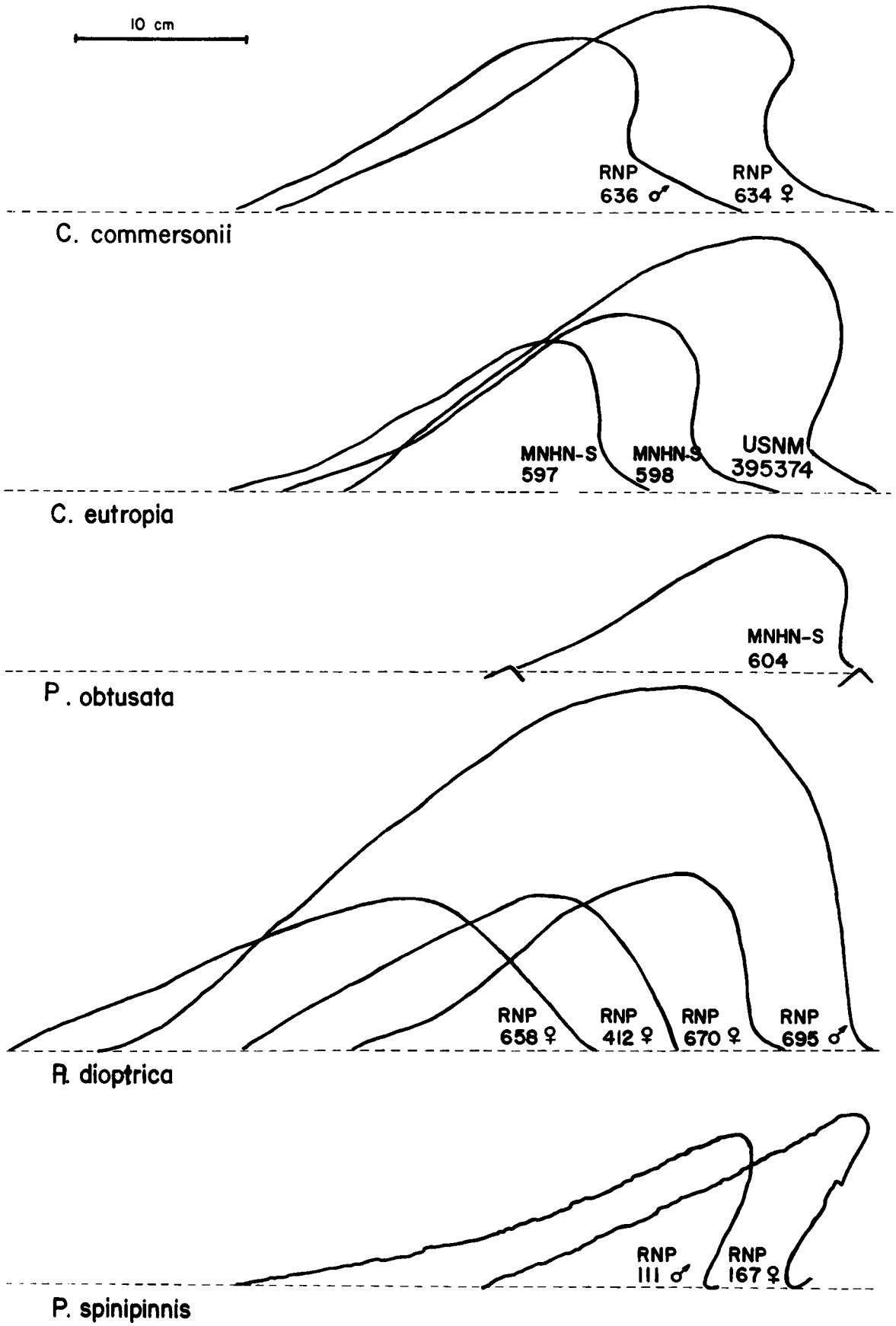

Fig. 6. Dorsal fin variation in four southern species and in *P. obtusata*. (The fin of *P. obtusata* was very dry).

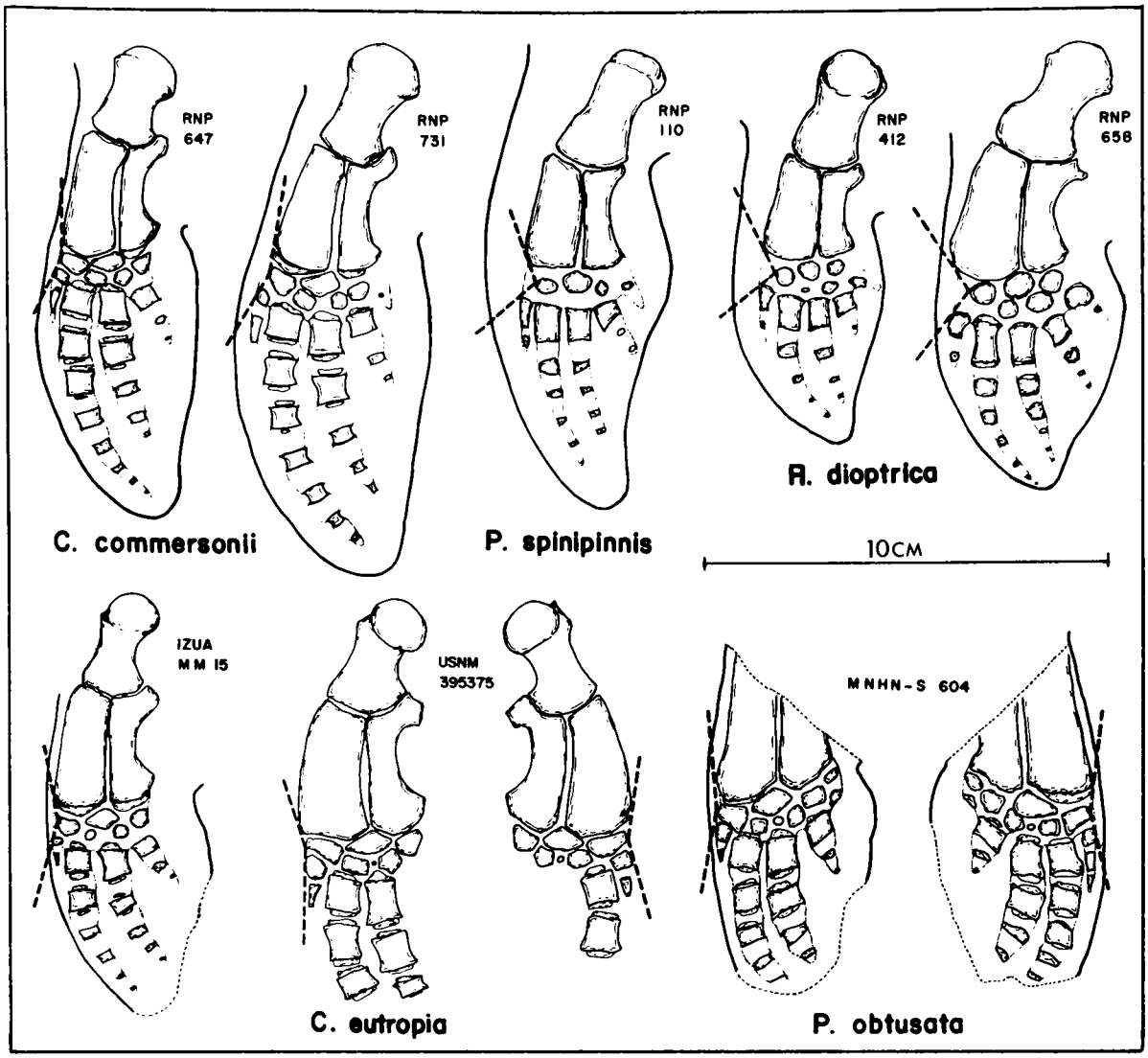

Fig. 7. Comparison of the shape and bone structure of the flippers of the South American phocoenids and *Cephalorhynchus* with that of *P. obtusata*.

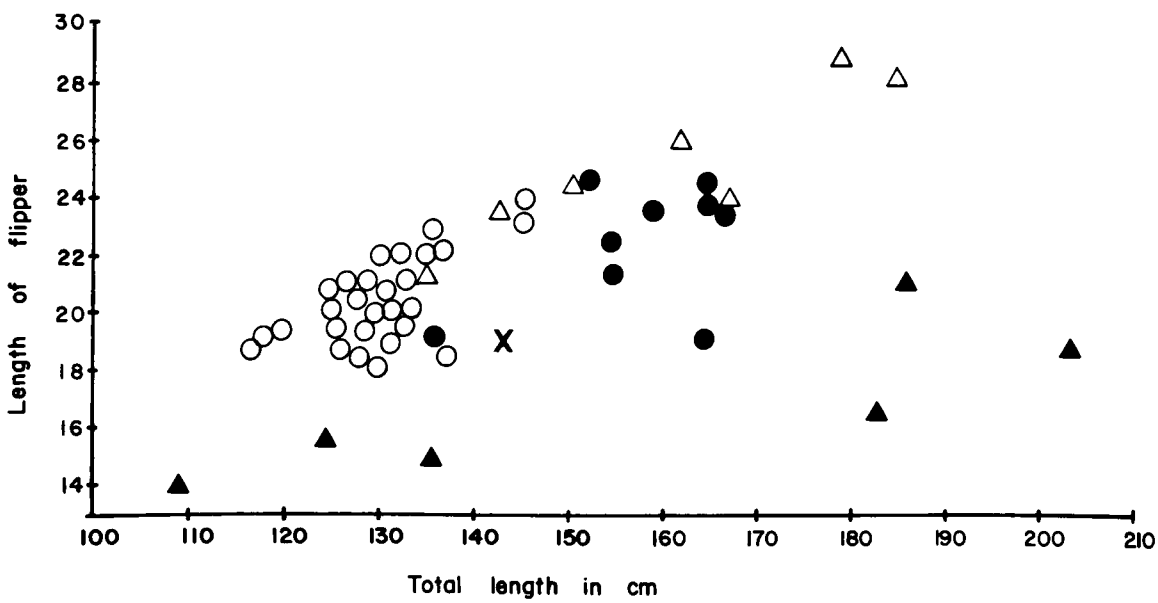

Fig. 8. Graph showing the flipper length as a function of total length for the four southern species. Open circles = *C. commersonii*, closed circles = *C. eutropia*, open triangles = *P. spinipinnis*, closed triangles = *A. dioptrica*, X = *P. obtusata*.

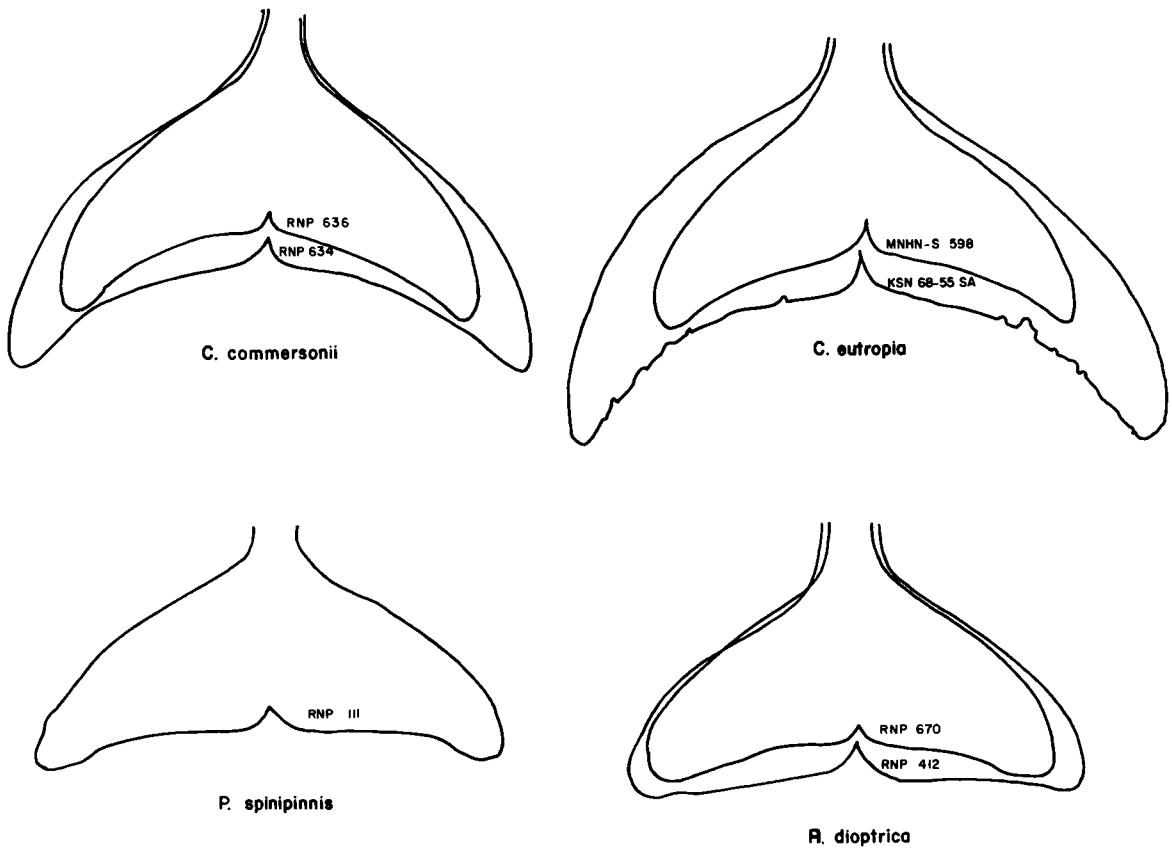

Fig. 9. Comparison of the shape of the flukes in four southern species.

proportion to their length, and more pointed. The shapes of the flippers of the southern South American phocoenids and *Cephalorhynchus* species are shown in Fig. 7.

On comparing flipper lengths, those of *C. eutropia* (mean length 224.6±2.1mm, n=9) were longer than those of *A. dioptrica* (mean ± 152.4±7.2mm, n=7) ($p<0.01$). The flippers of MNHN-S 604 could not be measured due to damage but Philippi's flipper length of 190 mm for *P. obtusata* falls on the upper limit of the confidence level for *A. dioptrica*. However, when the relation of flipper length to total length was compared, those of *C. eutropia* are again larger (14.9%±0.9, *A. dioptrica* 11.2%±1.6) and the flipper of *P. obtusata* falls within the confidence interval of *C. eutropia* (Fig. 8).

Flipper widths of the two species in question were compared. In relation to total length, the flippers of *C. eutropia* are wider than those of *A. dioptrica* ($p<0.01$). In flipper width, *P. obtusata* falls within the confidence interval of *C. eutropia* ($p<0.01$).

Head shape

Philippi (1893) believed that the head shape alone would be sufficient to distinguish this species. However, the head of MNHN-S 604 is deformed and none of the southern coastal smaller cetaceans have much of a beak. The four southern species discussed in this paper could not be distinguished at a distance on the basis of head shape alone.

Lahille (1912) mentioned that the mouth of *A. dioptrica* is very small, being

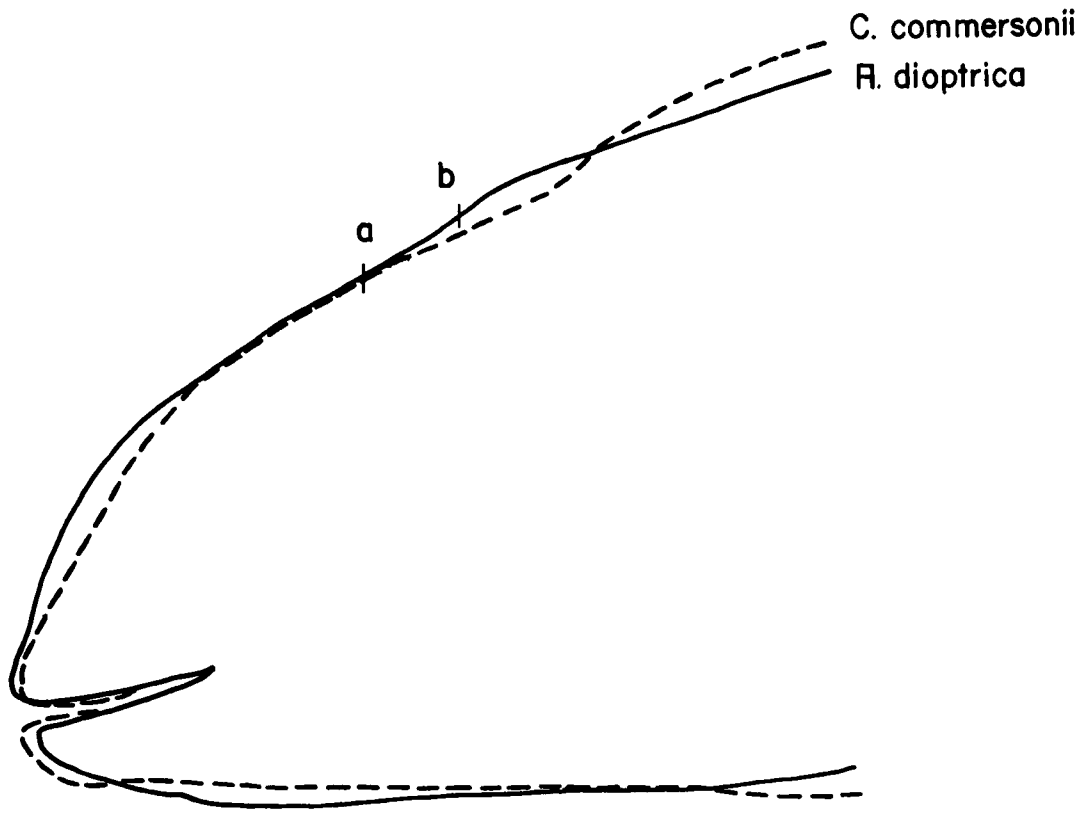

Fig. 10. Outline tracing of head shape of a juvenile female specimen of *Australophocoena dioptrica* (RNP 670) of 124.6cm and of an adult male specimen of *Cephalorhynchus commersonii* (RNP 620) of 127.2cm TL. a) posterior edge of blowhole of RNP 670 and b) of 620.

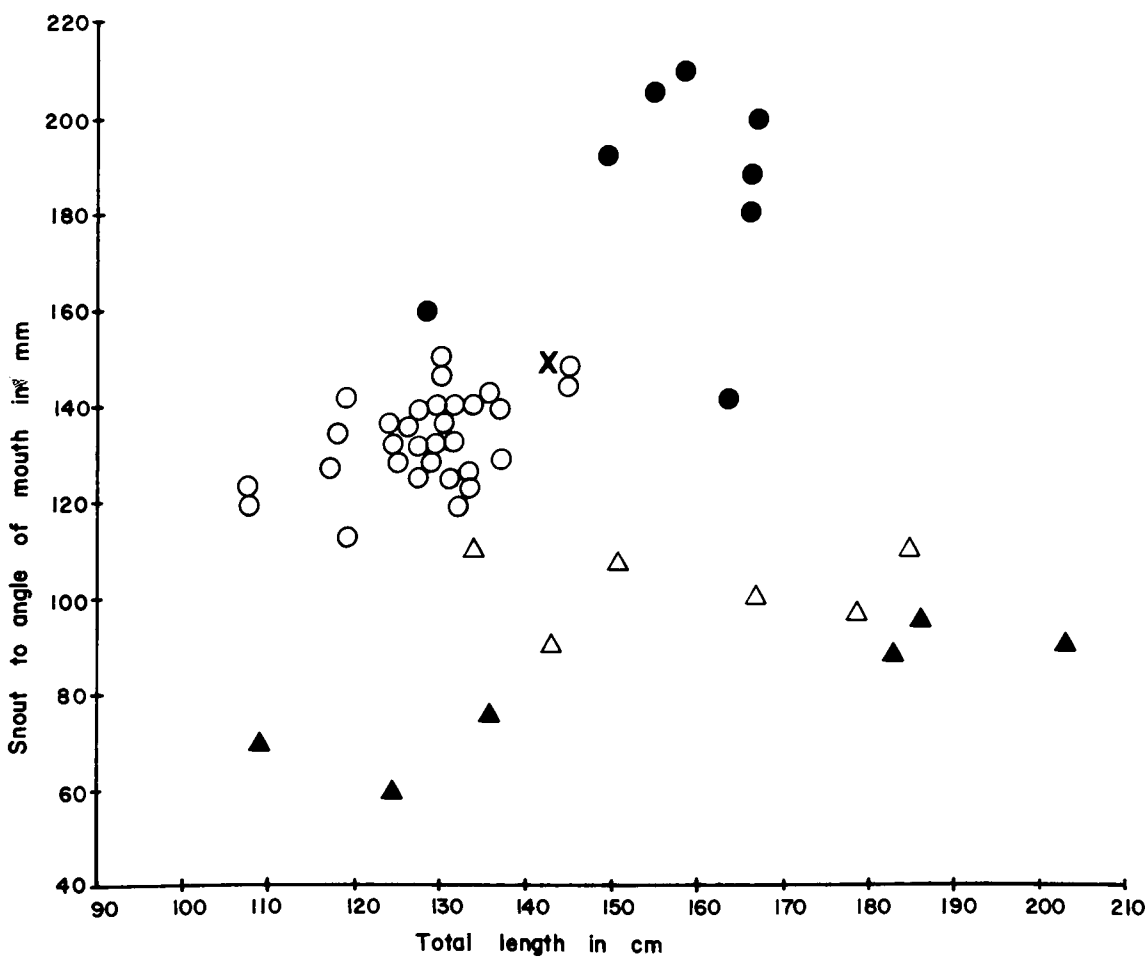

Fig. 11. Length of gape as a function of total length in the four southern species and *P. obtusata*. Symbols are the same as in Fig. 8.

less than half the length of the flipper. We found that the length of gape (snout to angle of mouth) was less than 57% of the length from snout to eye in *A. dioptrica*, but more than 75% of this distance in *C. eutropia*.

The ratio of length of gape to total length is over twice as long in *C. eutropia* as in *A. dioptrica* (12.6% n=7 versus 5.6% n=8). *Phocaena obtusata* falls within the confidence interval of *C. eutropia* ($p<0.01$) (Fig. 11).

Osteology

As mentioned above, the osteological materials in the type specimen are a few caudal vertebrae and part of the flippers, of which we have distorted x-rays.

Flipper bones

Scale drawings of x-rays of flippers of the four species are shown in Fig. 7. Although, as noted earlier, the x-rays of MNHN-S 604 are distorted the general shape of the flipper and its bone structure can be discerned. In spite of these obstacles and the very small sample size, we came to the following conclusions:

(a) In all the phocoenid specimens we have examined, the metacarpal (M) of digit II is always longer than that of digit III, while the reverse is true in *Cephalorhynchus*. The 'metacarpal index': (MII/MIII) of *A. dioptrica* is 1.1 ± 0.1, while that of *C. commersonii* (we lack oseous material of *C. eutropia* for direct measurements) is 0.87 ± 0.06. These values are statisticallly different ($p<0.01$), showing that in *A. dioptrica* these metacarpals are similar with MII being slightly longer, while in *C. commersonii* MIII is longer than MII. Metacarpal III is longer than MII in *P. obtusata*.

(b) There is a marked difference in the proportions of length of phalangeal bones in the two species, especially in digits II and III. In *A. dioptrica*, the metacarpal is over twice the length of its corresponding phalanx (FF) in both digits II and III (mean 2.4 ± 0.2, n=4 animals). In *C. commersonii* the metacarpal and its first phalanx of digit II are similar in length, while in digit III the metacarpal is only 50% larger than the phalanx (n=47 animals). Therefore, the ratio M/FF of digit II in *A. dioptrica* (2.4 ± 0.2) is twice that found in *C. commersonii* (1.1 ± 0.1), this difference being highly significant ($p< 0.001$) (Fig. 12).

In digit III, this relationship (M/FF) in *A. dioptrica* is 2.4 ± 0.2 while that of *C. commersonii* is 1.4 ± 0.1, also statistically different ($p<0.001$). In summary, in both digits the metacarpals in *A. dioptrica* are almost 2.5 times longer than the first phalanges, while this difference within each digit is less in *C. commersonii*. Although we cannot directly measure the bones of *P. obtusata*, the metacarpals are not twice the length of the first phalanx [= *Cephalorhynchus*] (Fig. 7).

(c) The epiphyses of the phalanges (including metacarpals) are slow in fusing in *C. commersonii* (de Buffrénil and Robineau, 1984; Robineau and de Buffrénil, 1985), and probably in *C. eutropia*, being quite visible even after all the vertebral epiphyses have fused. In all flippers of physically subadult specimens of *C. commersonii* examined (n=6), x-rays showed that epiphyseal fusion was only beginning in the first metacarpal, while other phalanges were as yet unfused. In

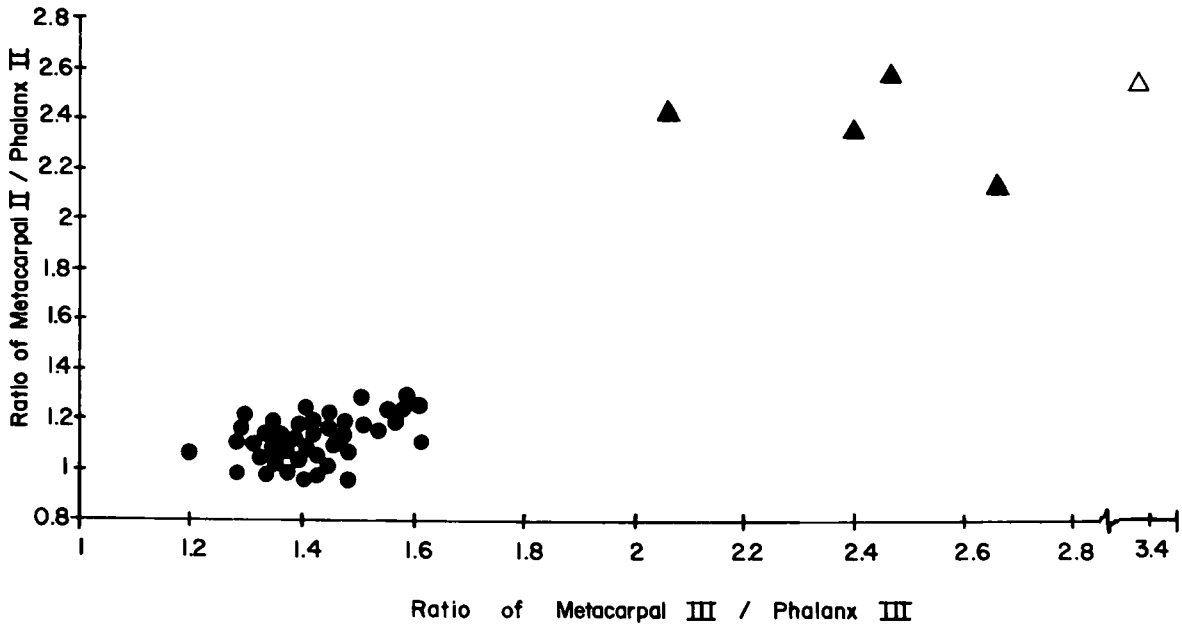

Fig. 12. Scatter plot showing the ratio of metacarpal (M) II/first phalanx (FF) II plotted on M III/FF III for *C. commersonii* (closed circles), *A. dioptrica* (closed triangles) and *P. spinipinnis* (open triangles).

30 physically mature adults examined, only one animal (age 11) had metacarpal and phalangeal epiphyses completely fused, while the others (including an 18 year old animal) were still in the process of fusion. In the two species of *Phocaena* examined, the phalangeal epiphyses are fused long before those of the vertebrae, showing no marked line of fusion. In this character, MNHN-S 604 falls in *Cephalorhynchus*; on the basis of phalangeal epiphyseal fusion, this animal would have been an adult.

Even after epiphyseal fusion is complete in *Cephalorhynchus*, the epiphysis remains visible, elevated and narrower than the body of the phalanx or metacarpal (Fig. 7). In *Phocoena*, as mentioned above, the epiphyses are not very noticable at any stage. The epiphyses of MNHN-S 604 are quite obvious.

DISCUSSION

We have no way of knowing if Philippi (1808–1904), one of the great natural historians of South America of the last century, who was aging and nearly blind in 1893, actually saw the specimen of *Phocaena obtusata* without the plaster or if the entire description came from an assistant. To what extent was the pigmentation pattern changed from the original during the painting of the skin (the plaster sheathing)?

The general distribution of the pigmentation on Philippi's drawing does most resemble that of *A. dioptrica*, and we believed, before going to Santiago, that the two were identical. The strange white marks on the side might, as Allen (1925) suggested, have been caused by folding of the skin. However, on folding a specimen, a dissimilar pattern would have been produced on the opposite side; the other side has never been mentioned in the literature. In our experience, some small cetaceans readily darken on exposure to air (*Orcinus orca*, *Globicephala melaena*). In *C. commersonii* the white areas become discolored,

gray and purplish, and the white areas evidently also darken in *C. hectori* (Mörzer-Bruyns and Baker, 1973) and in *C. eutropia* (Goodall, Norris *et al.*, 1988). However, in *A. dioptrica*, the white pigment remains startlingly white after a month or more on the beach. The only reason for white to extend upward would be due to mold.

Although the striking similarity in color between *P. obtusata* and *A. dioptrica* seems to have been the major feature in suggesting that they were conspecific, in view of the treatment of the specimen (loss of epidermis, burlap and plaster reinforcing, repainting) one must cast doubt on the accuracy of the original figure and description, and color pattern must be disregarded as a useful taxonomic character for this specimen.

It has been shown that MNHN-S 604 is not a specimen of *Australophocoena dioptrica* or *P. spinipinnis*. We tried, on the basis of a comparison of its exterior measurements with those of eight specimens of *C. eutropia* and 38 specimens of *C. commersonii*, which were physically either adult or subadult, to rule out the possibility that *P. obtusata* could belong to *C. commersonii*. However, due to the dried state of MNHN-S 604 (and Philippi's measurements) and the similarity in size of the two species of *Cephalorhynchus*, we could not reach clear conclusions. *C. commersonii* has yet to be found on the west coast of South America north of Isla Desolacion in the western Strait of Magellan (Goodall, Galeazzi *et al.*, 1988). *C. eutropia*, known from Cape Horn to Valparaíso, is the only likely species common at the collection site, Talcahuano.

Therefore, on the basis of measurements, shape of the dorsal fin, flipper and its bones, and taking into account the known distribution of the species involved, we conclude that Philippi's *P. obtusata* was actually a specimen of *Cephalorhynchus eutropia*, and that his name should be considered a junior synonym.

Similarities between phocoenids and *Cephalorhynchus* have been pointed out as far back as Flower (1883) and Beddard (1900) and are discussed by Goodall, Norris *et al.* (1988). We have tried to point out a few of the differences in the four species of these two genera from southern South America.

The striking color pattern of Commerson's dolphin should distinguish it at sea from any of the other species but our tracings of heads and dorsal fins show that these species would be very difficult to distinguish at any distance on the basis of shape (as seen in the water) alone, except for *P. spinipinnis* and the male of *A. dioptrica*.

All four species have poorly defined snouts, but the length of gape is much larger in *Cephalorhynchus*, being more than 75% of the distance from snout to eye.

The shape of flippers and flukes of the phocoenids and *Cephalorhynchus* species off southern South America are very different from each other, although more similar between species of the same genus. Flipper bones of *Cephalorhynchus*, especially the carpals, are flattened with angular edges and tightly spaced while those of the phocoenids are more rounded and separated. The first and second bones of the digits are more similar in length in the dolphins, while the first (metacarpal) is much longer than that of the second in *Cephalorhynchus*, while the reverse is true in the phocoenids.

Although there is still little information on South American species of

phocoenids a great deal of data are building up on *Cephalorhynchus*. Further research in the area should clarify many problems relating to these species.

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Heaviside's dolphin
Cephalorhynchus heavisidii

The External Appearance of Heaviside's Dolphin, *Cephalorhynchus heavisidii* (Gray, 1828)

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ABSTRACT

Previous original descriptions of the external appearance of Heaviside's dolphin are reviewed and compared with information from 18 animals collected at sea, stranded or recovered from incidental fishing mortalities. All previous descriptions are shown to be in error to various degrees, mainly because none of the earlier authors had access to a living or freshly dead specimen.

INTRODUCTION

Believed to be confined to the coastal waters off the west coast of southern Africa, Heaviside's dolphin *Cephalorhynchus heavisidii* (Gray, 1828) is one of the least known species of Cetacea. Very little has been published about its biology and behaviour, and the first published photographs of the whole animal only appeared in 1984 (Rice and Saayman, 1984).

This paper reviews published descriptions and provides new information on the external appearance of Heaviside's dolphin, based principally on observations and material collected since 1970.

MATERIAL AND METHODS

Although strandings have been monitored in South Africa since 1969, only six beach-cast examples of *C. heavisidii* have been examined, all but three of which were dehydrated and partly decomposed. Some material from fresh animals became available through incidental fishing mortalities, but the bulk of the information in this paper has come from 11 animals collected at sea as part of a programme to provide essential data on feeding habits and other biological information (Table 1). These animals were taken in a non-selective way from those that chose to ride the bow of the collecting vessel. Authority for their capture was provided in terms of the provisions of the Sea Fisheries Act, 1973 (permit issued to the author 3 March 1975).

Colour transparencies or black and white photographs (35mm) of each animal were taken as soon after death as possible (usually within 15 minutes). All fresh animals were measured according to the standardised methods proposed by

Norris (1961), with some additions from the form proposed by Mitchell (1975), using either steel or fibreglass tapes. All measurements made from the tip of the snout were taken as parallel to the body axis as possible. Entire casts were made of two animals (77/3 and 86/8) as a permanent record, and these are housed in the South African Museum (catalogue nos ZM 39125 and ZM 40532).

A sexually mature female was defined as one with at least one corpus luteum or corpus albicans in the ovaries, and a sexually mature male as one in which the seminiferous tubules were dilated and contained spermatozoa.

PREVIOUS WORK

Original descriptions of the external appearance of Heaviside's dolphin (i.e. based on personal examination of a specimen or an illustration of one) are provided by Gray (1828), Cuvier (1829, 1836), Rapp (1837), possibly Schlegel (1841), Pucheran (1856), Van Beneden (1873), Flower (1883) and Rice and Saayman (1984).

The type specimen of *Delphinus* (*Grampus*) *Heavisidii* described by Gray (1828) was a mounted skin from the Cape of Good Hope. When Flower (1883) described the same specimen, the colours mentioned by Gray were "no longer to be distinguished upon the specimen". At that time the skull remained concealed within the skin (Flower, 1883), but at some time before 1922 (when Harmer described and illustrated the skull of the type specimen for the first time) the skin was obviously dissected to remove the skull. The present whereabouts of the skin (if it still exists) are unknown (M.C. Sheldrick, *in litt.* 15 December 1983).

In 1829 Cuvier described a second specimen of *C. heavisidii* (under the name "Marsouin du Cap"), which he later attributed to a new species *Delphinus cephalorhynchus* (Cuvier, 1836). This specimen was collected by J.J. Dussumier in the vicinity of the Cape of Good Hope, and a recently– discovered sketch [by Dussumier, according to Arvy, 1972, although Dr Daniel Robineau (*in litt.* 21 December 1983) contests this] seems to have been the basis for Cuvier's figure of the "Marsouin du Cap".

A stuffed skin of Heaviside's dolphin (Fig. 1a, b) is presently lodged in the Muséum National d'Histoire Naturelle, Paris (cat. no. 26, Galerie de Zoologie). According to Dr Daniel Robineau (*in litt.* 21 December, 1983), this is probably the type of the "Marsouin du Cap", for the following reasons:

(1) it much resembles the figure given by F. Cuvier in 1829;

(2) it carries a label that indicates it as the type;

(3) Dussumier's manuscripts (which Dr Robineau has consulted) show that a "Marsouin du Cap" from the Cape of Good Hope (a whole animal in brine) was definitely donated to the Museum in November 1827; and

(4) Pucheran (1856) mentions and gives some measurements of the same specimen.

In October 1969 I measured this skin, and obtained an overall length (tip of snout to notch in flukes) of 5 feet 2 inches (1.57m). This is somewhat greater than Cuvier's 1829 measurement of the total length as nearly four feet (1 French foot = 32.5cm), but then his measurement is clearly an approximation. Pucheran (1856) gave the length of Dussumier's type as 1.612m, which is much

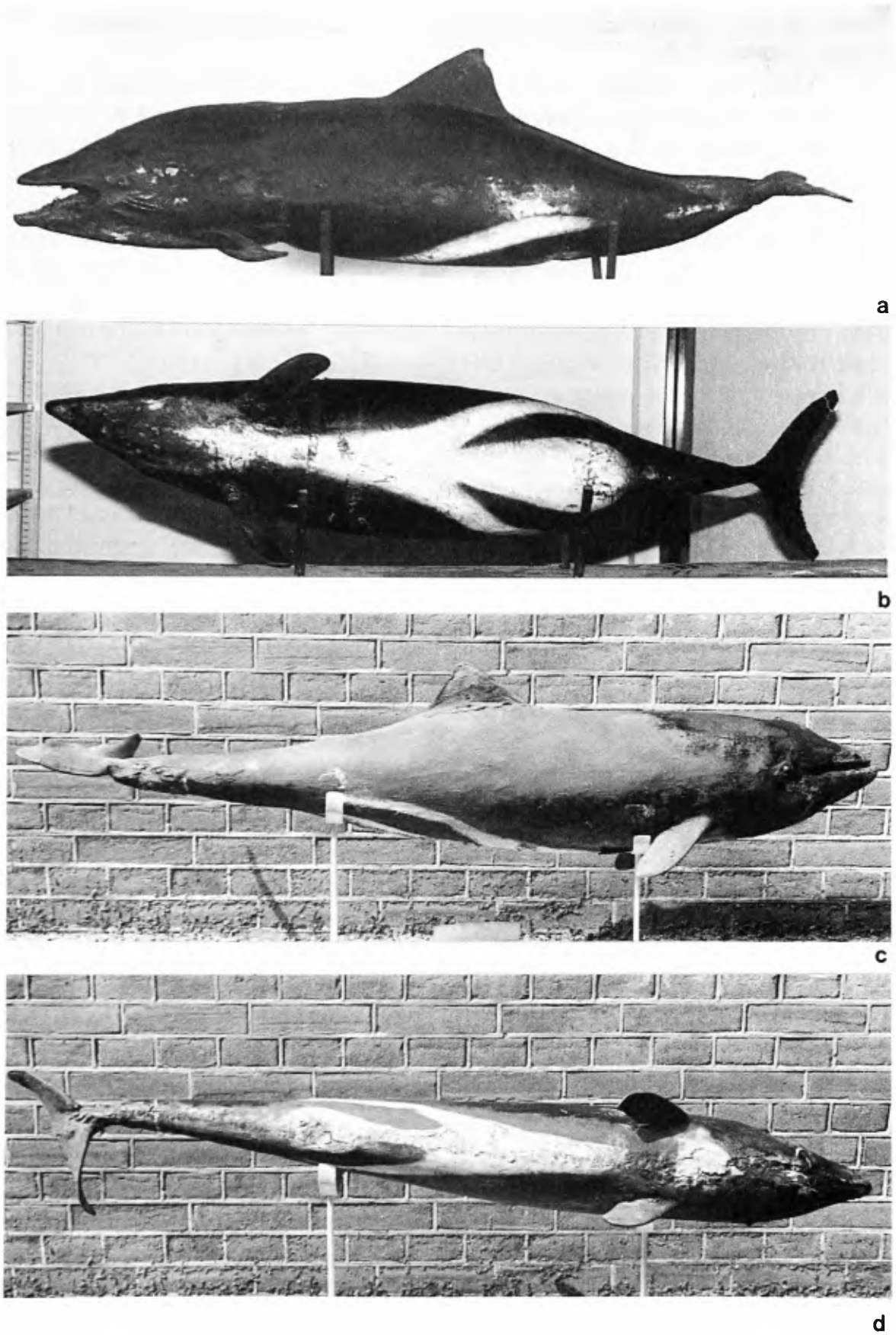

Fig. 1. Mounted skins of *C. heavisidii*; (a) lateral, (b) ventral views of Paris Museum no. 26, (c) lateral, (d) ventral views of Leiden Museum no. 24761.

nearer to my measurement, although Pucheran apparently measured the animal over the curve.

In 1836 Cuvier founded a new species (*Delphinus hastatus*) based on two descriptions with accompanying figures. The first of these was by J.R.C. Quoy, a naturalist on the Dumont d'Urville expedition of 1826 – 29 aboard *L'Astrolabe*. Quoy's previously unpublished description was of a prepared skin he found at the Cape of Good Hope "chez M. Verreaux" (presumably the taxidermist and naturalist Jules Verreaux – Arvy, 1977). The second description upon which *D. hastatus* was founded was Gray's (1828) description of the type of *D. heavisidii*. Although Cuvier (1836) published no figures of *D. hastatus*, a water colour by Quoy of the "hastate dolphin" from the Cape of Good Hope has been recently discovered in the Muséum d'Histoire Naturelle, Paris (Arvy, 1977), and this is presumably the figure referred to in Cuvier's description of the species. The fate of the specimen sketched by Quoy is unknown; there are no mounted skins of Heaviside's dolphin at present in South Africa. Gray (1846, 1850, 1866) stated that Quoy's description and figure were actually based on the type specimen of *D. heavisidii*, but the measurements given by Gray (1828) and Cuvier (1836) are not in good agreement. The total length, for instance, is given as 46 inches (1.17m) by Gray and five (French) feet two inches (*ca.* 1.86m) by Cuvier. I assume therefore that two different animals were involved.

A further specimen of Heaviside's dolphin was described and illustrated by Rapp (1837). This was apparently obtained from a Mr von Ludwig at the Cape, and when described was housed in the Royal Natural History Cabinet at Stuttgart. Rapp attributed the specimen to *D. hastatus*. The Staatliches Museum für Naturkunde, Stuttgart, no longer has any material pertaining to *C. heavisidii* (F. Dieterlen, *in litt.* 25 January 1985).

The brief description of the colour pattern of the species given by Schlegel (1841) may refer (at least in part) to a stuffed skin currently in the Leiden Museum, the skull from which was apparently illustrated by Schlegel (Fig. 1c, d). This specimen (catalogue no. 24761) was collected by Van Horstok at the Cape between 1825 and 1835 (Broekema, 1983). The mounted animal measures 1.33m from the tip of the snout to the notch in the flukes (J. W. Broekema, *in litt.* 13 August 1982).

Van Beneden (1873) published a drawing of a female dolphin at Cape Town made by Count Castelnau in September 1856, and attributed it to *Orca capensis* Gray (with *D. heavisidii* and *D. hastatus* as synonyms). This sketch (and Van Beneden's description of it) clearly show that the animal was a Heaviside's dolphin. No material is known to exist from this specimen.

In 1883 Flower listed a few measurements of the dorsal fin of the type specimen and repeated Gray's (1828) description of the coloration.

Rice and Saayman (1984) gave a brief description of the external appearance of *C. heavisidii*, apparently based on observers' descriptions and photographs of animals at sea, and included the first photographs of the species.

Table 1

Details of fresh specimens of *C. heavisidii* examined.

Field/ Cat. no.	Date collected	How obtained	Length (m)	Sex	Weight (kg)	Position	
SAM 19943	22.06.56	Collected	1.68	Male	-	Off Sea Point	
70/13	4.12.70	Collected	1.59	Female	62.6	33°48'S	18°26'E
77/3	17.03.77	Collected	1.59	Male	62.6	25°42.2'S	14°47.6'E
77/7	18.10.77	Collected	1.68	Female	64.4	23°00.8'S	14°22'E
77/8	20.10.77	Collected	1.61	Female	74.4	22°40.2'S	14°29.4'E
77/15[1]	6.11.77	Incidental	1.645	Female	(53.5)[2]	17°09'S	11°24'E
77/16[1]	6.11.77	Incidental	1.225	Male	(26.0)[2]	17°09'S	11°24'E
78/38	1.09.78	Collected	1.69	Male	70.8	26°38.5'S	15°04.5'E
79/10	16.03.79	Collected	1.574	Male	56.0	21°15'S	13°38.7'E
79/13	29.04.79	Incidental	1.66	Female	69.0	Within 50 n.miles of Walvis Bay	
80/17	24.08.80	Collected	1.66	Female	68.0	29°08'S	16°45.9'E
82/19	28.08.82	Collected	1.58	Female	52.5	30°51.6'S	17°33.2'E
84/8	26.02.84	Collected	1.47	Male	51.0	32°50.4'S	17°44.6'E
84/9	26.02.84	Collected	1.555	Male	56.0	32°44.7'S	17°45.5'E
84/30	29.09.84	Collected	1.56	Male	59.0	30°25'S	17°18'E
85/7	9.04.85	Stranded	1.183	Female	26.9	32°20.6'S	18°19.1'E
85/15	19.07.85	Stranded	1.51	Male	43.9	34°02.8'S	18°21.6'E
86/8	18.01.86	Stranded	0.847	Male	9.5	32°05.5'S	18°18.2'E

[1]Date and position of capture uncertain.
[2]Eviscerated weight.

MORPHOMETRICS

Size

The 18 animals in this study for which accurate measurements are known ranged from 0.847 to 1.69m in total length (Table 1). A further three beach-cast males examined (that were fairly dehydrated and decomposed) measured 1.56, 1.65 and 1.74m. Examination of epiphyseal fusion in the vertebral column indicated that the two largest males examined (1.74 and 1.69m long) were physically mature, whereas all males 1.59m or less were immature. No physically mature female was examined, while three females 1.66 to 1.68m in length were immature. This suggests that both sexes may reach full size at about 1.68 – 1.70m: the sample is too small, however, to determine whether there is any sexual dimorphism in size.

Earlier measurements usually indicated a somewhat smaller size (nearly four feet – Cuvier, 1829; 5 feet 2 inches – Cuvier, 1836; 46 inches – Gray, 1828; 4 feet 4 inches – Rapp, 1837). Some of these may have been juvenile examples, while others may have been measured as prepared skins after some shrinkage had taken place. Presumably on the basis of these statements, recent general accounts have underestimated the length of the species (average 1.2m, maximum about 1.4m – Watson, 1981; average adult length about 1.2 to 1.4m – Leatherwood and Reeves, 1983; "reach a total length of about 1.3m" – Smithers, 1983).

The smallest animal examined (86/8) was the only one with an unhealed umbilicus, and was presumably newborn.

Seventeen *C. heavisidii* have been weighed, 15 whole and two after evisceration

(Table 1). Those weighed whole ranged from 9.5 to 74.4 kg, with a length/weight relationship

$$W = 15.68L^{2.89}$$

where W = weight in kg and L = total length in m.

Twelve animals were also weighed piecemeal. Viscera accounted for an average 14.3% of the total body weight, so the total weights of the two eviscerated animals can be estimated as eviscerated weight/0.857. If the estimated weights of these two animals are included, the length/weight relationship for all 17 animals becomes

$$W = 15.95L^{2.85}$$

This second equation could be considered a more satisfactory representation of the length/weight relationship, as it is based on a slightly larger sample.

Watson (1981) gives an average weight for *C. heavisidii* of 40kg with a possible maximum of 55kg, but as there are no previously published weights for this species these can only be estimates.

Body proportions

There are only three sets of external measurements published for *C. heavisidii* that appear to have been recorded with reasonable accuracy, those of Gray (1828), Cuvier (1836 – *D. hastatus*), and Pucheran (1856). Data are presented in Table 2 for a further 16 animals measured while still fresh.

Heaviside's dolphin is a strongly built animal (Gray, 1828; Van Beneden, 1873), its maximum girth (usually at or a short distance in front of the anterior insertion of the dorsal fin) ranging from 57.9 to 68.2% of body length, with a mean of 62.5%. Gray (1828) gave a maximum girth of 62% of body length for the type specimen.

The head is cone–shaped and in profile the melon slopes down gradually to the tip of the snout (Fig. 2). Although the species therefore cannot be said to have a "beak", the border between rostrum and melon is demarcated on either side of the head by a groove that runs from the angle of the gape towards the snout, stopping just short of the apex of the melon. The distance from the anterior end of this groove to the tip of the snout could therefore be interpreted as a "beak", as reflected in the measurement tip of snout to apex of melon (Table 2). This varies from 0.5 to 2.0% of the body length (mean 1.1%). The lower jaw invariably projects beyond the tip of the snout, to an extent ranging from 0.2 to 0.8% of the body length (mean 0.5%), as noted by Cuvier (1829, 1836 – *D. cephalorhynchus*) and Van Beneden (1873), whereas in *D. hastatus*, upper and lower jaws are described as being of equal length (Cuvier, 1836).

The eye is small and situated on average 12.3% (range 10.5–14.5%) of the body length from the tip of the snout, just above and behind the angle of the gape. According to Cuvier, the mouth runs back to underneath the eye (1829) or the corner of the mouth closely approaches the eye (1836 – *D. cephalorhynchus*). The blowhole is at about the same or slightly behind the level of the eye (11.2–15.2% of body length, mean 12.6%), while Cuvier (1829, 1836 – *D. cephalorhynchus*) describes it as behind the eye or a little behind the eye,

Table 2

Body measurements of *C. heavisidii*. ToS = Tip of snout, CoE = Centre of eye.

Field no.	70/13	77/3	77/7	77/8	77/15	77/16	78/38	79/10	79/13	80/17	82/19	84/8	84/9	84/30	85/7	86/8
1. Total length (cm)	159	159	168	161	164.5	122.5	169	157.4	166	166	158	147	155.5	156	118.3	84.7
Sex	F	M	F	F	F	M	M	M	F	F	F	M	M	M	F	M
2. ToS to centre of anus (%)	75.3	70.8	69.9	72.7	72.3	68.2	74.0	70.5	69.3	69.3	70.9	71.1	70.4	71.8	68.5	67.5
3. ToS to centre of genital aperture	70.5	56.6	66.4	70.2	69.0	59.6	62.7	61.9	67.5	67.2	68.4	63.3	61.7	61.5	66.5	60.8
4. ToS to tip of dorsal fin	59.2	56.0	55.1	58.7	57.8	54.8	54.4	53.7	57.2	59.0	57.0	55.8	54.1	-	58.2	58.6
5. ToS to ant.ins. dorsal fin	45.6	44.7	43.2	44.7	45.0	44.5	42.9	43.2	45.2	45.8	45.6	43.9	42.8	45.5	46.7	48.1
6. ToS to centre of umbilicus	49.4	46.2	46.4	49.1	-	46.1	47.9	47.0	47.3	44.9	46.8	48.4	47.6	48.1	47.9	48.6
7. ToS to ant. ins. flipper	21.9	20.8	21.8	20.8	23.4	22.9	20.7	21.6	19.6	21.7	21.5	22.9	21.2	21.5	23.7	23.3
8. ToS to ext. auditory meatus	16.7	13.8	15.9	14.3	16.7	-	16.6	15.8	13.9	16.0	14.6	17.0	15.4	15.1	18.1	-
9. ToS to angle of gape	11.2	9.7	10.5	10.8	10.1	10.8	11.2	10.9	8.6	10.1	9.5	11.2	10.6	9.9	11.7	12.8
10. ToS to centre of eye	13.3	10.7	12.2	12.1	11.6	11.8	13.0	12.5	10.5	11.6	11.1	13.2	12.5	11.2	14.5	14.4
11. ToS to centre of blowhole	13.9	11.6	12.4	13.0	11.2	11.9	13.3	12.1	11.4	13.3	12.0	12.9	11.6	13.1	15.2	13.3
12. ToS to apex of melon	2.0	-	0.7	1.2	0.6	0.8	1.1	0.5	0.9	-	1.8	1.2	1.0	1.3	1.3	1.3
13. Girth, at axilla	55.8	58.2	53.9	63.4	-	-	53.3	52.6	55.9	56.0	53.2	57.1	56.8	57.4	64.9	59.5
14. Girth, maximum	62.9	62.9	59.5	70.8	-	-	60.4	58.1	64.5	62.5	57.9	61.9	61.1	62.2	68.2	62.3
15. Girth, at anus	33.9	38.4	33.3	37.3	34.0	33.9	36.4	34.4	35.8	35.7	33.2	36.7	35.6	37.2	37.1	34.8
16. Girth } midway anus	-	20.4	16.7	18.8	17.0	18.0	17.8	17.3	-	18.1	16.5	18.4	18.9	19.6	19.2	21.8
17. Height } to fluke notch	-	9.1	11.8	8.7	7.9	7.8	7.9	8.1	7.1	7.8	7.6	8.5	8.1	8.7	8.6	9.3
18. Projection lower jaw beyond upper	0.4	0.4	0.5	0.7	0.2	-	0.5	0.3	0.3	0.5	0.3	0.7	0.8	0.4	0.4	0.4
19. CoE to ext. auditory meatus	3.8	3.6	3.9	4.0	5.5	-	5.4	3.8	3.4	4.0	3.9	4.1	3.8	3.8	4.1	-
20. CoE to angle of gape	2.4	2.6	2.4	2.2	2.6	3.2	2.4	2.0	2.7	2.8	2.5	2.8	2.9	2.6	3.2	3.1
21. CoE to centre of blowhole	10.4	10.7	9.5	10.1	9.5	10.9	9.2	9.5	10.4	-[3]	9.9	10.9	10.0	10.6	12.0	12.6
22. Blowhole, width	1.6	1.4	1.5	1.7	1.7	2.0	1.8	1.6	1.6	1.6	1.7	1.6	1.7	1.7	1.9	2.6
23. Blowhole, length	0.8	0.7	0.8	1.1	1.0	1.0	0.9	1.1	0.9	0.7	0.8	0.7	0.8	1.1	0.9	1.3
24. Eye, height	-	0.6	0.5	0.6	0.4	0.7	0.6	0.7	0.6	0.5	0.6	0.5	0.6	0.7	0.4	0.2
25. Eye, length	1.0	1.0	1.1	1.2	0.9	1.1	-	1.1	1.1	1.0	1.1	1.0	1.0	0.6	1.2	1.8
26. Mammary slits, length L	1.6	-	1.8	1.6	1.0	-	-	-	1.1	0.7	1.5	-	-	-	-	-
R	1.6	-	1.8	1.6	1.2	-	-	-	1.2	0.6	1.6	-	-	-	0.8	-
27. Genital slit, length	8.0	6.3	6.0	7.8	-	4.2	9.4	6.2	5.5 }	7.2	8.4	5.8	6.3	6.8 }	6.8	8.4
28. Anal slit, length	0.8	1.8	0.5	0.6	-	1.5	3.3	1.2	0.4 }			3.3	3.5	3.8 }		3.8
29. Flipper } ant. ins. to tip L	14.3[1]	-	13.9	14.0[1]	12.7[1]	-	13.3[1]	14.3[1]	13.8[1]	14.2[1]	13.3	-	14.7	-	15.1	17.8
length } R		14.5	-	-	-	-	-	-	-	-	13.8	15.0	14.8	15.0	15.9	17.7
30. Flipper } axilla to tip L	10.2[1]	-	10.7	10.8[1]	9.8[1]	-	9.5[1]	10.4[1]	10.4[1]	10.5[1]	9.5	-	10.6	-	11.1	12.8
length } R		11.2	-	-	-	-	-	-	-	-	9.9	11.6	10.4	11.0	11.4	12.5
31. Flipper, maximum width L	5.4[1]	-	5.4	5.8[1]	4.9[1]	5.4[1]	5.4[1]	5.6[1]	4.8[1]	5.7[1]	5.1	-	5.9	-	5.8	7.2
R		6.2	-	-	-	-	-	-	-	-	5.1	6.0	5.8	5.5	6.0	7.0
32. Dorsal fin, height	9.8	-[3]	9.9	10.3	8.6	7.7	8.9	8.4	8.0	9.2	8.9	8.7	9.8	-	8.8	8.5
33. Dorsal fin, length of base	15.1	15.7	18.5	22.4	16.4	17.6	17.5	17.2	16.1	18.1	18.4	17.7	19.0	17.9	17.7	18.9
34. Flukes, width tip to tip	27.1	28.9	27.4	28.6	29.5	-	25.1	26.6	24.7[2]	25.6	24.7	26.9	29.3	26.9	25.1	26.0
35. Flukes, ant. border to notch	7.2	7.0	7.3	7.5	7.3	7.2	7.3	7.2	7.4	6.7	7.3	7.3	7.3	6.7	6.8	8.3
36. Flukes, depth of notch	1.8	1.9	1.8	1.9	2.2	2.0	1.7	1.9	1.7	1.8	2.2	2.0	2.3	1.9	1.9	2.1
Erupted teeth																
37. Number of maxillary L	24	26	28	26	-	26	25	24	25	28	23	25	26	27	24	0
R	22[4]	22	27	26	-	25	25	24	26	28	24	25	24	27	24	0
38. Number of mandibular L	24	26	28	25	-	24	22	24	24	27	26	23	24	26	25	0
R	23	26	28	24	-	24	25	24	23	27	26	24	23	26	25	0

[1]Side unknown. [2]Measured on one side and doubled. [3]Obvious recording error. [4]Allowing for one missing tooth.

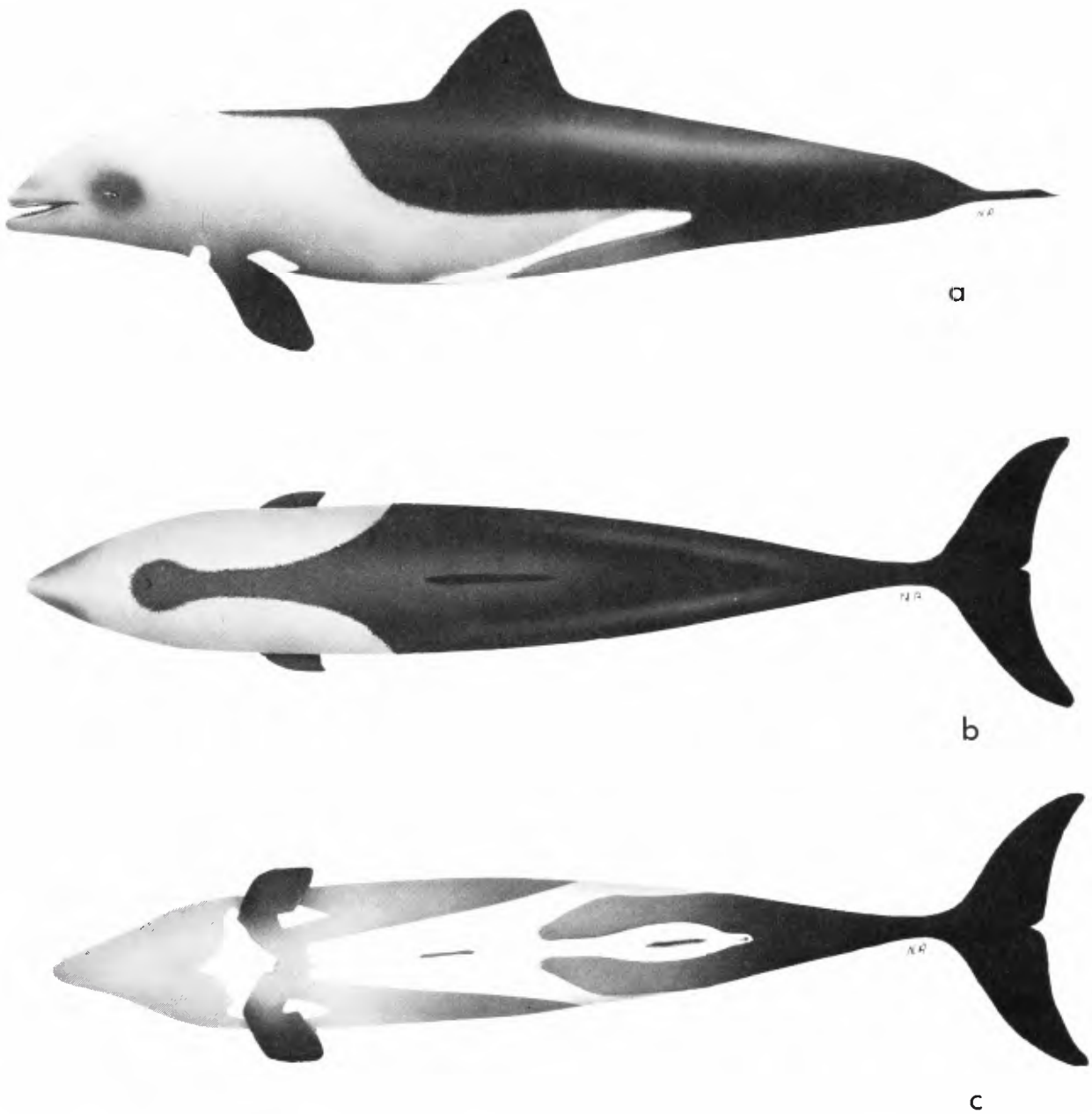

Fig. 2. Sketches of a male *C. heavisidii* in (a) lateral, (b) dorsal and (c) ventral view.

respectively. Pucheran (1856) gives the distance from the tip of the snout to the blowhole as 12.2% of the body length.

The flippers are small, ranging in length from anterior insertion to tip from 12.7 to 17.8% of the body length (mean 14.6%). This compares to published values of 14.1% (Gray, 1828), 14.5% (Pucheran, 1856) and 16.1% (Cuvier, 1836 – *D. hastatus*). Their shape is characteristically blunt, with the leading and trailing edges almost parallel for most of their length, but with the leading edge curving strongly back at the extremity (Fig. 3). Cuvier (1829) describes them as rounded at their free extremity but with a straight posterior edge. They are not oval in shape, as stated by Rice and Saayman (1984), although they were described as "rather ovate than falcate" by Flower (1883). The maximum width of the flippers is 4.8 to 7.2% (mean 5.7%) of body length. The distance from the tip of the snout to the anterior insertion of the flippers averages 21.8% (range

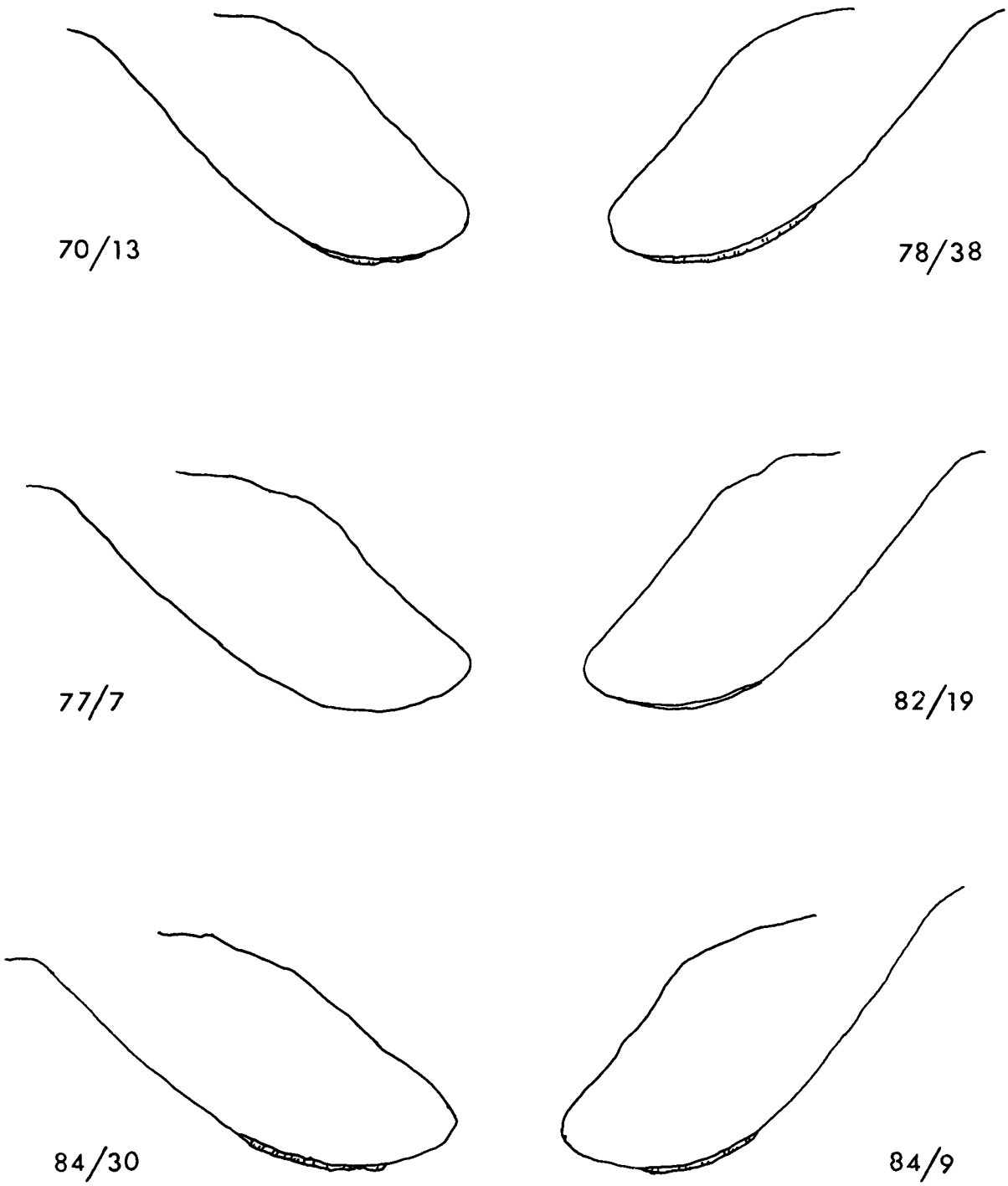

Fig. 3. Flipper shape in six *C. heavisidii*, traced from photographs. Outer aspect of left flippers on left, right flippers on right.

19.6–23.7%) of body length: published values are 21% (*D. hastatus* – Cuvier, 1836), 22.8% (Pucheran, 1856) or (for "tip of the nose to the pectoral fin") 26.1% (Gray, 1828).

A peculiarity noticed in 10 of the 16 *C. heavisidii* examined for one or (more usually) both flippers to have irregular serrations along their leading edge, located along the region of maximum curvature near the tip (Fig. 4). These serrations closely resemble imperfections found at mould joints after casting, projecting outward from the edge of the flipper. At their maximum development

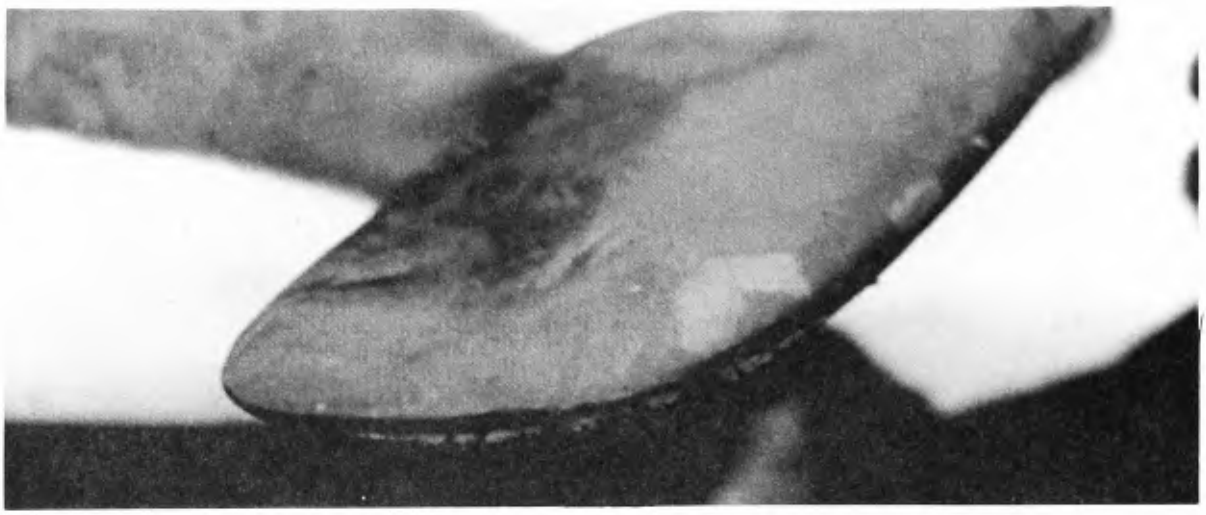

Fig. 4. Right flipper of male *C. heavisidii* (77/3), showing serrations along leading edge.

they cover the whole of the curved portion of the tip of the flipper, and project up to 5mm from the leading edge. They were never found on the trailing edge of the flipper. Such serrations were recorded in six out of eight males examined (the exceptions being a calf and a juvenile), and in four of the eight females (Table 3). In two of the four females, however, the structures were barely visible, forming only a slightly projecting ridge with few if any actual serrations. There may therefore be differences in the incidence and development of serrations between sexes and with age.

Table 3

Incidence of flipper serrations in *C. heavisidii*. – = either not specifically recorded or photograph unavailable.

Field no.	Sex	Sexual maturity	Presence/absence serrations		Field no.	Sex	Sexual maturity	Presence/absence serrations	
			Left	Right				Left	Right
70/13	Female	Mature	Present	–	77/16	Male	Immature	Absent	Absent
77/7	Female	Mature	Absent	Absent	78/38	Male	Mature	Present	Present
77/8	Female	Mature	Absent	Absent	77/3	Male	Mature	Present	Present
77/15	Female	Mature	Present[1]	Present[1]	79/10	Male	Mature	Present	Present
79/13	Female	Mature	Present	Present	84/8	Male	Immature	Present	Present
80/17	Female	Mature	–	–	84/9	Male	Immature	Present	Present
82/19	Female	Immature	Present[1]	Present[1]	84/30	Male	Mature	Present	Present
85/7	Female	Immature	Absent	Absent	86/8	Male	Immature	Absent	Absent

[1]Present as trace only.

The causation and function of these serrations are unknown, but their position on the flipper corresponds with that portion that would seem most likely to make contact with other objects when the flipper is extended. On none of the animals examined was there any external sign of associated scar tissue, as might be expected if the serrations arose because of contact with the substrate. If the structures are of natural origin, their location might indicate an importance in tactile communication between individuals. Extensive contact with flippers (and other parts of the body) during affiliative, play or precopulatory behaviour is

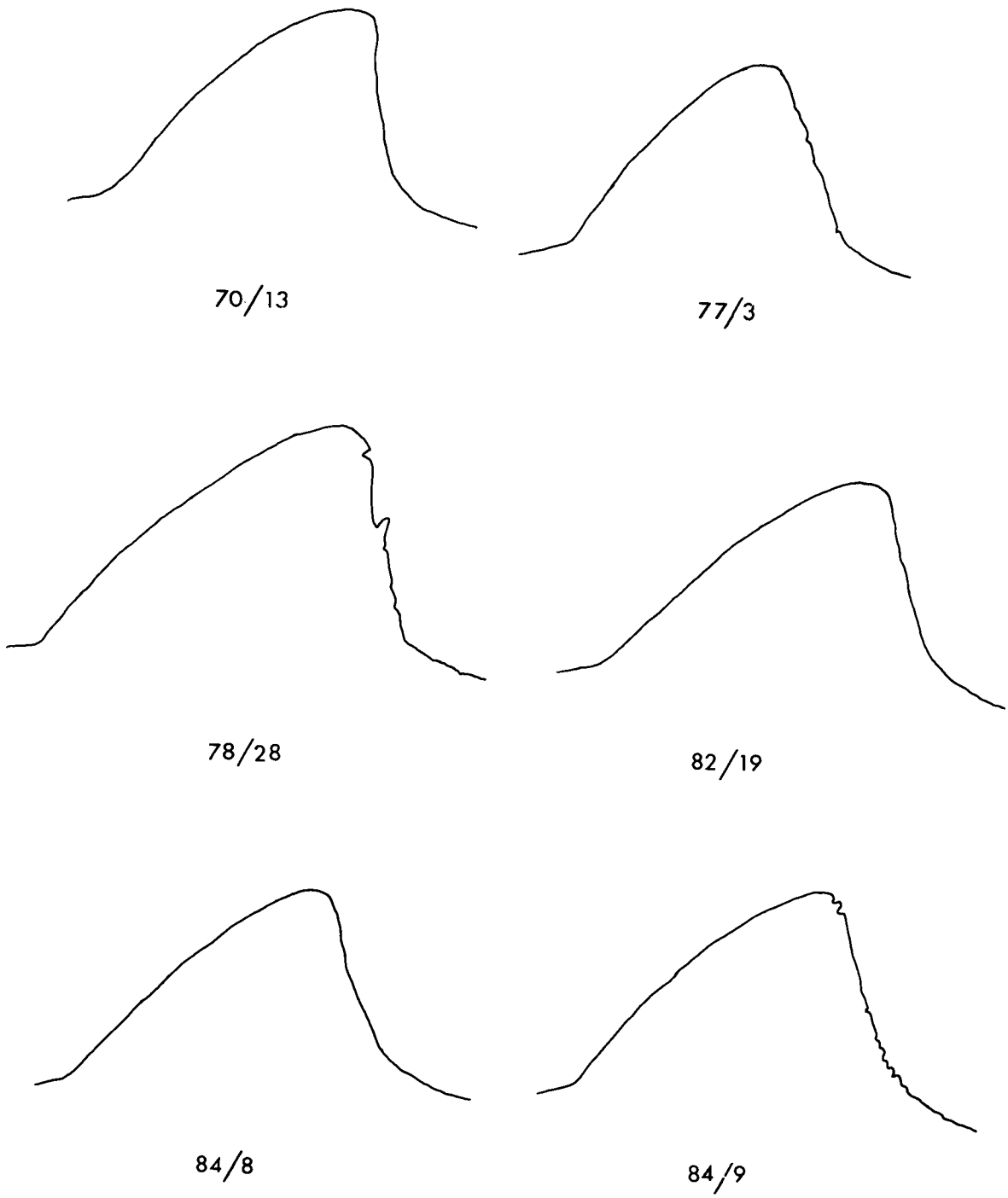

Fig. 5. Dorsal fin shape in six *C. heavisidii*, traced from photographs. Left side shown.

common among captive (and has been seen in wild) dolphins (Herman and Tavolga, 1980). [Also see discussion by Goodall, Galeazzi, Sobral and Cameron, 1988.]

The dorsal fin is also characteristic in shape, being roughly triangular with the leading edge longer than the trailing edge, so that the tip lies nearer the posterior insertion of the dorsal fin than the anterior insertion. The leading edge is also slightly convex, whereas the trailing edge is straight or very slightly concave and is subject to nicks and other damage (Fig. 5). Excluding one animal (84/30) in which the dorsal fin had been extensively damaged and the remnant was at its maximum only 8.5cm high, the dorsal fin averages 9% of the body

length (range 7.7 – 10.3%) in height. This compares with values of 7.6% for the type specimen (Gray, 1828) and 7.7% for the "Marsouin du Cap" (Pucheran, 1856), but these measurements were made on mounted skins in which the dorsal fin may have shrunk during preparation.

The shape of the dorsal fin is described as triangular by Gray (1828), large and triangular, low by Cuvier (1836 – *D. hastatus*), low by Van Beneden (1873), low and triangular (Flower, 1883) and "triangular" by Rice and Saayman (1984), and figured as triangular by Gray (1828), Cuvier (1829), Rapp (1837) and Van Beneden (1873). The figure of the hastate dolphin reproduced by Arvy (1977) and attributed to Quoy shows a somewhat recurved fin, despite the description given by Cuvier (1836).

The dorsal fin is situated about (or slightly behind – Cuvier, 1829) the middle of the body, its anterior insertion being on average 44.8% from the tip of the snout (range 42.8 – 48.1%) and its tip on average 56.6% from the tip of the snout (range 53.7–59.2%). In his description of *D. hastatus*, Cuvier (1836) gives the distance from the tip of the snout to the anterior insertion of the dorsal fin as 46.8% of the body length, while Gray (1828) and Pucheran (1856) list the dorsal fin (exact point unspecified) as 47.8% and 46.7% respectively from the tip of the snout. Pucheran also gives the distance from the posterior insertion of the dorsal fin to the notch in the flukes as 36.4% of the body length.

As in other cetaceans, while the anus is in a similar position in both sexes (average distance from the tip of the snout 70.5% in males and 71.0% in females), the genital aperture is situated further forward in males (range 56.6–63.3%, average 61%) than in females (range 66.4–70.5%, average 68.2% of the body length). The latter is the only measurement in which sexual dimorphism is apparent, although only a limited number of animals have been examined.

The tail is crescent – shaped in outline, with the trailing edge forming an almost perfect curve, broken only by the notch between the flukes and an occasional incidental nick (Fig. 6), described in *D. hastatus* as large, well scooped – out, and a little pointed at the extremity of the two lobes (Cuvier, 1836). The span of the flukes averages 26.8% of the total length of the animal (range 24.7 – 29.5%), while in the type specimen Gray (1828) gives this measurement as 23.9%, Cuvier (in his 1836 description of *D. hastatus*) as 24.2%, and Pucheran (1856) as 22.8% (measured above the notch) of the body length. As all of the latter measurements seem to have been made on mounted skins, the smaller apparent span of the flukes may represent shrinkage during preparation.

TEETH

Above the gum the teeth of *C. heavisidii* are similar to those of other small delphinids in shape, being small and conically pointed with a maximum diameter (at gum level) of 2 – 3mm. According to Schlegel (1841) the teeth are shorter, stronger curved inwardly, and considerably less sharp than in other delphinids, ending in conical, more or less blunted points. Excluding the newborn animal, the total number of erupted teeth in 14 specimens examined ranged from 93 to 111 with a mean of 100.1 (Table 2). Values for each teeth row ranged from 22 to 28 (mean 25.2) for maxillary teeth and 22 to 28 (mean 24.9) for mandibular

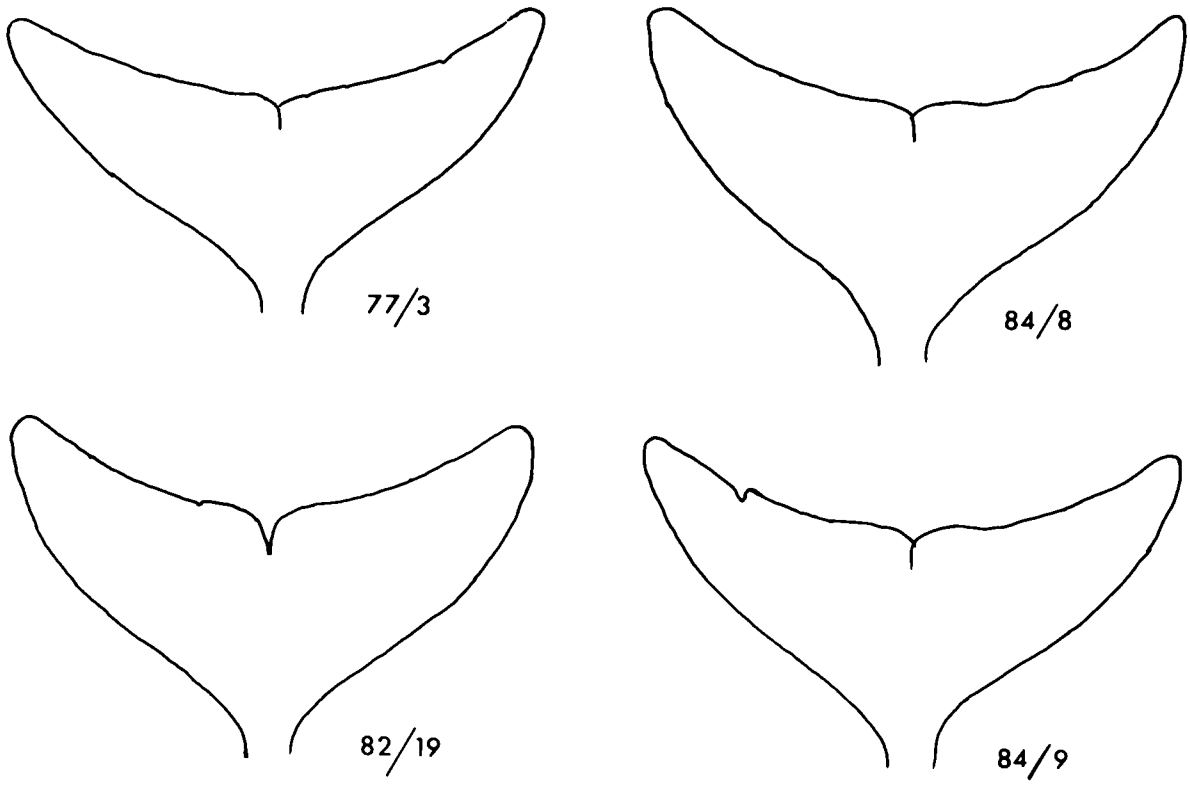

Fig. 6. Shape of tail flukes in four *C. heavisidii*, traced from photographs. Dorsal aspect.

teeth. Published tooth counts (for what are apparently erupted teeth, being based on descriptions of mounted skins or whole animals) are as follows:

Gray (1828)	25–26 for maxillary and mandibular
Cuvier (1829)	26 each side maxillary
	23 each side mandibular
Cuvier (1836)	26 maxillary } *D. hastatus*
	25 mandibular } *D. hastatus*
Rapp (1837)	27 each side maxillary
	25 each side mandibular
Van Beneden (1873)	23 maxillary
	24 mandibular

The latter counts (given on the original sketch by Castelnau) seem to have been misinterpreted by Van Beneden as referring to the entire upper and lower jaws respectively, so that he gives the counts for each tooth-row as 11 above and 12 below, thus supporting his classification of the specimen as an *Orca* species. If Van Beneden's interpretation is ignored, all the published values fall within the range of tooth counts in Table 2.

PIGMENTATION

Juvenile and adult

Basically *C. heavisidii* is a dark blue-black above with a grey "cape" over the head and thoracic region, a light grey flank blaze and with four well-defined unpigmented areas ventrally (Fig. 7).

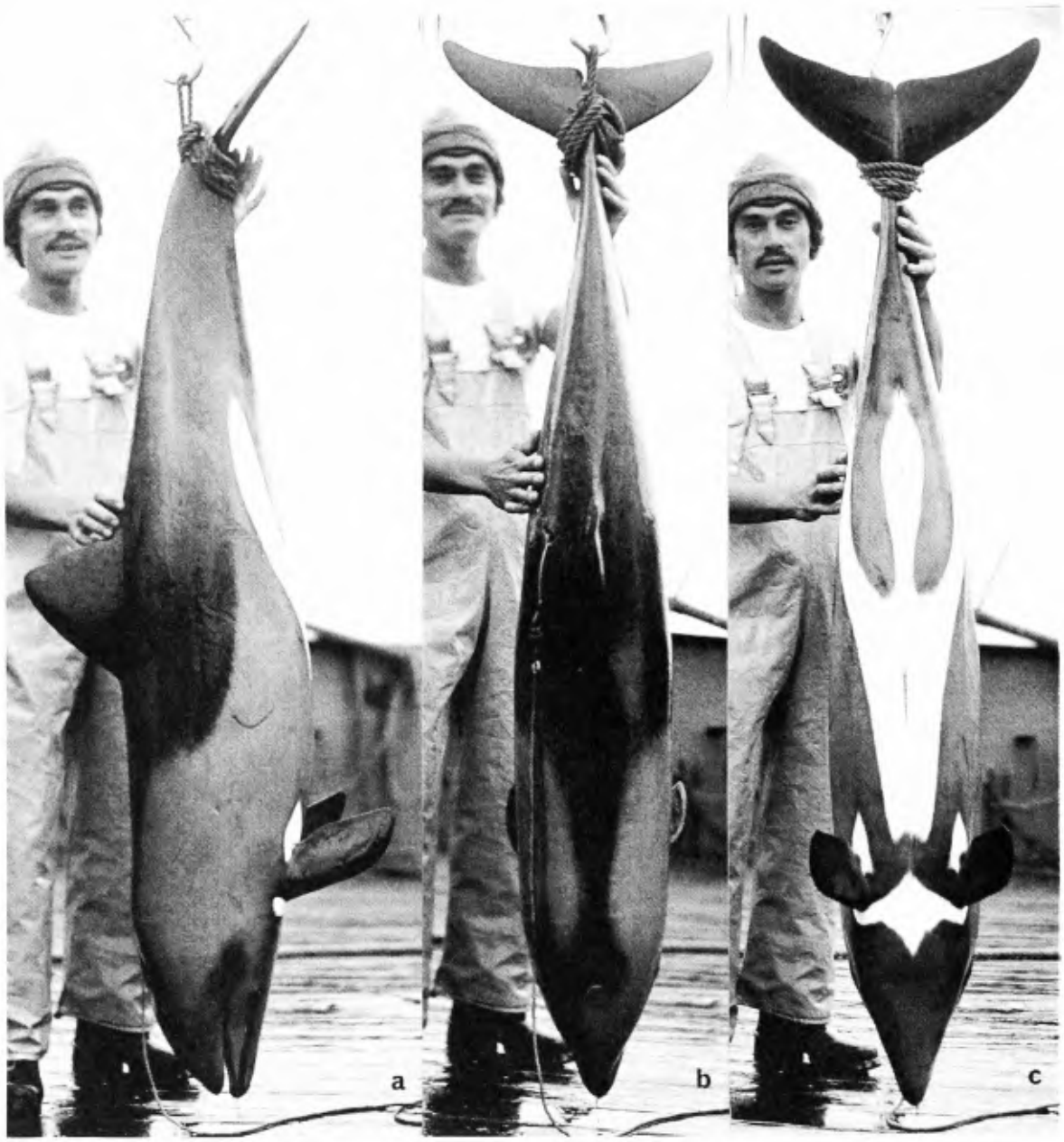

Fig. 7. (a) Lateral (b) dorsal, and (c) ventral views of *C. heavisidii*, (79/10).

The grey cape starts on the melon, which it covers almost entirely apart from a roughly circular area round the blowhole and a roughly elliptical area round the eye, both of which are dark blue–black in colour. The area round the blowhole is continuous with a narrow isthmus of dark pigment mid–dorsally that connects with the blue–black colour of the posterior half of the dorsal surface of the body. This isthmus separates the grey cape of left and right sides of the body. As it progresses posteriorly it broadens, particularly from about halfway between the flipper insertion and the dorsal fin, where it spreads out and down the sides of the animal, so that the grey cape ceases about the level of the posterior insertion of the dorsal fin. The grey cape covers the rest of the head, thorax and (apart from the non–pigmented areas) the belly anterior to the anus, darkening somewhat as it passes ventrally.

This grey cape was not mentioned in the descriptions of the species by Gray (1828), Cuvier (1829), Cuvier (1836 – *D. cephalorhynchus*), Rapp (1837),

Schlegel (1841), Van Beneden (1873), or Rice and Saayman (1984). In his description of *D. hastatus*, however, Cuvier (1836) mentions that the rest of the body (apart from the white areas ventrally) is black, except for the head, which is more slate – coloured, and the sketch of the hastate dolphin attributed to Quoy clearly shows a grey head (Arvy, 1977), though not extending sufficiently posterior. A more accurate depiction of the lateral appearance of the cape is given in Castlenau's sketch as reproduced by Van Beneden (1873), although the brightness of the grey pigmentation is insufficiently reproduced. This (and the general failure to describe the cape by previous authors) probably arose because the grey pigmentation darkens rapidly after death (especially in direct sunlight), and would probably disappear completely in a prepared skin. Such a situation also seems to have arisen in another *Cephalorhynchus* species, *C. hectori*, where early erroneous descriptions of a dark form of the dolphin were based on dry skins which had undergone considerable colour change after death and skinning (Mörzer Bruyns and Baker, 1973).

A less conspicuous coloration feature is a light grey dorso-lateral blaze extending posteriorly along the flank from the level of the tip of the dorsal fin to the dorsal keel of the caudal peduncle about three-quarters of the way back from the dorsal fin. It is indistinct in outline and almost straight throughout its length; in some animals it extends anteriorly as a narrow streak towards the cape. In dead animals it seems to fade rapidly and is easily mistaken for a highlight in photographs (Fig. 7a). This blaze appears to be a previously undescribed feature.

Ventrally the most conspicuous features are the four separate non – pigmented areas. The most anterior of these is a roughly diamond – shaped wedge across the chest at the anterior insertion of the flippers. This is quite variable in shape (Fig. 8), but the lateral extremities invariably curl around and terminate immediately in front of the anterior insertion of either flipper. It was described by Gray (1828) as "a transverse band in front of...the pectoral fins", in *D. hastatus* as a large diamond shape in front of the flippers of which, when the animal is in its natural position, the two points appear as a patch outside and above the sides of the flippers (Cuvier, 1836), and as a white shield on the throat (Rapp, 1837) or simply a white chest (Schlegel, 1841). Rice and Saayman (1984) refer to a "lobe of white" in front of the flipper.

In the axilla of either flipper there is a small ovoid patch of white that anteriorly embraces the posterior insertion of the flipper. Gray (1828) describes this as "a triangular spot behind each of the pectoral fins", Cuvier (1836) as two little oval patches behind the flippers (*D. hastatus*), and Rapp (1837) as a pointed white patch behind the pectoral flipper. Rice and Saayman (1984) refer to a "lobe of white...behind the flipper".

The last and largest of the non-pigmented areas is a trident-shaped mark mid-ventrally. This commences at about the level of the posterior insertion of the flipper and runs back in the midline as a gradually widening band until the middle of the body, when it splits into three, a central tongue that continues back as far as the anus and two lateral tongues that run one up each side. At their greatest dorsal extension the latter barely reach the mid-lateral region, and terminate opposite the anus. The lateral tongues vary little in width, whereas the central tongue widens distinctly where it surrounds the genital

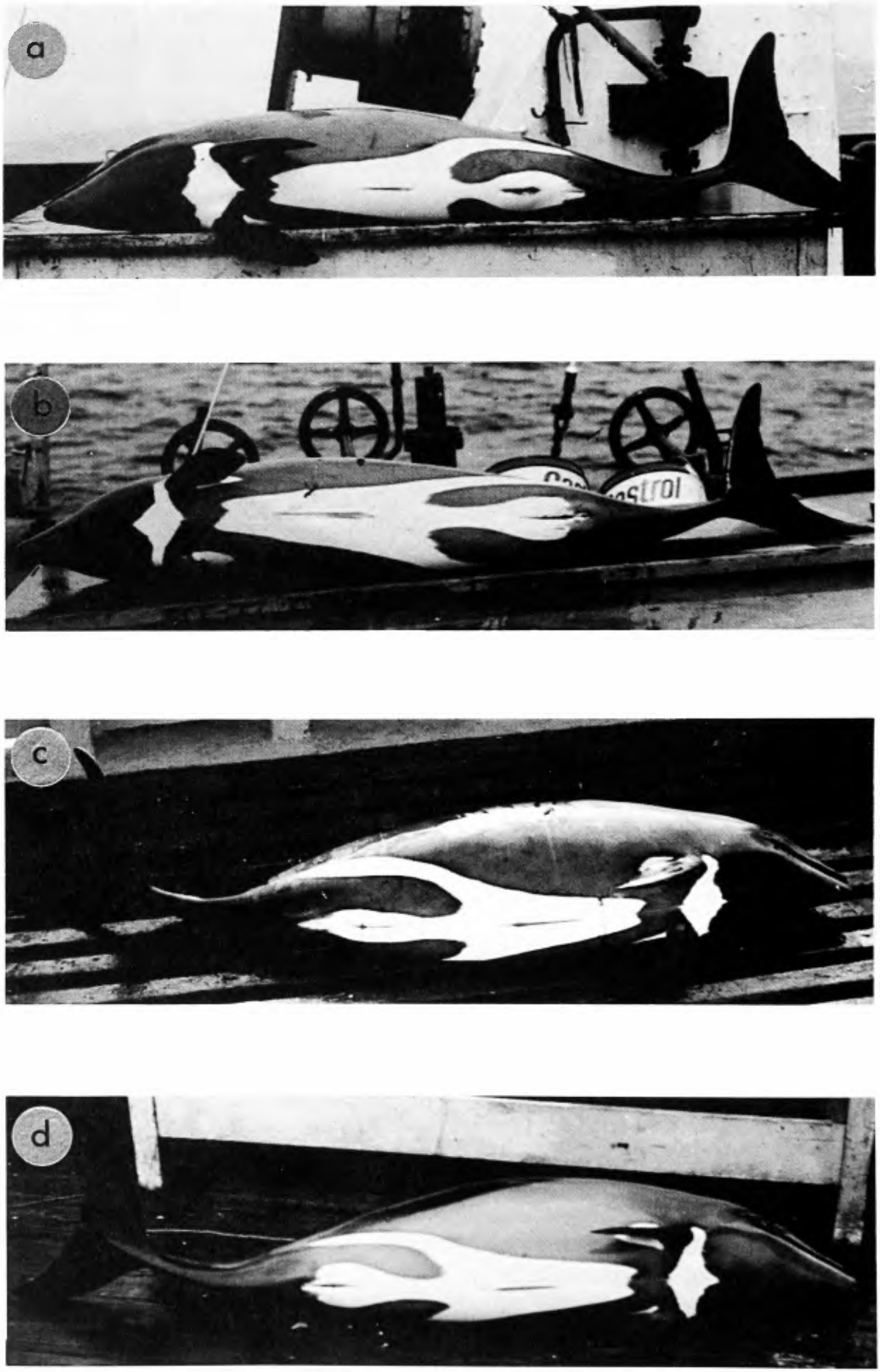

Fig. 8. Variation in ventral coloration of *C. heavisidii*, (a) 77/3 ♂ (b) 70/13 ♀ (c) 78/38 ♂ (d) 77/7 ♀.

aperture. Enclosed within this trident mark there are usually two pigmented regions, a narrow dark grey streak in the region of the umbilicus, and a similar dark grey streak or streaks at the opening of the genital aperture. There also appears to be sexual dimorphism in the shape of the posterior end of the central tongue. In males this terminates behind the anus in a smooth tapering-off of the wider area round the genital aperture (Fig. 8a, c). In females, however, it terminates more abruptly and less regularly (Fig. 8b, d). The non-pigmented area rapidly narrows behind the mammary slits and then extends towards the anus as a narrow mid-ventral streak, terminating at the anus. This distinction could assist in visual identification of sexual partners, or alternatively serve to pinpoint the position of the mammary slits for nursing young.

With one exception, previous descriptions of this trident-shaped mark are in general agreement with the present material. This mark is described by Gray (1828) as "a longitudinal line on the belly, which separates just beneath the dorsal fin into three equal forks, the central one of which is continued in its direct course, while the lateral ones extend obliquely up the sides". In *D. hastatus*, Cuvier (1836) described the large white patch that covered the belly as having a little the shape of a lance head, the branches of which would be elongated and strongly curved downwards. These branches extended onto the flanks of the animal, while the ventral part of the lance head continued posteriorly and ended in a clover shape; the anterior part continued forwards and ended pretty much in a point. Rapp (1837) described the mark as a large white area on the belly that sent three extensions posteriorly, with a black streak in the midline of the body within this white area, while Schlegel (1841) described it as a white belly patch from which a streak ran onto the sides of the tail. Rice and Saayman (1984) state that a "third major lobe [of white] reaches obliquely along the flank rearwards to the tailstock".

Van Beneden (1873) appears to have interpreted all the non-pigmented areas ventrally as forming one continuous band. In his description the belly is a very pale yellow from the middle of the throat to the anal opening, this pale band being clearly demarcated at its edge from the black dorsal colour, and widening slightly at the front and back. It extends laterally in front of the flippers beneath the throat, and also behind the flippers, so that in looking at the animal from its ventral side the outline of this yellow band resembles a cross of Lorraine. Behind the flippers the yellow band slowly widens, but at the posterior boundary of the adominal cavity it suddenly expands, elongates like a large comma to both right and left, and then proceeds to outline the reproductive organs and the anus. According to Van Beneden, if the band looks like a cross of Lorraine anteriorly, posteriorly it rather resembles a trident. As Van Beneden only reproduces a sketch of the lateral view of the animal, it is not clear whether this description is based on an actual sketch of the ventral surface, or whether it is simply Van Beneden's interpretation of what is visible in lateral view. No other animal has been seen or described with all four non-pigmented areas forming one continuum (but see below).

The only original description of Heaviside's dolphin in which the ventral non-pigmented areas are not mentioned is that of *D. cephalorhynchus* (= "Marsouin du Cap"), where the colour is given as entirely black except for a white patch visible from each side (Cuvier, 1829), or black on both upper and

lower parts of the body with the exception of a white patch behind the dorsal fin, visible from each side (Cuvier, 1836). This white area is not indicated in the illustration of the "Marsouin du Cap" (Cuvier, 1829), nor in Dussumier's (?) sketch (Arvy, 1972). The stuffed skin no. 26 in the Paris Museum (which is probably the type of the "Marsouin du Cap") shows the typical trident mark ventrally, but extending forward onto the throat as a narrow, continuous prolongation, with no white shown in the axillae or round the anterior insertion of either flipper (Fig. 1 a,b). This pattern appears to have been painted on the skin. Cuvier's white patch presumably refers to the lateral extensions of the trident, but whether the rest of the ventral pattern was visible at the time of his description, or whether it is the interpretation of a subsequent museum preparator, is uncertain.

Apart from the flank blaze the entire body behind the anus is a dark blue-black, including both dorsal and ventral surfaces of the tail. Both surfaces of the flippers are also blue-black in colour.

The lining of the palate, mouth and tongue is coloured pink with irregular spots of blue-black.

From the only newborn calf examined, this basic colour pattern appears to be present from birth.

Foetal

The following description is from photographs of a 28.8cm long female foetus removed from dolphin 79/13 (Fig. 9).

The head is almost completely black, apart from a lighter area surrounding the eye, and is the darkest part of the body. The lining of the palate and interior of the mouth is bright pink, well–defined at the edges of the upper and lower jaws from the dark pigmentation of the head. The latter is continued mid-dorsally as far back as the dorsal fin, becoming greyish-pink on the caudal peduncle. Laterally the animal is various shades of greyish-pink behind the head, being lightest in the scapular region of the thorax and behind the dorsal fin, and darkest mid-laterally. This pattern is reflected ventrally, where the animal is a light greyish-pink from just anterior to the flippers to the anus (the epidermis is damaged posterior to the anus), but darkest at the mid-length just anterior to the umbilicus. The outer surface of both flippers is dark grey, and the little epidermis left on the tail flukes suggests a similar colour.

There is therefore no trace of the grey cape, and only the slightest indications of the white ventral markings (specifically a distinct lightening at the anterior insertion of the flippers and a possible pale marking in the position of the lateral tongue of the trident).

COLOUR VARIANTS

Certain colour variants of Heaviside's dolphin have been seen. In Table Bay, at least two different albinistic *C. heavisidii* have been seen and photographed on various occasions since 1980. Both animals appear to be almost entirely white, at least on the dorsal and dorso-lateral surfaces, apart from a dark tip to the snout on one or both animals. The two animals can be distinguished because one has a distinct V-shaped notch at the base of the dorsal fin while

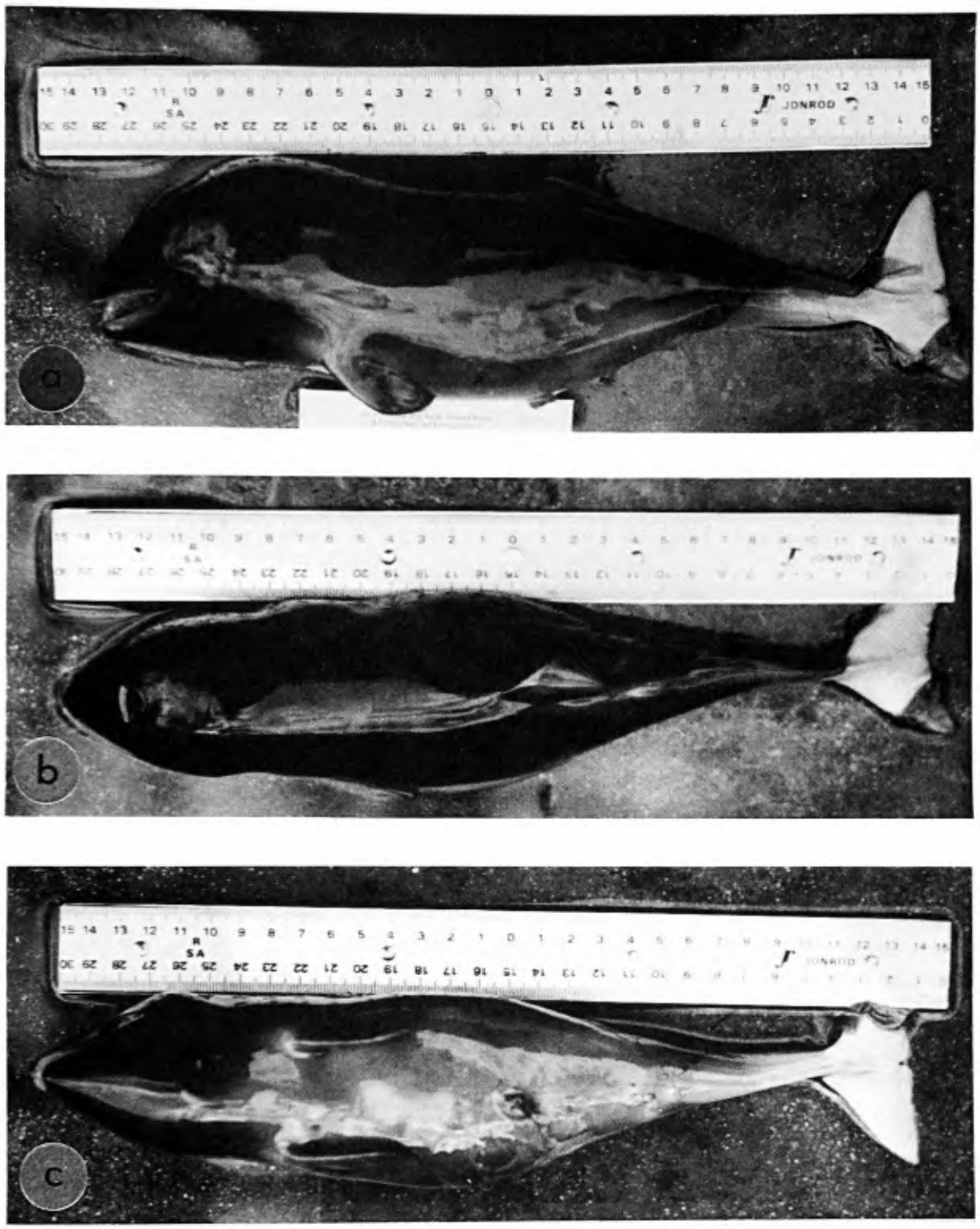

Fig. 9. (a) Lateral, (b) dorsal and (c) ventral views of a *C. heavisidii* foetus.

the other does not. They are figured by Rice and Saayman (1984). A third albinistic animal was seen and photographed from the air near Modderivier (33°28′S, 18°17′E) on 8 October 1981. It had dark flukes and caudal peduncle, and a dark tip to the dorsal fin and snout, the rest of the dorsal surface appearing white (Fig. 10). Near Kleinsee (29°43′S, 17°01′E) another *C. heavisidii* was seen on 31 August 1982 with pale streaking over the dorsal surface so that the overall colour resembled that of an adult Risso's dolphin.

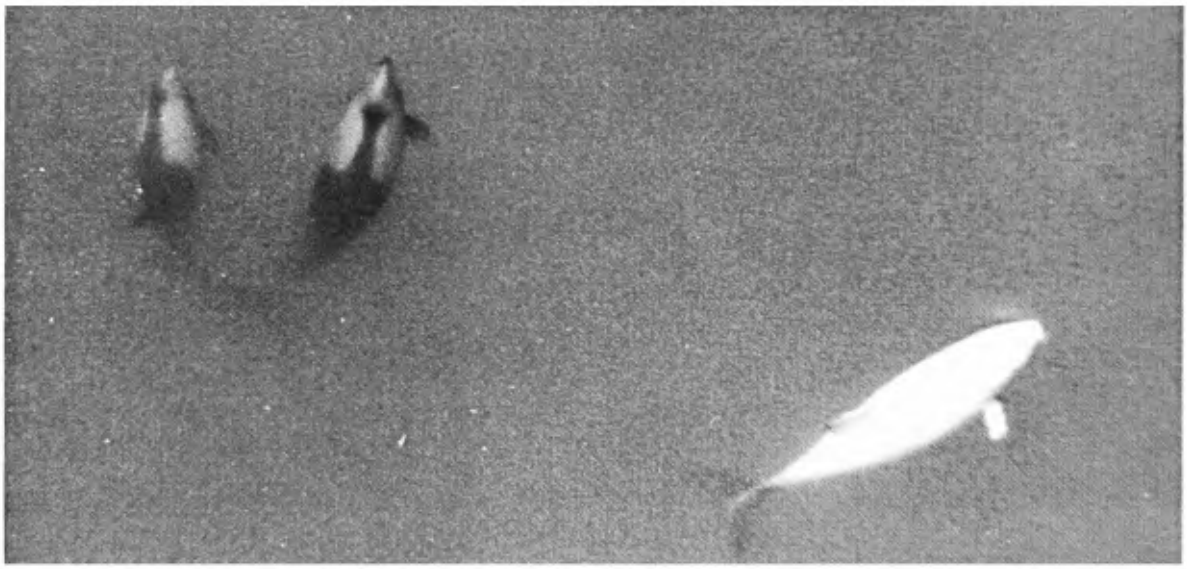

Fig. 10. Albinistic and normally-pigmented *C. heavisidii*, photographed from the air.

DISCUSSION

All the previous descriptions of the external appearance of Heaviside's dolphin, particularly the coloration, are incomplete or incorrect. This is not surprising, as none of the earlier authors had actually seen a living or freshly dead specimen, and were dependent on stuffed skins or other people's illustrations or descriptions of the animal. Unfortunately, nearly all the more recent descriptions of *C. heavisidii* (Norman and Fraser, 1948; Barnard, 1954; Watson, 1981; Leatherwood and Reeves, 1983; Smithers, 1983) seem to have used Van Beneden's (1873) interpretation of the colour pattern (presumably because it was the most recent), despite its inconsistency with earlier descriptions and with actual published illustrations of the ventral view of the animal (Rapp, 1837; Arvy, 1977). This had the corollary that the similarity to the pigmentation of the killer whale (*Orcinus orca*) was accentuated, leading Mitchell (1970) to propose a mimetic resemblance between the two species, a suggestion that would seem to be less tenable now that the actual coloration of *C. heavisidii* is known.

The Marine Mammal Laboratory of the Sea Fisheries Research Institute, Cape Town, now has on file about 120 sightings of 450 Heaviside's dolphins. Apart from behavioural characteristics, the dorsal fin shape and grey cape of this species provide excellent field characters for identification.

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Hector's dolphin
Cephalorhynchus hectori

Recent Observations of Hector's Dolphin, *Cephalorhynchus hectori*, in New Zealand

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ABSTRACT

Hector's dolphin is endemic to New Zealand waters. The species is thought to be semi-resident in some areas and is known to be more widely distributed and abundant than previously thought. The total population is speculated to be between 5,000 and 6,000 animals with 77% of the population south of Cook Strait. New evidence for predation by broad-snouted seven-gill sharks is presented. Incidental mortality in set gillnets may be in the order of 2–4% a year.

INTRODUCTION

The genus *Cephalorhynchus* has a disjunct circumpolar distribution in the Southern Hemisphere. There are four known species in the genus; *C. hectori* (Fig. 1) is endemic to New Zealand coastal waters. Little is known of the species (Mörzer Bruyns and Baker, 1973; Baker, 1978); the first field research into its biology, distribution and movements was made in 1978-79 by the National Museum, Wellington.

Although a subjective impression of a decline in the stock had been proposed (Gaskin, 1976), recent data from incidental sightings and other sources tends to contradict this. It is probable this species is more widely distributed and more numerous than previously believed.

Since this paper was written, a summary of more recent work on this species has been given by Dawson and Slooten (1988) and Slooten and Dawson (1988).

LIFE HISTORY PARAMETERS

The diagnostic features and general characteristics of the species have been detailed by Oliver (1922), Gaskin (1968; 1972) and Baker (1978). Some data on organ weights, distribution, feeding, calving, parasites and pollutants in tissues of *C. hectori* have been summarised by Baker (1978). Because of the scarcity of specimens at that time further biological observations were not possible.

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Fig. 1. Hector's dolphin in the wild (Photo. S. Dawson).

SIGHTINGS

Number of animals observed and seasonal distribution data were collected from incidental observations recorded by mariners and fishermen, research ships' crews and others. These data were contributed to the MAF (Ministry of Agriculture and Fisheries) national cetacean observation scheme and are summarised in Table 1 and Fig. 2.

The reliability of observations is difficult to assess. All observations of any doubt were discarded. Effort is not quantifiable except in the case of research ships and some other vessels which recorded search time.

Locations were recorded at the point of first observations. Numbers of *C. hectori* observed were taken to be the maximum of animals observed in any one sighting incident.

BEHAVIOUR

This species characteristically occupies turbid[1] inshore coastal waters and appears to congregate off river mouths, estuaries, shallow bays and fiords – usually within 8km of the coast (Baker, 1983). Pod sizes are small, ranging from 2 to 13 (mean 9) but groups of 58 and 83 have been observed in single locations in individual sightings. These large groups are most usually aggregations of a number of small pods in a single area, rather than one large cohesive unit travelling together over a period of time. One observation of 200–300 off Kawhia (38°05′S, 174°34′E) was quoted by Baker (1978).

C. hectori characteristically approaches moving vessels rapidly, taking station on the bow for a very short time before falling back into the wake. It shows a definite attraction to moored or stationary vessels and will stay around a boat

[1]But see Dawson and Slooten (1988).

for up to 30 minutes under these circumstances. When travelling, pods have been observed to adopt a shallow chevron pattern, or to form up line-abreast. Hector's dolphin jumps clear of water infrequently but a recent (April 1984) observation of a pod of 30 in Kenepuru Sound, recorded animals, apparently in a high state of excitement, repeatedly jumping vertically from the water and milling around what was thought to be a school of anchovies (*Engraulis australis*) or 'bait-fish' (J. Meredyth-Young, pers. comm.). In calm conditions pods of Hector's dolphin surface with little disturbance and move inconspicuously through the water.

Table 1

Hector's dolphin sightings March 1970 - March 1984

Year/Month	Day	No.	Location	Year/Month	Day	No.	Location
1970				**1980** (cont.)			
March	18	3	Queen Charlotte Sd.	April	-	12	White Rocks, Q. Charlotte Sd.
March	20	6	Queen Charlotte Sd.				
February	9	30	Banks Peninsula	April	-	6	Jacksons Bay
March	26	8	Banks Peninsula	June	-	3	Banks Peninsula/ Rakaia R.
December	28	5	Manawatu Beaches				
January	17	4	Jackson's Bay	August	-	2	Banks Peninsula
January	23	10	Banks Peninsula	August	-	3	Buller Bay
March	29	2	Pukearuhe	October	-	5	Greymouth/Hokitika
April	17	3	New Plymouth	**1981**			
April	18	1	Pukearuhe	March	15	10	Tasman Bay
August	-	12	Westport	May	22	4	Kaikoura-S. Bay
September	27	2	Banks Peninsula	October	1	1	Banks Peninsula
1977				October	1	3	Banks Peninsula
January	8	6	Banks Peninsula	October	1	6	Akaroa
January	12	3	Lyttleton Hbr.	October	26	1	Mokau-New Plymouth
January	25	5	Otago Bay	November	19	2	Westport
February	10	5	Whitianga	**1982**			
February	12-17	26-30	Banks Peninsula	February	12	30	Manakau Hbr Hds
February	19	9	Queen Charlotte Sd.	February	14	2	Manakau Heads
February	-	4	Wellington Hds.	February	18	10	Wanganui R., S. Is.
March	15	5	Whakatane/Whale Is.	February	-	2	Manukau Heads
June	6	83	Te Wae Wae Bay	April	7	58	Greymouth/Westport
August	-	3	Te Wae Wae Bay	May	31	6	Banks Peninsula
September	10	2	Te Wae Wae Bay	June	20	2	45nm E Mernoo Bank
December	16	20-30	Cloudy Bay	July	3	2	Tasman Bay
1978				August	23	7	Westport
June	-	5	Banks Peninsula	September	23	1	Cape Campbell
1979				November	4	2	Wairau R. Bar
May	-	6	Banks Peninsula	**1983**			
September	-	6	Banks Peninsula	August	-	2	Golden Bay
September	-	4	Banks Peninsula	November	-	3	Tasman Bay
1980				December	-	5	24m S of Timaru
January	-	3	Westport	**1984**			
January	-	7	Akaroa	January	-	5	Kaikoura
February	-	3	Westport-Greymouth	January	-	8	Te Wae Wae Bay
March	-	15	35nm E Waitaki R.	February	-	4	Waikato R. mouth
March	-	6	Lyttleton Hbr	February	-	2	Raglan Bar, Pt. Waikato
April	-	24	Banks Peninsula	March	-	3	Hapuka R.

DISTRIBUTION

In 1978–79, a tagging programme was conducted by A.N. Baker at the National Museum, Wellington, to ascertain distribution and local population sizes of Hector's dolphins in the Marlborough Sounds (41°S, 174°E) and Cloudy Bay (41°28′S, 174°03′E). Twenty two animals were marked with 2.5cm Allflex

plastic sheep ear tags applied through the dorsal fin; and some of these were also freeze branded. Of the marked animals, 6 bearing tags have been resighted since the programme began and one of these has been observed with its tag in good condition after 5 years at sea (A.N. Baker, pers. comm.). Although Hector's dolphins often have scarred, cut, notched or otherwise disfigured dorsal fins, the scars left by the type of tags used in the above survey are distinctive and characterised by white circular or sub-circular depigmented spots, about the same diameter as the tags. Sightings of Hector's dolphins with such scars in the general area of first capture would suggest that after tag loss known animals could continue to be identified photographically.

All resightings of marked *C. hectori* have occurred within a few kilometres of the tagging localities suggesting that this species forms semi-resident or resident groups with relatively small ranges (Baker, 1983). This observation has been supported by repeated sightings over a number of years by crews of MAF research ships, of concentrations of Hector's dolphin in the same locations off the mouths of the Buller River (Figs 2 and 3), Clarence River, Kaikoura Peninsula, Banks Peninsula and off the mouths of three major rivers between Banks and Otago Peninsulas (Figs 2 and 3).

C. hectori is relatively abundant around the entire South Island with the exception of the southwest (Fiordland) coast where the shelf is particularly narrow with very deep oceanic water to within 1km of the shore. One record only exists for Fiordland where three Hector's dolphins were taken in Milford Sound in 1977 (Baker, 1978). The coastal marine environment off the west coast of the North Island is somewhat similar to that of South Island, where Hector's dolphin is regularly encountered. It is characterised by a broad coastal shelf, the outfall of six large rivers and has a number of large shallow harbours north of Cape Egmont. The northeast coast is deeply indented and, in some areas (Whangarei, Hauraki Gulf, Bay of Plenty), harbours and bays are shallow and turbid, with large expanses of mudflats at the heads. The coastal shelf in the north is narrow and in the Bay of Plenty deep water intrudes close inshore.

Around North Island, distribution is primarily restricted to the west coast from Cook Strait north to about 35°S. Sightings of *C. hectori* have been made from ships at sea, and by observers ashore, in waters off the Wanganui River, New Plymouth and north along the coast to Manukau Harbour. A sighting of 30 Hector's dolphins was made in February 1982 from a naval survey vessel about 65 n.miles west of Manukau Heads at 37°06′S, 173°05′E, in water over 750m deep. There is no doubt that the identifications on these sightings are correct but the distance offshore is so great they must be considered extra limital. Baker (1983, p. 118) states that *C. hectori* 'is only rarely seen north of East Cape and Kawhia', (38°05′S, 174°50′E). However, the recent series of observations of this species off Manukau Heads suggests that, although it has not been regularly reported, it is not rare in this area. A stranding of a young (85cm) *C. hectori* on Dargaville Beach (Cawthorn, 1982) confirms the coastal presence of this species at 35°S and it is probable that reported sightings by a fisherman of 'small grey-white dolphins, with black fins and no beak, close inshore off Kaipara Harbour and Hokianga Harbour' (R. Cooper, pers. comm.) are of *C. hectori*. No sightings have been reported from either the east or west of the northern peninsula from Cape Reinga south for about 70 miles.

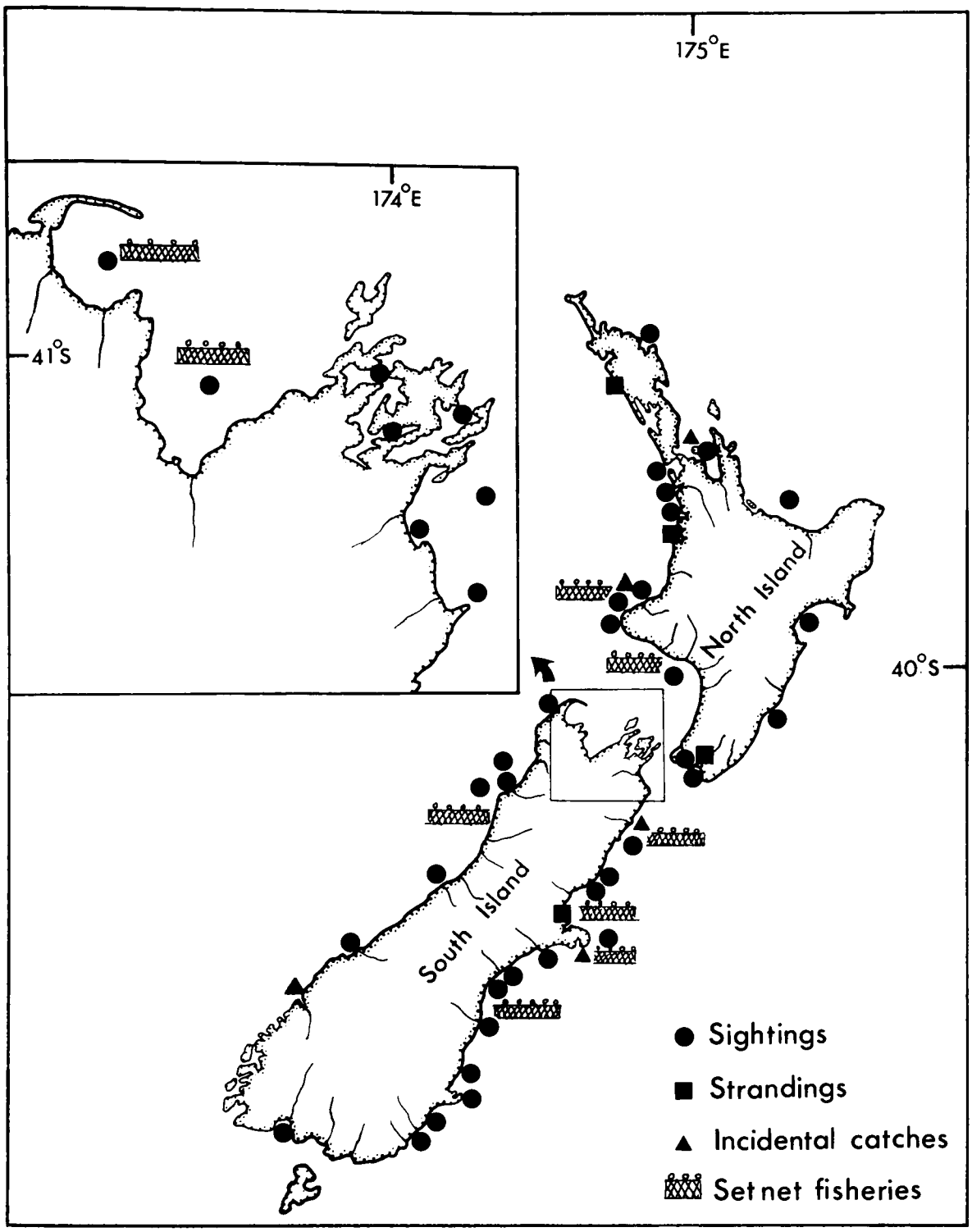

Fig. 2. New Zealand, showing positions of sightings, strandings, incidental catches and set net fisheries.

On the east coast a specimen was reported from Bay of Islands (Oliver, 1922), which also happens to be the northern limit of the known range of *C. hectori* (Baker, 1983). Further south on the north coast of North Island a 1.50m female was taken incidentally in a gillnet off Waiheke Island (34°46′S, 175°08′E), Hauraki Gulf, in October 1980 (Cawthorn, 1982). Five Hector's dolphins were sighted at Whitianga in February 1977 and a pod of 5 animals was seen from a tuna boat off Whale Island (37°51′S, 176°59′E) in the Bay of Plenty on 15

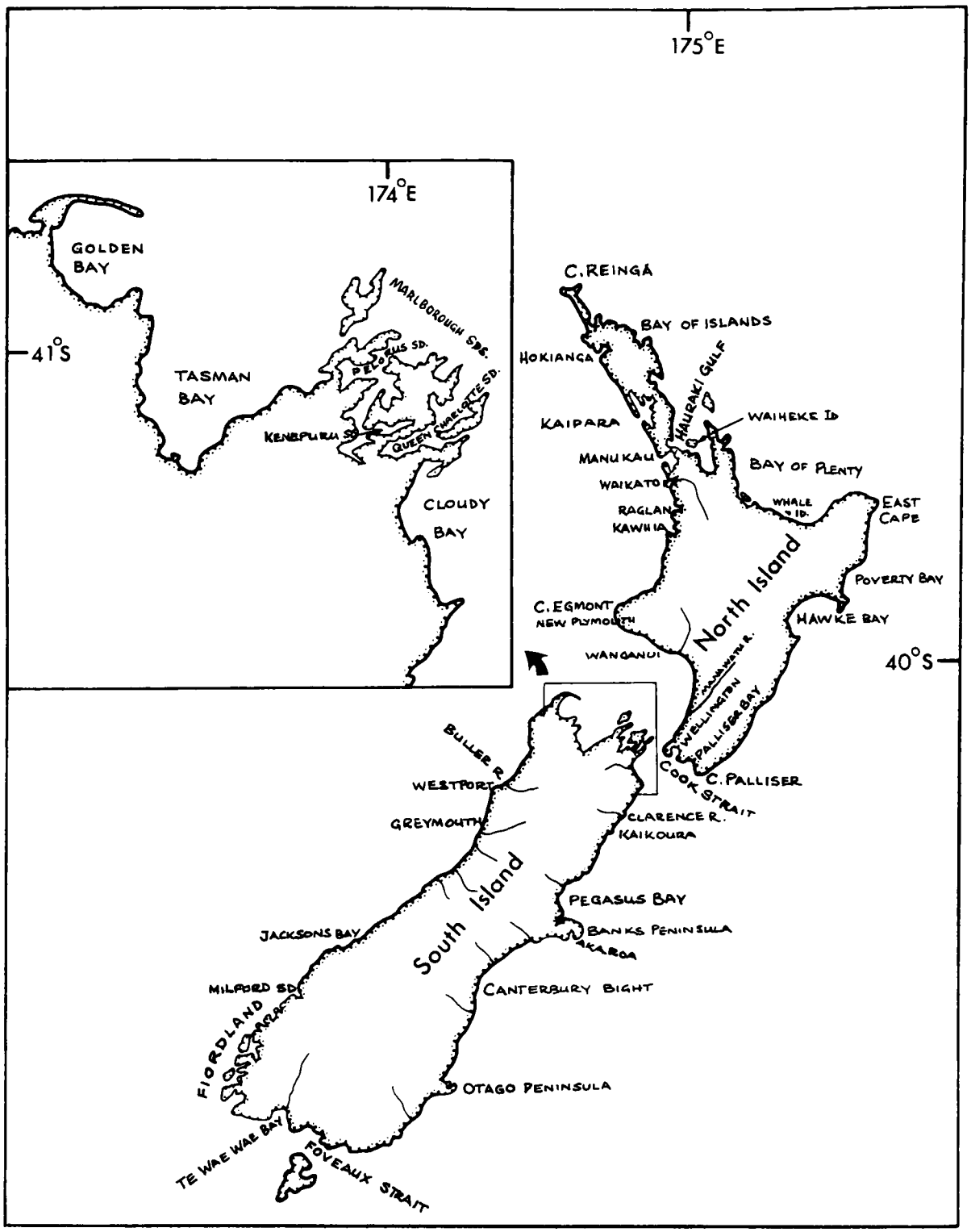

Fig. 3. New Zealand, showing place names mentioned in the text.

March 1978 (G. Tunnicliffe, pers. comm.). Hector's dolphin has been reported only twice on the east coast between East Cape and Cape Palliser (Baker, 1978). Its presence in Hawke Bay is alluded to by Gaskin (1972, p. 128) who states 'the dolphin collectors of the Marineland of New Zealand regard it as a very rare visitor to Hawkes Bay'. Hector's dolphin is observed frequently in Palliser Bay, east of Wellington Harbour, by fishermen and, although unusual in Wellington Harbour, recent incidental sightings have been reported on the eastern side a few miles north of the harbour entrance (A.N. Baker, pers. comm.).

SEASONALITY

Sightings from all sources around New Zealand increase in the late austral summer and autumn with about 63% of the total being recorded between January and April (Fig. 4). Because of the paucity of data, the reasons for the apparent February peak in percent frequency of sightings are obscure. Inshore fisheries research does not increase during the austral summer–autumn period and there is no evidence of seasonal migrations of *C. hectori*. Two broad categories to which the increased sightings may be linked are weather and food.

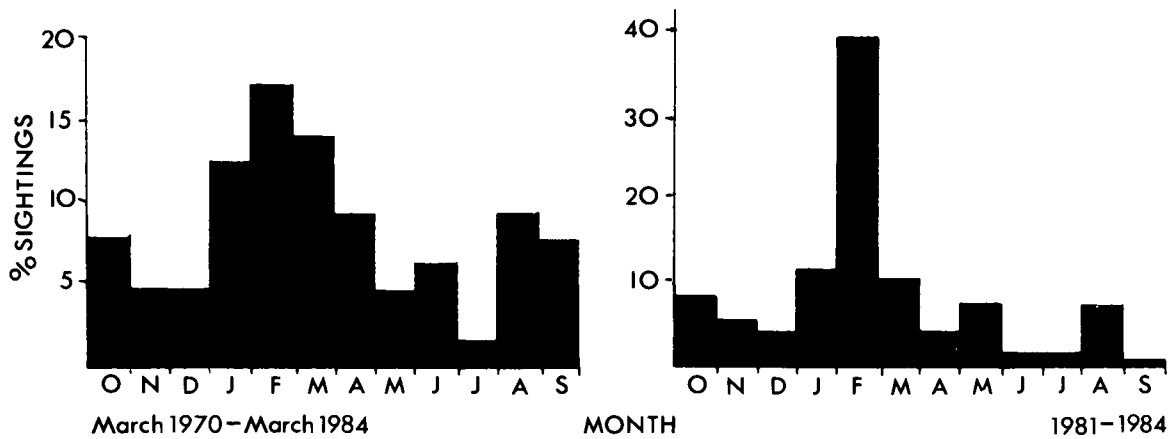

Fig. 4. Monthly distributions of sightings of Hector's dolphin by month. (a) March 1970–March 1984; (b) 1981–84.

In the case of weather, late summer and autumn is generally a climatically stable period with reduced wind runs and periods of calm resulting in marked stratification of the water column, particularly off the east coast of South Island. Calm conditions would obviously aid sighting of these small dolphins yet, in areas where they are regularly observed, Hector's dolphin travels so close to the coast it can often be seen just outside breakers in choppy or disturbed water.

Significant zooplankton blooms occur inshore in late summer–early autumn along with settlement of species such as *Munida gragaria*, common in eastern South Island inshore waters in late summer. The presence of zooplankton blooms is paralleled by increased abundance of squid, schoolfish, e.g. kahawai (*Arripis trutta*), yellow-eyed mullet (*Aldrichetta forsteri*) and demersal species such as red cod (*Pseudophycis bacchus*), hoki (*Macruronus novaezelandiae*) and barracoutta (*Thyrsites atum*). *C. hectori* taken incidentally in gillnets set off Banks Peninsula in March were recovered with yellow-eyed mullet clamped in their jaws (G. Tunnicliffe, pers. comm.). Other food species documented include horse mackerel (*Trachus novaezelandiae*), red cod, sand stargazer (*Crepatulus novaezelandiae*) and engraulids (Baker, 1972). Regrettably, no comparable information is available from North Island observations. Only one animal has ever been recorded taken incidentally in set nets off the North Island and its stomach was not examined.

PREDATION

It is possible that killer whales and leopard seals prey on Hector's dolphin throughout the year as both are frequent visitors to South Island's coastal waters. However, it is more likely that sharks are the major predators on this inshore species throughout its range. Five types of shark commonly occur in Cook Strait, and in the coastal waters around South Island and North Island; they are blue sharks, bronze whaler, great white, mako sharks and broad-snouted seven-gill sharks – all of which are inshore predators.

On 6 March 1984 it was reported that five sharks were taken in set nets just north of Banks Peninsula. On examination it was found that each of the sharks had the remains of Hector's dolphins in their stomachs. The sharks were subsequently identified as broad-snouted seven-gill sharks, *Notorhynchus cepidianus* (G. Tunnicliffe, pers. comm.), which reach a maximum length of about 3m and are most common in shallow waters. This is believed to be the first record of predation by sharks on *C. hectori.*

STRANDINGS

Although recorded regularly each year, Hector's dolphin does not mass strand and, typically, only one or two animals come ashore each year on all types of coast (Fig. 2). Forty seven strandings have been recorded to 1982 and 19 of these have occurred since 1973 (Table 2). The large number of strandings recorded over the last decade is probably a result of improved data collection procedures but the frequency of annual strandings has shown little change over the last 13 years. Forty percent of all recorded strandings have occurred in the austral summer (November–January), 25% in the late summer and autumn (February–April), 10% in the winter (May–July) quarter and 25% in spring (August–October). The summer peak in strandings is most probably a reflection

Table 2
Strandings (FRD = Fisheries Research Division)

Date	Number	Sex	Length (m)	Location	Source
9 January 1973	1	–	–	Banks Peninsula	Baker (1978)
January 1973	1	–	–	Pukearuhe Beach	Baker (1978)
7 February 1973	1	–	–	Sumner Beach	Baker (1978)
22 October 1973	2	–	–	Te Wae Wae Bay	Baker (1978)
14 January 1974	1	–	–	Pegasus Bay	Baker (1978)
28 June 1974	1	–	–	Hokitika	Baker (1978
28 August 1974	1	–	–	New Plymouth	Baker (1978)
14 January 1975	1	–	–	Waimarie	Baker (1978)
4 December 1976	1	–	–	Banks Peninsula	Baker (1978)
4 January 1977	1	–	–	Pegasus Bay	Baker (1978)
17 December 1979	1	Male	1.37	Wakaputa Beach, Invercargill	FRD
16 January 1980	1	Male	1.07	Avon River Estuary, Christchurch	FRD
6 December 1980	1	?	0.85	Dargaville Beach	FRD
18 January 1982	1	Male	1.38	Ruapuka Beach	FRD
5 May 1982	1	Male	1.46	New Brighton	FRD
23 February 1985	1			Manukau Harbour	FRD
19 April 1985	1	Male	1.19	Brighton Beach	FRD
14 December 1985	1	Female	1.67	Onaero Beach	FRD

of increased activity on the coast rather than a seasonal change in dolphin behaviour.

INCIDENTAL CATCHES

Hector's dolphin had been reported taken in both trawl and set net fisheries but the latter are most significant (Table 3). MAF records show incidental catches from Waiheke Island, New Plymouth, Kaikoura, Banks Peninsula – Pegasus Bay and Golden Bay – Tasman Bay. Baker (1978) records three animals taken off Milford Sound in 1977.

Table 3

Reported incidental catches of Hector's dolphin 1983-84. Unreported: Approx. 100 year-1 Timaru-Canterbury fishery (Francis, pers. comm.); Approx 6- in 1983-4 Pegasus-Banks Peninsula (G. Tunnicliffe, pers. comm.)

Date	Location	Method	Sex	Length
3 November 1983	New Brighton	Set gill net	Female	1,159
17 February 1984	New Brighton	Set gill net	Female	1,020
17 February 1984	New Brighton	Set gill net	Female	1,130
17 March 1984	New Brighton	Set gill net	Female	(Adult, lost at sea)
17 March 1984	New Brighton	Set gill net	Female	(Calf) 750

By the mid 1970s, a fishery for rig (*Mustelus lenticulatus*) had developed rapidly around South Island and on the west coast of North Island (Fig. 2). Trawlers working inshore take rig as a by-catch and the inshore set-net fishery targets most effectively on this species. The fishery, which peaked around South Island in the mid to late 1970s (Table 4), has subsequently shown signs of being overexploited and is now declining in most areas. Because of the high market value of rig and the low capital investment required to enter the fishery, it has benefitted fishermen still involved to increase gillnet lengths worked as other vessels drop out. Consequently, effort has remained high. Currently, 57% of the total annual rig catch of about 3,000 tonnes is taken with monofilament gillnets, with a 15–16cm stretched mesh measurement, set close inshore, often in the surf zone.

Although small cetaceans (*Tursiops*, *Delphinus*, *Cephalorhynchus*) and a few fur seals have been taken in these nets, fishermen show a natural reluctance to

Table 4

Rig (*Mustelus lenticulatus*) gillnet fishery

Area	Season	Peak year	Average number boats fishing season	Average net length worked	Net days worked	Status
Canterbury	Nov–Feb	1977–78	15	2,800m	18,500	Decreasing
Pegasus	Oct–Jan	1977–78	12	1,600m	6,800	Decreasing
Kaikoura	Sep–Dec	1980–81	20	1,500m	17,700	Stable
Golden/Tasman Bay	Nov–Feb	1978–79	15	1,600m	10,000	Decreasing
Greymouth	Oct–Dec	1983–84		–		
Wanganui	Jan–Mar	1982–83		1,200m		
New Plymouth	Jan–Feb	1977–78		1,200m		

report incidental catches of marine mammals fearing official constraints would be placed on their operations. In a previous report (Cawthorn, 1979) it was stated that an unreported catch of about 12–20 Hector's dolphins is taken off Banks Peninsula (Pegasus) annually. The MAF biologist responsible for the rig fishery believes that the unreported catch of Hector's dolphin in the Canterbury and Pegasus fisheries is probably 100 plus per year and expects proportionally high catches in all other inshore set-net fisheries for rig (M.P. Francis, pers. comm.).

The implications of this are particularly serious. Gillnets are worked seasonally in all the coastal areas known to be inhabited by *Cephalorhynchus hectori* (Fig. 2). The rig season in South Island waters runs from September to March and *C. hectori* sightings begin to peak in the late austral summer (Fig. 4) – at the height of the set-net fishery. Calving takes place in late spring and an adult and calf have been taken in nets off Banks Peninsula in March (Table 3).

In the absence of accurate catch figures it is possible that between 100 and 200 Hector's dolphin are taken incidentally in coastal set nets in New Zealand annually.

NUMBERS

An attempt has been made using available incidental sightings data to speculate on the possible population size of *C. hectori* in New Zealand waters. Local coastal area boundaries were arbitrarily selected using convenient landmarks, known concentrations of Hector's dolphins and frequency of observations.

About 77% of the estimated population is found south of Cook Strait. Approximately 45% occur on the east and west coasts of South Island with 29% and 3% off the north and south coasts of South Island respectively. Around North Island 16% of the estimated population is found off the east coast – including Cook Strait – while only 6% is allotted to the north and east coasts combined (Fig. 5).

Low incidental sightings numbers in North Island waters are undoubtedly affected by the strong bias in research ship time to operations around South Island. Little ship time has been spent in west coast North Island inshore waters and, in that area observations of Hector's dolphin were recorded by known observers and FRD staff. Along the north and east coasts of North Island Hector's dolphin is uncommon and has never been recorded in significant numbers, although ship time and sightings effort in those areas has been high for a number of years.

Because of the incidental nature of observations, the animal's small size, cryptic behaviour and apparent preference for turbid inshore waters, sightings effort for *C. hectori* is thought by observers to be only 20–30% efficient, thus any population assessment will underestimate the population size. Expanding the total figure to 100% effort yields a maximum population of *Cephalorhynchus hectori* in New Zealand waters between 5,000 and 6,000 animals. This value is somewhat larger than the 3,000-4,000 obtained from survey data by Dawson and Slooten (1988) but they noted that they believed theirs to be a conservative estimate.

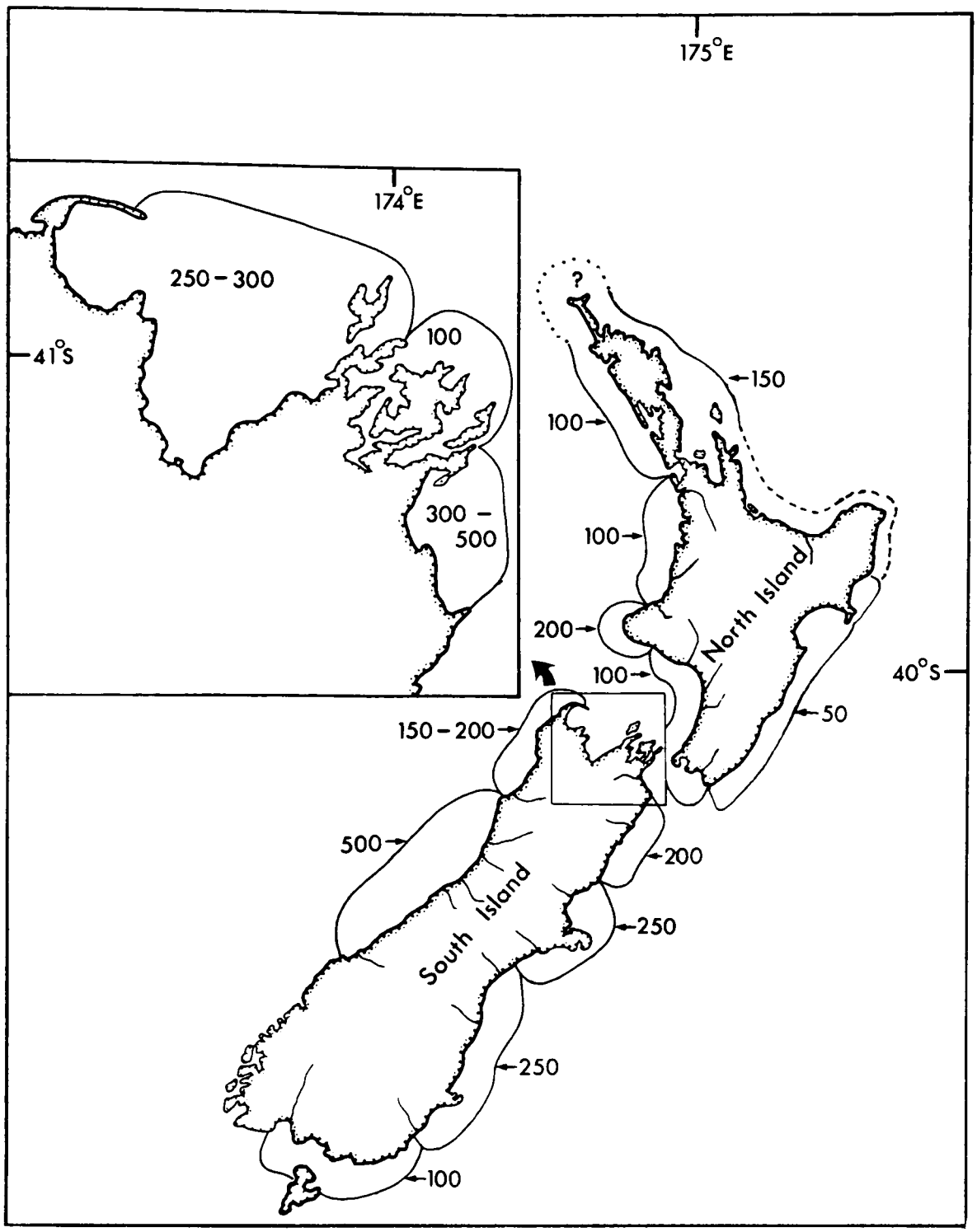

Fig. 5. Speculative distribution and abundance of Hector's dolphin (see text).

CONCLUSION

Hector's dolphin is more widely distributed around New Zealand than previously believed with about 75% of the estimated population found south of Cook Strait. Seasonality is marked by a peak in sightings in late summer – early autumn which may be related to weather and availability of inshore demersal food. Natural mortality is unknown but predation on *C. hectori* by inshore shark species has been established and a real threat to the population is presented by gillnets set inshore. Females (mean length 110 cm)

predominated in the reported 1983–84 incidental catches off Banks Peninsula. In the absence of firm data a speculative estimate places the population of Hector's dolphin at between 5,000 and 6,000 animals with a potential incidental catch mortality of about 2–4%.

FUTURE RESEARCH NEEDS

There is an immediate need for research to be initiated to ascertain: (1) the true size of the population and the incidental catch; (2) pregnancy rates; (3) geographical distribution and discreteness of localised groups; and (4) the ecology and feeding requirements of *C. hectori* in New Zealand waters.

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Hector's Dolphin, *Cephalorhynchus hectori*: Distribution and Abundance

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ABSTRACT

A boat survey of the distribution and abundance of Hector's dolphin, *Cephalorhynchus hectori*, covering 4,500 n.miles, was undertaken during 1984/85. The species' distribution is described and discussed. Analysis of survey data and calibration of the survey technique results in an abundance estimate of 3,408. We suggest this figure represents a total population of 3,000–4,000 individuals.

INTRODUCTION

The genus *Cephalorhynchus* comprises four species of small dolphins, each with a relatively limited distribution and endemic to a different region of temperate/cool temperate coastal waters in the Southern Hemisphere. Of these, Hector's dolphin, *Cephalorhynchus hectori*, inhabits New Zealand waters and is the only dolphin found solely within those waters. It is normally found in small groups of two to eight individuals which, in areas of high abundance, tend to cluster together (Slooten and Dawson, 1988). Hector's dolphins are remarkably coastal animals and are most often seen within half a mile of the shore (Dawson, 1985) and very rarely straying more than 5 n.miles from the coast (Mörzer Bruyns and Baker, 1973; Baker, 1978, 1983). Recent reviews of the biology of this species are given by Slooten and Dawson (1988), and Slooten and Dawson (in press).

As is the case for all of the *Cephalorhynchus* species, information on distribution and abundance has so far been scant (IWC, 1985). Until now, estimates of the abundance of Hector's dolphins have been based either on analysis of incidental observations, mostly from fisheries research vessels and fishermen (Cawthorn, 1988) or extrapolation from a small part of the distribution to arrive at a total population estimate (Baker, 1984). Both authors described their estimates as speculative (Baker, 1984; Cawthorn, 1988). In keeping with recommendations for future research made by both of these researchers, a survey of the distribution and abundance of Hector's dolphin was carried out as the first step in a four year study of the behaviour and ecology of the species; the central aim being to obtain an estimate of total population size.

Incidental sightings data (Cawthorn, 1988) provided information on the

distribution of this species, indicating that it is regularly seen around much of South Island, except Fiordland, but is known only from a few North Island areas. Cawthorn (1988) writes:

'Around North Island, distribution is primarily restricted to the west coast.... Sightings of *C. hectori* have been made from ships at sea, and by observers ashore, in waters off the Wanganui River, New Plymouth and north along the coast to Manukau Harbour.'

This west coast area lies between latitudes 39°56.9′S to 37°03.7′S. According to Cawthorn (1988) there have been no recent (since 1977) sightings of the species in other North Island areas.

Based on this information and fishermen's reports, we undertook a continuous boat survey of the species' South Island habitat, as well as a survey of North Island areas where Hector's dolphins are regularly seen. In addition, we interviewed fishermen in each fishing port. Most of these people have had many years of experience at sea and encounter Hector's dolphins frequently and their observations are thus valuable.

To allow estimation of population size from the survey data, the data were supplemented by two series of offshore transects and simultaneous clifftop/boat surveys.

A long-term behavioural and acoustic study of Hector's dolphins is now underway (see Slooten and Dawson, 1988). Although the results of this may in time suggest reinterpretation of some of the survey results, the survey data establishes a baseline and a repeatable technique with which future surveys may examine population change.

MATERIALS AND METHODS

Coastal strip surveys

The entire South Island coast (except Fiordland south of Milford Sound) was surveyed. South Fiordland and Stewart Island (47°00′S, 167°50′E) were not surveyed due to an absence of recent sightings from that area, despite extensive boat traffic (including some experienced observers). The North Island west coast area between 10 miles south of the Wanganui River (40°04.2′S, 175°08′E) to the Kaipara Harbour (36°25′S, 174°14′E) was also surveyed using the same survey technique. The South Island survey data were gathered between 14 November 1984 and 15 April 1985. Due to time constraints the North Island survey data were gathered in winter between 4 August and 24 November 1985.

A systematic survey was decided upon as randomised techniques were considered inappropriate due to the clumped nature of this animal's distribution (B.A. McArdle and G.A. Seber, pers. comm.). The vessel used for the survey was a 3.9m inflatable (*Lancer* 390SP) powered by a 25hp (*Yamaha*) outboard.

A set of trials using known distances established that 400m was the range over which we could reliably sight Hector's dolphins in average survey conditions. The boat surveys were conducted in predominantly calm weather (Beaufort 0–3, wind speed less than 10 knots) beginning at dawn or soon after. During the survey the boat was taken parallel to the shore 400m from the shore, at a constant speed of approximately 10 knots. An 800m wide strip of coastal water

was surveyed with one observer facing seaward and one facing landward. On sighting dolphins the boat would be stopped and all Hector's dolphins seen within 400m either side of the boat counted. The position of each group and the number of individuals were recorded directly onto marine charts. After making the count we would leave the group(s) at about 20 knots, slowing to 10 knots after about 200m. The temporary burst of high speed was necessary to leave the counted group behind, to minimise the risk of recounting the same individuals.

The survey was two-way; that is, we would travel 25–40 n.miles along the coast and then return, making separate counts there and back. The larger of the two counts was used for analysis, although the two separate counts tended to differ very little. Each successive day a contiguous section of coast was surveyed.

Although there is no evidence for migration in this species, the possibility of migration confounding the survey was controlled for in two ways. We attempted to survey faster than the animals would be expected to migrate and an extremely good 1984/85 summer season allowed very fast progress. In addition, any distinctive animals seen were photographed using standard photo-identification techniques (Würsig and Würsig, 1977; Balcolmb, Boran and Heimlich, 1982) so that we could determine if we were resighting dolphins that had been photographed elsewhere.

Calibrating the survey method

All survey methods count a proportion of the true population. To estimate the total population that proportion must be known so that a correction factor can be applied to the survey data. Two sources of error in the survey method were identified:

(i) dolphins beyond the 800m wide surveyed strip were not counted; and
(ii) the boat surveys are unlikely to count all dolphins within the surveyed strip.

These two sources of error were estimated using offshore transects and simultaneous boat/clifftop surveys.

Offshore transects

Offshore transects were conducted to investigate the offshore distribution of Hector's dolphin. A number of offshore transects were undertaken in different South Island locations during the main survey in the summer of 1984/85 but the data are not presented here due to variability in transect length caused by weather constraints.

A set of 20 additional offshore transects was conducted off the south side of Banks Peninsula during the following year. To control for any seasonal differences in offshore distribution these transects were conducted over the same months as the South Island survey in the following summer (December 1985 – March 1986). The transects were started within 20m of the coast and a constant speed of 15 knots was maintained to reach five miles offshore. A series of trials using a standard load and calibrated engine speed over a known distance established that 15 knots could be maintained to within 5% variation. Extensive

conversations with many fishermen had established that Hector's dolphins are rarely seen further offshore than 5 miles and this was also the finding of Mörzer Bruyns and Baker (1973) and Baker (1978).

The position and size of groups sighted was recorded. Position along the transect was determined from the known speed (15 knots) and elapsed time (using a stopwatch) since the transect began. As during the main survey, when dolphins were sighted the boat would stop (and the stopwatch was stopped) and a count made. On leaving the area (at 15 knots) the stopwatch would be restarted. The transects were placed randomly within a 10 n.mile section of the south coast of Banks Peninsula. A further series of 18 transects (following the methods above) was undertaken during the winter of 1986.

Simultaneous clifftop/boat surveys

In order to determine the accuracy with which the boat crew counted the number of dolphins within the surveyed strip, we conducted a series of simultaneous boat/clifftop surveys. To aid judging of distance from the clifftop, buoys were placed at radar-verified distances of 400m and 800m from the shore. For the trials one observer (ES) would be dropped ashore in an area where dolphins were easily visible from a high vantage point and two observers (SMD and another) would remain in the boat and leave the area. The clifftop observer would determine the position of groups within the area and would closely track one to three particular groups and determine how many animals were present in each group under observation. The trials were only done when the clifftop observer was confident that she could accurately score the numbers in each dolphin group under close observation.

The clifftop observer would then contact the boat crew by two-way radio and the boat would come through the area exactly repeating the standardised survey technique used in the population survey (see 'Coastal strip surveys' above), one observer looking for dolphins on the port side of the boat and the other looking to starboard. The boat crew would inform the clifftop observer of the position of each group and the number of animals in each group while remaining ignorant of what the the clifftop observer had seen.

To maintain consistency of observations from the boat, only the observations of the experienced observer (SMD) were used in the analysis. The clifftop observer scored whether that boat observer had correctly counted each group on his side of the boat. These trials were conducted in weather conditions approximating those of the survey.

RESULTS

Boat survey

During the boat survey 1,162 individual Hector's dolphins were seen around the South Island coast and a further 22 were seen in the surveyed North Island areas (see Fig. 1). The boundaries of the areas indicated with broken lines in Fig. 1 reflect areas of obviously different abundance. Analysis of photographs taken of distinctive individuals suggests that individual dolphins were not counted more than once, nor were any distinctive animals resighted in different areas.

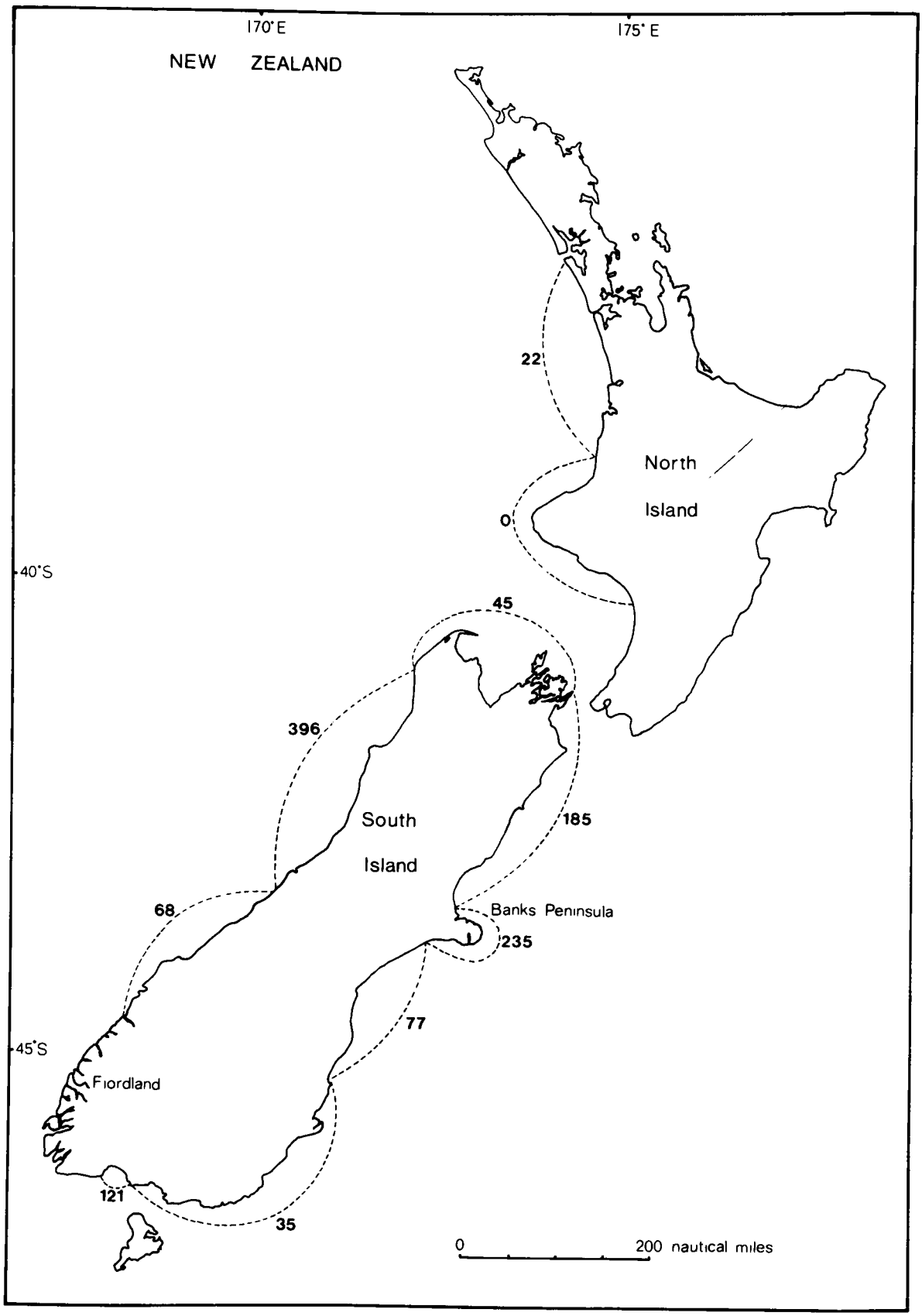

Fig. 1. The distribution and number of Hector's dolphins sighted during the survey. The broken lines indicate areas covered by the boat survey.

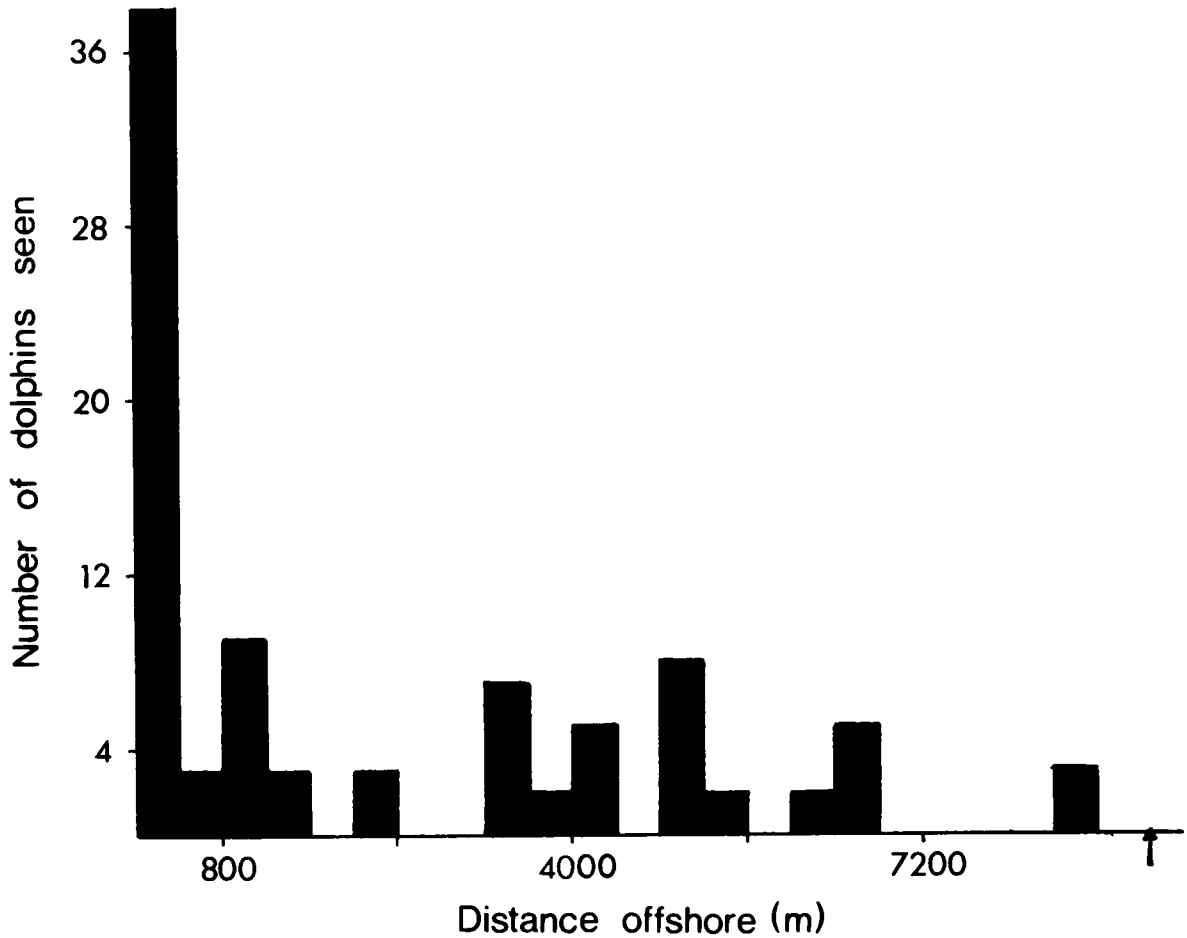

Fig. 2. The offshore distribution of Hector's dolphins in summer and winter. Dolphin abundance is given in percentage of the total seen during the transect series. The arrow indicates five nautical miles (9,260m).

During the survey we saw Hector's dolphins in sea surface temperatures ranging from 13 to 21.5°C.

Offshore transects

Summer transects

We conducted 20 five-nautical mile offshore transects as detailed above. Dolphins were seen on ten of these transects with an average of 9 dolphins per transect (mean $\pm$ 95% confidence interval = 9.0 $\pm$ 4.5). These data are shown in Fig. 2 and indicate that approximately 45.5% of the animals are found within 800m of the shore (i.e. within the surveyed strip). In total 90 dolphins were seen in 27 groups containing one to nine individuals (mean $\pm$ 95% CI = 3.33 $\pm$ 0.870). The data from a number of offshore transects conducted during the 1984/85 survey in different localities around the South Island coast confirm the results from the 20 offshore transects above. This indicates that the results from the Banks Peninsula transects are likely to be representative of offshore distribution in other areas.

Winter transects

A further series of 18 offshore transects (following the same methods) was conducted over the winter of 1986. A total of 34 dolphins was seen on 11 of

these transects with an average of three dolphins per transect (mean ±95% CI = 3.09 ± 1.32). These data are presented in Fig. 2. The 34 dolphins were seen in 15 groups containing one to seven individuals (mean ± 95% CI = 2.27 ± 0.87). In winter approximately 21% of the dolphins are seen within 800m of the shore.

Simultaneous clifftop/boat surveys

We conducted 17 trials of simultaneous surveys, scoring the effectiveness of the boat crew at spotting dolphin groups within the survey zone and at assessing the size of those groups. Of a total of 176 dolphins under observation from the clifftop, the boat crew sighted 138. During these trials the boat crew counted 78% of the dolphins within the surveyed zone.

Population abundance

The population survey results given above can now be modified by the offshore transect and simultaneous survey data to extrapolate a population estimate. The data above show that the offshore distribution of dolphins is different between summer and winter but we have no reason to suspect that the sighting efficiency of the boat crew differs seasonally. The South Island survey data were gathered in summer. In summer, on average, 45.5% of the dolphins are within the surveyed area and, of those, an average of 78% are counted. Hence, the survey data give a population estimate of 3,274 in South Island waters. The method precludes the calculation of confidence intervals. In winter, an average of 21% of the dolphins are within the surveyed zone. Correcting for offshore distribution, and assuming the same sighting efficiency, results in an estimated 134 dolphins in North Island waters. The estimated total population of Hector's dolphins is 3,408 individuals.

Fishermen's reports

Throughout the duration of the survey we interviewed over 100 coastal fishermen and a smaller number of fisheries officers and research workers to gain their information on and observations of Hector's dolphins. The fishermen were either crayfishermen, gillnetters or trawlermen. All of the 78 people (mostly fishermen) who were familiar with the species and saw it regularly had predominantly seen them close inshore (within 2 n.miles). Of these, only four fishermen had seen Hector's dolphins further offshore than 5 n.miles, the furthest sighting being 8.6 n.miles offshore. Of the 22 North Island west coast fishermen interviewed, only three saw the species regularly (between Raglan and Kawhia).

DISCUSSION

The abundance of Hector's dolphins is similar on both the west and east coasts of South Island. They are relatively uncommon in the north of South Island. In general, the distribution of Hector's dolphins is highly clumped and, even within areas of high abundance (Fig. 1), groups are unevenly spaced. Hector's dolphins

are most often seen in small groups - single individuals are uncommon. In many areas the distribution of these groups is also clumped, with a tendency for small groups to cluster together (Slooten and Dawson, 1988).

The south of South Island presents an interesting anomaly. According to fishermen and tourist boat operators, Hector's dolphins are absent in Fiordland and scientists on extensive marine surveys of the area have not seen the species (K. Grange, pers. comm.). Our survey results indicate that they are rare along the southeast coast. However, on the south coast of South Island and between these areas is Te Wae Wae Bay (46°16′S, 167°31′E), a large shallow bay which at the time of the survey contained a large number of dolphins (121 individuals sighted). Fishermen report that Hector's dolphins are always seen there and both Baker (1978) and Cawthorn (1988) report sightings of large groups in the bay. Thus, Te Wae Wae Bay represents an area of high abundance of Hector's dolphins in between two areas of extremely low abundance (see Fig. 1). It would be very interesting to know the extent of movement and cohesiveness of the Te Wae Wae population and determine whether they have any contact with east and west coast populations. Similarly, the small North Island population may have little or no contact with the main South Island population.

The species' distribution does not seem to be related to particular coastal types as it is found off both sandy and rocky shores and within its range does not appear to be restricted by latitude or sea temperature. It is regularly seen as far north as Port Waikato (37°22′S, 174°40′E) and as far south as Te Wae Wae Bay, although most of the population is restricted to South Island waters.

Hector's dolphins are not obviously restricted by wave action. They occur commonly along the west coast (New Zealand's most exposed and roughest coast) and appear to live and reproduce successfully without shelter from rough conditions. Conversely, on the more sheltered east coast these dolphins often enter the protected water of harbours.

The most consistent factor influencing the distribution of Hector's dolphin appears to be water depth. This, if correct, would explain their apparent absence from Fiordland (depths in excess of 300m are very common in inshore waters in this area) and their apparent reluctance to cross Cook Strait to North Island waters.

Some authors have commented that Hector's dolphins are often seen in discoloured water near river mouths and estuaries (Abel, Dobbins and Brown, 1971; Baker, 1972, 1978, 1983; Mörzer Bruyns and Baker, 1973) implying, or actually stating (Abel *et al.*, 1971; Baker, 1983) a preference for this habitat. We suggest that this interpretation may result from an unintentional bias in boat observations. Especially on the west coast of South Island, access to the sea is largely from river mouths. Boat traffic is much heavier in these areas than along other parts of the coastline. Although our survey often found dolphins near river mouths, there seemed to be no obvious association as we found dolphins in most inshore habitats. Similarly, we have seen the species in a wide range of water clarity, in water visibility of less than 10cm to greater than 15m (measured using a 25cm Secchi disk). We suggest that water clarity is unlikely to be a major factor limiting the offshore distribution of Hector's dolphin. The correlation of their distribution and turbid water is more likely to be the result of a preference for the inshore coastal habitat rather than a preference for muddy water *per se*.

Our observations do not indicate any significant seasonal differences in colour pattern, nor any systematic colour difference between east and west coast populations of Hector's dolphins, as was suggested might be the case by Mörzer Bruyns and Baker (1973).

In the absence of survey data, both Baker and Cawthorn have used records of incidental sightings, strandings and captures (Baker, 1978; Cawthorn, 1988) to determine the distribution of the species. This approach, although entirely justifiable, has two problems. Firstly, as in all analyses of incidental sightings, the reliability of species identification is not always perfect and some of the sightings may have been misidentified at sea. Secondly, such an analysis tends to place a disproportionate importance on isolated, rare and outlying records, indicating that the distribution is more extensive than it is. For example, there is a record of an incidental catch of a Hector's dolphin in the Hauraki Gulf (36°46.9′S, 174°59.4′E; Cawthorn, 1988), yet seven years of full-time patrol of that area by the Ministry of Agriculture and Fisheries vessel *Tokatea* has not resulted in a single sighting of this species (Whitehouse, pers. comm.). For this reason we suggest that regular sightings provide the most reliable indication of distribution and that extreme caution should be exercised in the interpretation of distributional information from rare or isolated records.

The strip-survey method used in this study should be conservative as it is unlikely that we counted more animals in an area than were present. As indicated above, photoidentified individuals were not resighted during the survey, suggesting that the survey data are not confounded by frequent recounting of individual dolphins. There is no evidence of any migration and, in certain areas, it appears that individuals are resident throughout the year (Slooten and Dawson, unpub. data). Some fishermen report that they have seen identifiable individuals in the same area for several years and, in our current behavioural work, we have rephotographed a number of individuals in the same area during all seasons (Slooten and Dawson, 1988).

Although the survey data are conservative, we have no reason to believe that the corrected estimates (at least for the summer survey data) are conservative except in areas which were not surveyed at all, or where no animals were seen. There are likely to be a few animals present in areas that were not surveyed and areas where we made no sightings, which therefore cannot be assessed and included in the population estimate. The histograms of offshore distribution (Fig. 2) suggest that the winter correction factor, which was applied to North Island data, may be more conservative as it seems likely that there are more dolphins beyond the end of the transects in winter than in summer. However, we should point out that the survey never failed to find dolphins in any area in which others had seen the species regularly and that the problems outlined above all concern areas of relatively low abundance. Even a doubling of the estimated number of Hector's dolphins present in these low abundance areas would not significantly affect the total population estimate.

In the light of these influences and using our numerical estimate of 3,408 individuals as a guide, we suggest that the current population of Hector's dolphins probably numbers between 3,000 and 4,000. This is a low figure for a marine mammal and underscores the urgent need to discover more about the biology and status of this species.

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Studies on Hector's Dolphin, *Cephalorhynchus hectori*: a Progress Report

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ABSTRACT

This paper summarises work carried out by the authors, as part of an ongoing Hector's dolphin research programme, since November 1984. It examines the following topics: distribution and abundance; external characteristics, ecology and behaviour; human-dolphin interactions. In particular, incidental catches in gillnets are a cause for concern and further work is needed to determine the status of this species.

INTRODUCTION

Hector's dolphin, *Cephalorhynchus hectori*, is the only dolphin found solely within New Zealand waters. In November 1984 the authors began a comprehensive research programme focussing primarily on four areas of interest: distribution and abundance, general biology, ecology and behaviour, and acoustic behaviour.

METHODS

Fieldwork

This study uses data gained through boat and shore-based observations which are carried out during all seasons. Regular boat surveys, conducted using a 4m inflatable and 25hp outboard, are used in conjunction with a photo-identification programme to study group composition, behaviour, movements and the associations between individuals. Photographs are taken on Kodak Tri-X black and white film with a motor-driven Pentax LX 35mm camera, using lenses ranging from 50mm to 300mm. The camera is equipped with a databack that imprints the time and date on each photograph. The photographic catalogue contains over 300 identifiable individuals. Land-based behavioural observations include tracking of dolphin groups with a theodolite. A *Racal Store* 4DS tape-recorder (running at a tape speed of 60 or 30ips), *Brüel and Kjaer* 8103 hydrophone, and a *Brüel and Kjaer* 2635 conditioning amplifier are used to record the sounds of this species.

Dissections

Dolphins that have been found beachcast (and are still reasonably fresh) or incidentally killed in fishing nets are measured, photographed and dissected.

The reproductive organs and stomach contents are preserved. Five teeth from the middle of the lower jaw are fixed in formalin for later sectioning (the rest are retained with the skeleton). Internal organs are weighed and passed on to parasitologists (J. McKenzie and D. Blair) at Canterbury University. Samples of blubber, muscle, liver, kidney and spleen are frozen for analysis for heavy metals and pesticides. Each skull and skeleton is placed in a plastic bin with holes in the top and moored in the shallows for amphipods to clean. The skeletal material is retained for analysis of epiphyseal fusion.

DISTRIBUTION AND ABUNDANCE

The results of a boat survey of the distribution and abundance of Hector's dolphin indicate a total population of 3,000–4,000 individuals (Dawson and Slooten, 1988). The species is frequently seen off both coasts of the South Island, being most common between 41°–44°S on the west coast, and between 41°–45°S on the east coast. The species is much less common in the waters of the North Island, and is regularly seen only off the west coast from the latitudes 37°–38°10′S.

Like Commerson's dolphin (see Goodall, Galeazzi, Leatherwood, Miller, Cameron, Kastelein and Sobral, 1988 – hereafter Goodall, Galeazzi *et al.*, 1988), the species favours an inshore neritic habitat. Hector's dolphins are most often seen within half a mile of the shore and are seldom found further than 5 n.miles offshore (Dawson, 1985; Dawson and Slooten, 1988). They are very commonly seen within 100m of the shore, off rocky, weed-dominated shores as well as sandy beaches, and are often seen surfing at beaches, repeatedly riding waves into water as shallow as half a metre deep. They are occasionally seen swimming a short distance up rivers, especially the large South Island Buller and Grey Rivers. In Banks Peninsula waters we have seen Hector's dolphins in sea surface temperatures from 6.3–22°C.

EXTERNAL CHARACTERISTICS

Morphology

Hector's dolphin is a small species, sexually mature adults usually falling within the range 117–145cm (for table of external measurements see Slooten and Dawson, in press). Its most distinctive feature is the rounded dorsal fin with its convex trailing edge. This feature is unique to the genus *Cephalorhynchus*. There is considerable variation in fin shape in Hector's dolphins and fin damage is common. The dorsal fins of a substantial part of the population are individually recognisable, allowing study of movements and associations using photographic identification. The rear edge of the dorsal fin is the most commonly damaged. The longest resightings in our photo-identification catalogue go back over two years to the beginning of the study, with dorsal fin nicks showing no signs of healing in that time. Many cases of dorsal fin damage appear to be caused by gillnet entanglement. Many of the nicks noted in the field are very similar, in character and positioning, to the fresh nicks observed on animals killed in gillnets.

Like the other three species in this genus, Hector's dolphins are short and stocky with proportionately large flukes. Baker (1984) lists maximum size (TL) and weight as 153cm and 57.27kg for females and 138cm and 52.72kg for males. Data from 33 dolphins we have dissected to date confirm this trend, suggesting that the sexual dimorphism in size shown by Commerson's dolphin, with females larger at all maturity stages (Goodall, Galeazzi *et al.*, 1988) holds also for Hector's dolphin.

As in Commerson's dolphin, the head shows no well-defined beak and slopes smoothly from the blowhole to the tip of the jaw. A rostral groove is present in very young animals but later disappears. Hair follicles were noted in the four youngest individuals we dissected (TL 76.6, 84, 90 and 99cm respectively), usually positioned in a row of four just below the rostral groove on each side of the head (but on the 90cm individual three on one side, and four on the other). The blowhole is always situated slightly to the left of centre.

The pectoral fins have rounded tips and, in most individuals, are slightly serrated along the leading edge. Baker (1978) noted '7–10 rugose nodules' on the leading edge of the pectoral flippers in subadult specimens, and similar flipper serrations are described from Commerson's dolphin (Goodall, Galeazzi and Sobral, 1988) and Heaviside's dolphin (Best, 1988). We have found serrations on the leading edge of both pectoral flippers in male and female Hector's dolphins. The degree of serration is variable but it is very rarely absent except in the very smallest individuals.

Colour pattern

The colour pattern of Hector's dolphins consists of a complex pattern of white, grey and black areas (Fig. 1), and has been accurately described by Mörzer Bruyns (in Mörzer Bruyns and Baker, 1973), Baker (1978; 1983) and Dawson (1985). Accurate illustrations are given by Baker (1983), Dawson (1985) and Foster (*in*: Leatherwood, Reeves and Foster, 1983). Slooten and Dawson (in press) provide a detailed description of the external appearance of this species, with photographs illustrating the differences between the coloration of adults and juveniles.

Newborn calves have the distinctive colour pattern of the adults insofar as the pattern of white, grey and black areas is fully developed. The newborn coloration differs in that the grey areas are a darker grey, and in very young calves the white areas have a yellowish tinge, as if a darker hue overlies the normal colour pattern. The newborns have a series of 4–6 vertical light bands along the grey flanks, perpendicular to the body axis and encircling the body between the flippers and anus (see Fig. 2). The vertical bands are only visible on the grey flanks and are the adult shade of grey. The light bands represent foetal fold marks and, in very young calves, are actually indented. A very young calf seen in the field had a light grey stripe along the base of its dorsal fin (on the right side) almost certainly caused by folding of the dorsal fin *in utero*, providing supporting evidence for the light bands being foetal fold marks.

The general body colour becomes progressively lighter over the months following birth, causing the light bands to become less distinct. The bands are still clearly visible after at least three months and have not disappeared

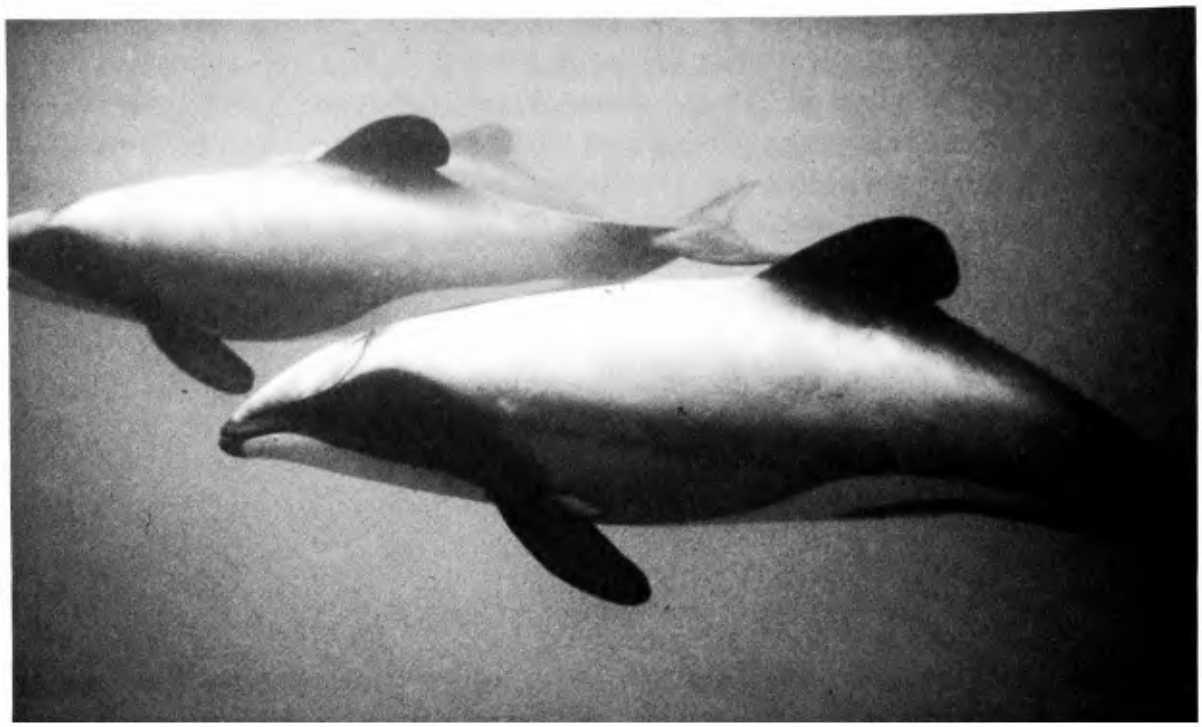

Fig. 1a. (top) Hector's dolphins photographed underwater off Banks Peninsula, South Island of New Zealand.

Fig. 1b. (bottom) Hector's dolphins leaping in Akaroa Harbour, South Island of New Zealand.

completely until about six months after birth, at which time the colour pattern of the calf has become lighter overall and indistinguishable from that of the adult.

Apparently Commerson's dolphins show some similarities with Hector's dolphins in the differences in colour pattern between adults and newborns. In

Fig. 2. Hector's dolphin mother and calf. The calf is probably less than a month old and has the light bands typical of newborn Hector's dolphins.

Commerson's dolphins the sides and back which are white in the adult are a dark grey in newborn calves, gradually fading to lighter grey within the first months and to white by one or two years (Goodall, Galeazzi *et al.*, 1988). Light bands, described as foetal fold markings, were noted on a Commerson's dolphin calf born recently at Sea World in San Diego (Stafford, 1985). This calf was described as a dark charcoal on the flanks where the adult is white, with the foetal fold marks giving it a striped appearance. Goodall, Galeazzi *et al.* (1988) describe a young Commerson's dolphin (103cm TL) which had four white lines on its left side, perpendicular to the body axis, which they felt could represent foetal folds.

Like Commerson's dolphin (see Goodall, Galeazzi *et al.*, 1988), male and female Hector's dolphins are sexually dimorphic in the coloration of the genital area (see Fig. 3). In males the genital slit is surrounded by a large, oval, dark grey patch, contrasting with the surrounding white of the belly. Ventral coloration is more variable in females which either have a much smaller grey, often finger-like mark along the genital slit, or a plain white belly without any grey markings. While in females the grey area around the genital slit is variable in size, it never takes the form of the large oval patch which is typical of males. The dimorphism is distinctive, not only in the extent of the grey, but also because the genital slit and the surrounding grey patch of the male are much further forward than the genital slit in females. Providing one gets a brief glimpse of the belly, the dimorphism allows easy sexing of animals in the field, especially underwater. This sexual dimorphism in coloration of the genital/mammary area may be important in sexual signalling and mate recognition. Unlike Commerson's dolphins, the mammaries are not highlighted by the female's genital patch, and the genital coloration of the female is unlikely to be of use to her calf in finding the mammary slits. The posterior edge of the white belly, behind the anus, shows a less obvious difference between males and

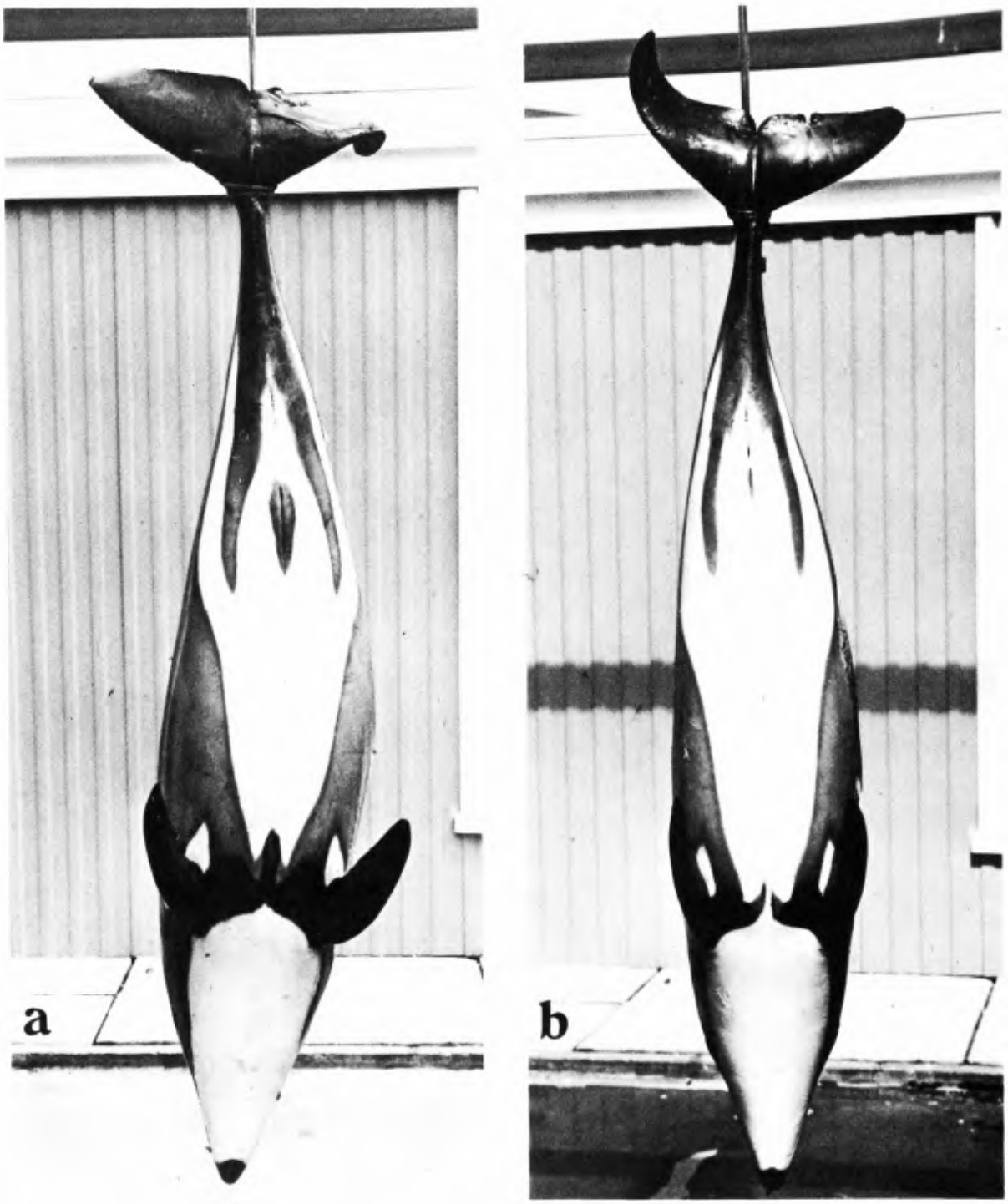

Fig. 3. Sexual dimorphism in the genital coloration of Hector's dolphin. (a) Male, 117cm TL. (b) Female, 117.2cm TL.

females. In males the white belly tapers smoothly into a point in males, while in females two side lobes tend to give the posterior edge a vaguely three-pronged appearance (see Fig. 3). However, the presence and extent of these side lobes is variable among females.

Slight differences in coloration between individuals are noticeable in the field, but are only occasionally obvious enough for easy identification of individuals. Our photo-identification catalogues contain at least one very pale (almost albino) individual on which even the normally black markings around the eye and just behind the blowhole are so light as to be nearly indistinguishable, but

usually colour pattern differences are more subtle. A small number of the animals dissected by us have had a small white 'spot' (approx. 5mm in diameter) surrounding the external ear opening similar to the marks described for *C. eutropia* (Goodall, Norris, Galeazzi, Oporto and Cameron, 1988) and *C. commersonii* (Goodall, Galeazzi *et al.*, 1988). Suggestions that there could be two separate populations (Mörzer Bruyns in Mörzer Bruyns and Baker, 1973) or subspecies (van Bree, 1972) of *C. hectori*, have not been confirmed and variations in colour pattern show no evidence of geographical trends.

External scars, diseases and parasites

Scars formed by healed injuries and patchy skin afflictions are more useful in individual identification. Patches of white, unpigmented skin on the black and grey parts of the body appear to represent scar tissue resulting from extensive skin damage. Dark patches are apparently caused by less extensive skin damage, often resulting from skin pathogens and parasites. Many of the Hector's dolphins in our study area bear dark skin markings consisting of circular patches of tiny dark dots (1mm or smaller), identical to those described as 'tattoo' lesions in the literature (Flom and Houk, 1979; Geraci, Hicks and St Aubin, 1979; Britt and Howard, 1983). Similar tattoo lesions on *Tursiops truncatus* and *Lagenorhynchus acutus* have been found to be caused by poxvirus (Flom and Houk, 1979; Geraci *et al.*, 1979) but we cannot yet confirm this for *C. hectori*. On Hector's dolphins, tattoo lesions have been found on all parts of the body but are more visible on the grey back and flanks where they show up as patterns of dark grey dots. Similar lesions on the white parts of the skin are barely visible as off-white or yellow markings, while on the black areas they are virtually invisible. While they may change slightly in shape and extent, tattoo lesions seem to persist for long periods and some of the dolphins in our catalogues have been identified and followed for over a year by distinctive patches of tattoo lesions.

Toothrake scars made by the teeth of other Hector's dolphins are commonly seen in the field and on animals passed to us for dissection. They stand out clearly as a row of parallel scratches with the same spacing as Hector's dolphin teeth, but are less visible on the black parts of the skin. Toothrakes tend to heal and virtually disappear within weeks or months (depending on depth of scarring) and are therefore relatively unreliable as a means of individual identification.

Ectoparasitic 'whale lice' *Scutocyamus antipodensis* (Lincoln and Hurley, 1980) are visible on Hector's dolphins swimming close to the boat as small dark-brown spots (3–4mm). *Scutocyamus* are common on the skin of Hector's dolphins and were first reported by Baker (1978). These cyamids are easily dislodged after the death of their host and are often not present on specimens that have been roughly handled, washed down, or been dead for more than a few hours. On one dolphin which had been dead less than 24 hours, we found 35 *Scutocyamus*. They apparently feed on sloughing-off skin and, despite possible annoyance, seem to do no harm to the dolphins.

INTERNAL ANATOMY, DISEASES AND PARASITES

The internal anatomy of this species is briefly discussed in Slooten and Dawson (in press) including a table of internal measurements. The skeletal structure of *C. hectori* has been described by van Bree (1972), Mörzer Bruyns and Baker (1973), Baker (1978) and Slooten and Dawson (in press).

Studies of the parasites of Hector's dolphin have been undertaken by McKenzie and Blair (Canterbury University) and some preliminary results are given in McKenzie and Blair (1983) and Slooten and Dawson (in press). Fluke-induced lesions of the mesenteric lymph node described by Hutton, Blair, Slooten and Dawson (1987) have now been found in four of the 33 dolphins dissected by us.

LIFE HISTORY AND POPULATION DYNAMICS

Relationships of age or length to sexual maturity are as yet poorly known. The 33 Hector's dolphins we have dissected to date (February 1987) included only two sexually mature females and five sexually mature males. Samples and histological material are still under study but preliminary results suggest that females mature rather late, which causes concern about the potential for population growth. Females 134.5cm TL and smaller were all immature. The smallest female with at least one corpus was 139cm TL and 44kg, while the smallest mature male was 117cm and 31kg. Another male of 117cm TL was still immature, as were all males smaller than 117cm and two males of 119cm TL. Sexually mature males in the sample (with testes 140g each or larger) were 117, 127, 129, 131 and 132cm TL respectively, suggesting that size at onset of maturity in males is variable, and around 117–127cm TL. Age/length relationships are not yet known. However, teeth from all dolphins dissected have been retained and estimates of age (GLG counts) will soon be available.

The smallest individual dissected by us was a female of 77cm TL and weighing 9.5kg. A piece of umbilicus was still attached, the teeth had not yet erupted, and the foramen ovale of the heart was still flimsy suggesting that this female had not long been born. On the basis of this specimen, as well as field observations of newborns, we estimate neonatal size at 60–75cm, or about half the length of the mother.

Calves are born during spring and early summer, from early November to February. The gestation period is not yet known for Hector's dolphins. Recent photo-identification data strongly suggest that the interval between calves is at least two years. Several mothers first photographed with a newborn calf in 1985/86 have been resighted in 1986/87 still accompanied by the yearling calf. We have not yet seen a known female with a new calf in two successive seasons.

The length of lactation is also unknown but squid beaks have been found together with milk in the stomach of a small female estimated to be less than six months old. This animal was incidentally caught in April, less than six months after the onset of calving, and still had very faint folds as described above. By comparison, the stomach of a young male estimated to be a year old contained a large number (80–100) of very small fish (averaging 3cm long).

Mating behaviour appears to peak in early winter. Although courtship-type displays have been observed at other times of the year, we have only seen actual mating in Hector's dolphins during autumn/winter.

Predation by sharks is a known source of mortality for Hector's dolphins. Remains of Hector's dolphins have been positively identified from the gut contents of at least six seven-gill sharks *Notorhynchus cepedianus* (Sintes and Tunnicliffe, pers. comm., 1985), and from blue sharks *Prionace glauca*. Seven-gill sharks average two metres in length (Ayling and Cox, 1982) and are particularly common around Banks Peninsula. However, the incidence of their predation on Hector's dolphin is unknown (and see Cawthorn, 1988).

ECOLOGY AND BEHAVIOUR

Group composition

Hector's dolphins are normally found in small groups of two to eight individuals (Baker, 1978; Dawson, 1985), which in areas of high density tend to cluster together. Diver observations suggest that most groups are of mixed sex and mixed size. Occasionally in summer we have seen groups comprised exclusively of two to four large females each with a young calf but it appears that these uncommon and seemingly temporary 'nursery' groups are the only ones in which any sexual segregation occurs.

While the individual groups are small, consisting of only two to eight individuals, up to 50 dolphins may be present within an area of half to one nautical mile in diameter. Within this area groups frequently come together, merge and then split up again. When groups merge in this way, up to 30 dolphins may mingle in what appears to be an intensely social context, before splitting up again into small groups. That the same may be true for Commerson's dolphins is suggested by Goodall, Galeazzi *et al.*'s observation (1988) that group size is usually small but that careful searching may reveal other groups nearby. Goodall, Galeazzi *et al.* (1988) suggested that in *C. commersonii* the predominantly small groups may be part of a large, scattered group which, when visible, may occasionally reach even into the hundreds. The same appears to be the case for *C. hectori*. The stability of the small groups and larger associations are poorly known but under study. Preliminary results suggest that the larger associations are relatively stable, while the composition of the smaller groups is in constant flux.

Feeding activity and bow riding on passing boats on the part of one of the smaller groups can cause several groups to converge. The mingling of individuals from previously separate groups tends to result in a marked increase in activity. Jumping, lobtailing, bubble-blowing, body contacts and aggression are all more common when two or more groups have just come together, beyond what one would expect from the simple increase in number of dolphins present.

Movements

Photographically identified dolphins have been resighted over time periods of over two years from the Banks Peninsula area during winter and summer, suggesting that many individuals remain in the general area year-round. Within

this area, however, a yearly pattern of inshore/offshore movement is becoming apparent. At Banks Peninsula, Hector's dolphins show a pronounced movement inshore into larger bays and harbours during summer from early November to late April. During these summer months, it is usual to see 30–90 Hector's dolphins in Akaroa Harbour (the largest harbour on Banks Peninsula), while during the rest of the year dolphins are seldom seen within the confines of the harbour. Even on the outer shores of Banks Peninsula outside the harbours, Hector's dolphins are distributed closer inshore in summer than in winter (Dawson and Slooten, 1988). Pascal (1981) and Robineau (1985) have suggested that the Commerson's dolphins at the Kerguelen Islands undertake similar seasonal movements.

Behaviour

Adult and juvenile Hector's dolphins are strongly attracted to small boats, especially those travelling slowly (less than 10 knots). They are not attracted to fast boats, and usually dive on their approach, surfacing after the boat has passed, not far from where they had dived. They do not appear to leave areas of high boat traffic. During summer, the eastern side of Akaroa Harbour tends to have the highest boat traffic, and the dolphins favour that side of the harbour, regardless of the level of boat traffic on the day. Mothers with newborn calves are relatively shy, and seldom approach stationary or moving boats.

Hector's dolphins show a wide range of behaviours including a number of different postures, body contacts, bubble-blowing, leaping, lobtailing, 'spyhopping', surfing and playing with pieces of seaweed and other objects. These behaviours are described elsewhere (Slooten and Dawson, in press).

Respiratory patterns

The dolphins spend a large amount of time in 'long-diving' sequences consisting of a long dive of about 90s (mean $\pm$ 95% confidence interval = 89.95 ± 6.16; $n = 58$ timed dives), followed by an interval of around 45 to 65s (54.36 ± 10.86; $n = 33$) during which each dolphin breathes an average of six times (6.03 ± 0.74; $n = 33$), before starting another long dive. This breathing pattern is almost certainly associated with mid-water and bottom feeding. During bouts of social and resting behaviour as well as surface feeding, long dives are absent and times between individual breaths tend to be longer; up to 26.5s between breaths, compared to the average of 9s (8.86 ± 1.04; $n = 33$) during intervals between long dives.

Feeding

Hector's dolphins are opportunistic feeders, feeding both at the bottom and throughout the water column. Prey selection appears to be by size rather than species. The stomach contents of dissected dolphins show that surface-schooling fish (e.g. yellow-eyed mullet, *Aldrichetta forsteri*) and arrow squid *Nototadarus sp.* are taken along with benthic fishes such as ahuru, *Auchenoceros punctatus*, and red cod, *Pseudophycis bacchus*. The largest prey item so far

recovered was an undigested red cod weighing 500g, having a standard length of 35cm. Crustaceans are occasionally found among the stomach contents, including *Ovalipes catharus*, *Hymenosoma depressum* and *Macropthalmus hirtipes*, but these appear to be mostly derived from the stomach contents of fish taken by the Hector's dolphins. Juveniles appear to start their solid diet with small fish and squid. The stomach of a young male estimated to be a year old contained a large number (80–100) of very small fish (average 3cm long), while the stomach of a calf estimated to be no more than six months old contained milk and very small squid beaks. Regurgitated food is very often found in the oesophagus and mouth of dolphins which have been caught in gillnets.

Hector's dolphins occasionally follow inshore trawlers fishing in water 20 to 60m deep, possibly feeding on the fish which are stirred up but not caught by the trawl gear. More usually they are seen feeding at the surface, or going through long-diving sequences of apparently bottom and mid-water feeding. Groups of feeding white-fronted terns, *Sterna striata*, are frequently associated with feeding Hector's dolphins.

ACOUSTICS

To investigate the sound repertoire, and to examine the contextual relationship of the sounds, recordings of free-ranging dolphins were made from a 4m inflatable boat. The first recordings of Hector's dolphins were made off Kaikoura by Watkins, Schevill and Best (1977). They reported low-level underwater cry sounds similar to those they had recorded from *Cephalorhynchus heavisidii* but their equipment was of extremely limited bandwidth (60Hz–10kHz). Recently we have made many recordings with a system having a bandwidth in excess of 200kHz. The dolphins are very vocal in the field and frequently approach within a metre of the hydrophone, occasionally rubbing on the cable. Preliminary analysis of some of the tapes indicates that many of the sounds are short (less than 200μs) high-frequency clicks with most energy concentrated in a narrow band around 120. These sounds are reported in Dawson (1988).

HUMAN EFFECTS

Captivity

Currently there are no Hector's dolphins in captivity, and there appear to be no plans to reintroduce Hector's dolphins to New Zealand's only marineland at Napier (Marineland of New Zealand). Four Hector's dolphins were held there from February 1970. Their capture, transport, captivity and some veterinary details are described in Abel, Dobbins and Brown (1971). The four (two males, two females) were captured by a 'tailgrab' in Cloudy Bay (41°20′S, 174°15′E) between 6–12 February 1970, and were flown to Napier. They arrived in good condition and ate well but did not survive well in captivity. One female died six weeks after capture, the second female dying three weeks later following an accident in which she was savaged by a captive leopard seal. One of the males died a week later, although unhurt by the seal. The remaining male lived for two and a half years in captivity (Cawthorn and Gaskin, 1984).

Directed and incidental catch

Historically, Hector's dolphins have been subject to a low but directed take, mainly for use as bait in traps for rock lobster *Jasus edwardsii* (A.G. Dobbins, pers. comm.). This directed catch seems to have stopped in recent years, following the popularisation of dolphins through television and the introduction of New Zealand's Marine Mammal Protection Act in 1978. Much more important is the incidental catch of this species. Hector's dolphins, dusky dolphins and common dolphins are all frequently caught in New Zealand waters, mostly in coastal gillnets, but only occasionally in trawls.

The Hector's dolphin incidental catch is probably worst around Banks Peninsula, where gillnetting is a popular fishing method, and where Hector's dolphins are common. Hector's dolphins are found close inshore, especially over the summer months when they are very often seen in bays and harbours, calving over the months of November to February. Unfortunately, highly-valued commercial fish species also move inshore in summer, hence gillnets are set close inshore. The main target species of commercial gillnetters have been two elasmobranchs, rig, *Mustelus lenticulatus*, and elephant fish, *Callorhynchus milii*, although catch effort for these two species is greatly declining due to overfishing and reduced quotas. One fisherman alone caught 44 Hector's dolphins in the 1985/86 season, all on the northern side of Banks Peninsula. We estimate that at least 50–90 Hector's dolphins are caught in commercial gillnets each year in the Banks Peninsula area.

Over the summer holiday period recreational gillnetting is extremely popular in the Banks Peninsula area. The nets are set in two types of environments, over rocky reefs, mainly targetting blue moki, *Latridopsis ciliaris*, and butterfish, *Odax pullus*, and over muddy areas targetting flatfish. We know of 9 Hector's dolphins that have been killed in recreational gillnets over the period November 1986 to mid-February 1987 in Akaroa Harbour alone. The 34 dolphins passed on to us from both commercial and recreational gillnetters ($n=26$) and found beachcast ($n=8$) show a sex ratio of exactly 1:1.

Clearly commercial and recreational gillnetting may be having a substantial impact on the Hector's dolphins found around Banks Peninsula, an area which was inhabited by an estimated 662 dolphins at the time of our population survey (Dawson and Slooten, 1988). It is impossible to provide an accurate estimate of the total number of dolphins incidentally caught because many fishermen are reluctant to inform anyone of their incidental captures. On the basis of the captures which we do hear about, the annual incidental catch (60–100 from the above commercial and recreational data) may be 10–15% of the total population (662) in the Banks Peninsula area. This is higher than the number of calves seen in a season and suggests that the Banks Peninsula population may be declining. Further work is clearly needed to determine the status of these animals.

In conjunction with the small population size and low reproductive rate of this species, we feel that the incidental catch constitutes a serious threat to the continued survival of this species, certainly in the areas of intensive gillnetting.

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The High Frequency Sounds of Free-Ranging Hector's Dolphins, *Cephalorhynchus hectori*

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ABSTRACT

Wideband recordings of the sounds of *Cephalorhynchus hectori* were made over the austral summer of 1986/87. Analysis of these sounds shows them to be low-level, high-frequency, single and double pulses that occur in sequences of very variable repetition rate. The structure of these sounds has much in common with those described from *Cephalorhynchus commersonii* and the distantly related *Phocoenoides dalli*. Like *P. dalli*, *C. hectori* is often incidentally caught in gillnets and the similarity of these two species' sonar systems suggests that this type of sonar system is poorly suited to detecting monofilament gillnets.

INTRODUCTION

Hector's dolphin, *Cephalorhynchus hectori*, is a small, coastal delphinid which occurs only in New Zealand waters (Slooten and Dawson, 1988). It is usually found in small groups within 5 n.miles (9.2km) of the shore and its total population is estimated at between 3,000 and 4,000 individuals (Dawson and Slooten, 1988).

Until recently the only sound recordings made of any of the *Cephalorhynchus* genus were those made by Watkins, Schevill and Best (1977). They recorded the sounds of four Heaviside's dolphins, *Cephalorhynchus heavisidii*, that were temporarily held in a sealed-off rock pool near Paternoster Bay, South Africa. The sounds recorded were:

> 'clicks at slow and variable repetition rates, bursts of clicks at relatively constant rate but variable frequency emphases, and pulse series at a variable but rapid enough rate to produce a tonal 'cry' sound.' Watkins *et al.* (1977, p. 316).

They found only low-level pulsed sounds with a bandwidth less than 5kHz and often less than 2kHz, with major frequency emphases at around 800Hz and secondary, non-harmonic emphases at 2–5kHz. Watkins *et al.* also noted that they had recorded some similar sounds from Commerson's dolphin, *C. commersonii*, and from a group of *C. hectori* recorded off Oaro (42°34′S, 173°30′) near Kaikoura, New Zealand. As the equipment used for these recordings had a limited bandwidth of 60Hz–10kHz, they were unable to record the high-frequency sounds made by these species. Watkins and Schevill (1980)

described similar sounds from four captive *C. commersonii* held temporarily at Mystic Marinelife Aquarium (Connecticut, USA) but again the upper frequency limit of their recording equipment (100kHz) prevented recording of the high-frequency sounds.

Studies of the high-frequency sounds have been made on only two of the species in the genus *Cephalorhynchus*, *C. commersonii* (Kamminga and Wiersma, 1981, 1982; Shochi, Zbinden, Kraus, Gihr and Pilleri, 1982; Hackbarth, Awbrey and Evans, 1985; Evans, Awbrey and Hackbarth, 1988) and *C. hectori* (this study). The high-frequency pulses of *C. commersonii* were found to be low-level, narrow band, single pulses with peak energy around 124kHz, and durations of 120 to 180μs (Shochi *et al.*, 1982). Similar conclusions were reached by Kamminga and Wiersma (1982). That the results of these two groups of researchers are similar is not surprising as they made their recordings from the same group of *C. commersonii* held at the Duisburg Zoo in Germany. Evans *et al.* (1988) report that this species produces two types of pulse, single pulses and double pulses. The single pulses recorded by Evans *et al.* (1988) seem to have been of slightly higher frequency (133kHz) than those of Shochi *et al.* (1982) and Kamminga and Wiersma (1982) and the pulses appear significantly longer (350-500μs).

METHODS

Recordings were made in Akaroa Harbour (43°50′S, 172°56′), on the south coast of Banks Peninsula, New Zealand (Fig. 1). Nine hours of vocalisations were recorded from free-ranging dolphins over the summer season of 1986/87. The sounds described here were recorded from a group of three dolphins that was playing with seaweed at the water surface. These recordings were made between 0802 and 0804 on 19 November 1986 and are typical of the sounds analysed from the rest of the tapes.

The recording system comprises a *Brüel and Kjaer* 8103 hydrophone, *Brüel and Kjaer* 2635 charge amplifier and a *Racal Store* 4DS recorder, operated at 60ips (152.4cm/s). The signal/noise ratio of this recorder is in the order of 40dB and the recording system has a frequency response that is essentially flat (±3dB) from 300Hz to 150kHz. As with the equipment of Evans *et al.* (1988), the upper end of this response is limited by the *B & K* 8103 hydrophone (-10dB at 200kHz). The equipment is battery powered and all recordings were made from a 4m inflatable boat. While the tape was running, a simultaneous behavioural commentary and timing information were dictated into another channel of the recorder. The settings of the signal input amplifier on the recorder were varied (and noted in the commentary) to avoid saturation.

Before detailed analysis, the tapes were transcribed at 1/16 speed using a *Multigon Industries Uniscan* II spectrum analyser. The transcripts provide a directory of sound type, location on the tape and intensity, along with a written version of the commentary. The tapes were analysed at 1/32 speed using a *Hewlet-Packard* 3561A 100kHz Dynamic signal analyser (analysing filter bandwidth 59.678Hz) with an *HP* 7470A plotter and *Gould* OS4000 digital storage oscilloscope. Several thousand pulses have been analysed using the *Unigon* analyser and 200 of these have been analysed in detail with the *HP* signal analyser and the oscilloscope.

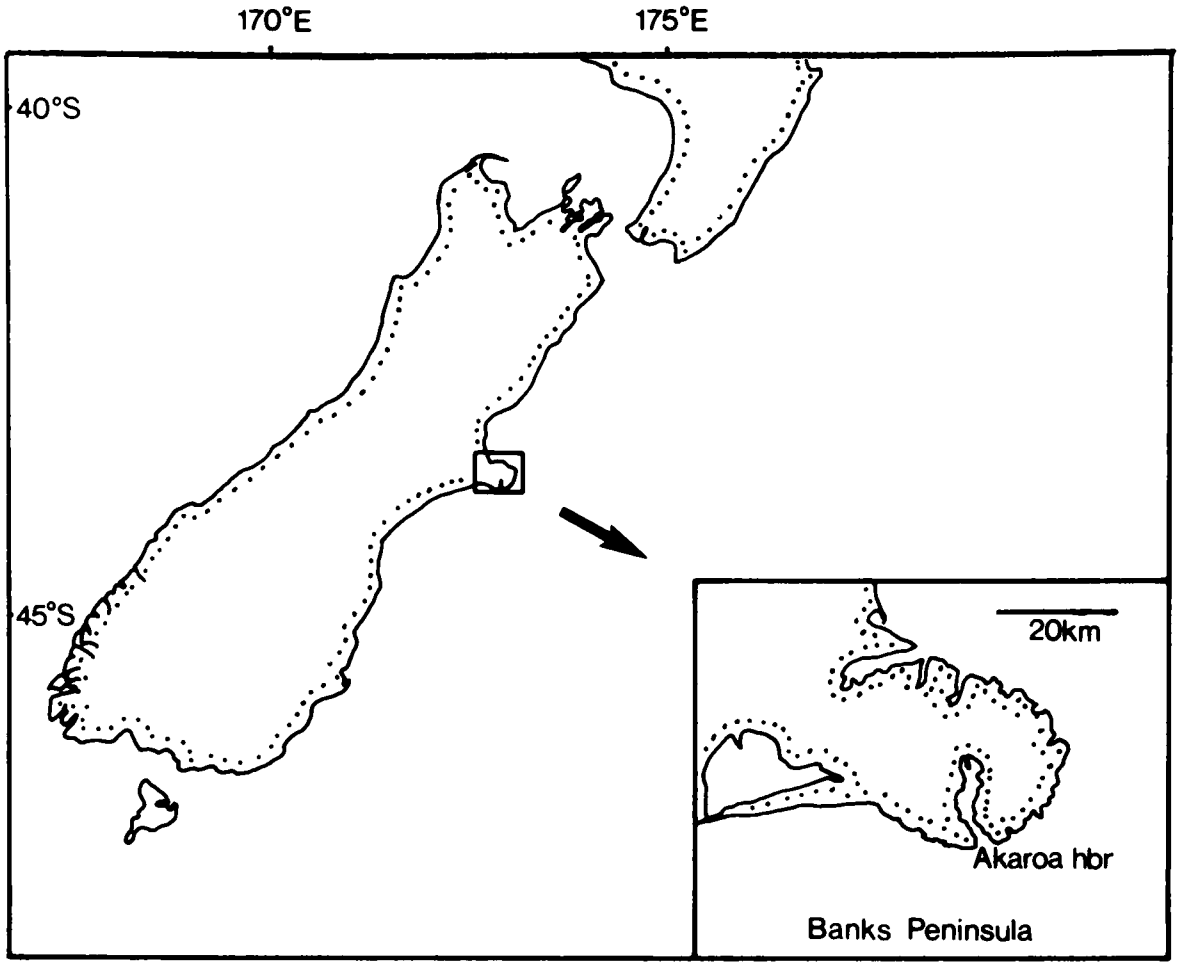

Fig. 1 Location of study site.

RESULTS

Being curious animals, Hector's dolphins are easy to approach, repeatedly coming to the boat to investigate the boat and hydrophone. They are also very vocal, so recording opportunities are frequent. The sounds are highly directional, however, and the examples reported here are from animals oriented directly at the hydrophone.

The recorded sounds are almost exclusively high-frequency pulses which, as in *C. commersonii* (Evans *et al.*, 1988), can be single or double pulses. A typical single pulse (Fig. 2) is centred around 120kHz. Of the pulses analysed in detail, the peak energy was always between 112kHz and 130kHz. Single pulses are usually less than 200μs long. The maximum sound pressure so far calculated (from a dolphin 1m from the hydrophone) was 150.7dB re 1μPA.

Double pulses (Fig. 3) occurred less frequently than single pulses. They are generally similar in their energy spectra and are approximately twice as long as single pulses, being usually less than 400μs in duration.

Both types of pulse occur in 'trains', series of pulses that can be extremely variable in length. The repetition rate of pulses within trains is also highly variable, ranging from about 2 to over 600 pulses per second, one of the highest rates recorded from a cetacean. Such high repetition rates generate the tonal 'cry' that Watkins *et al.* (1977) observed.

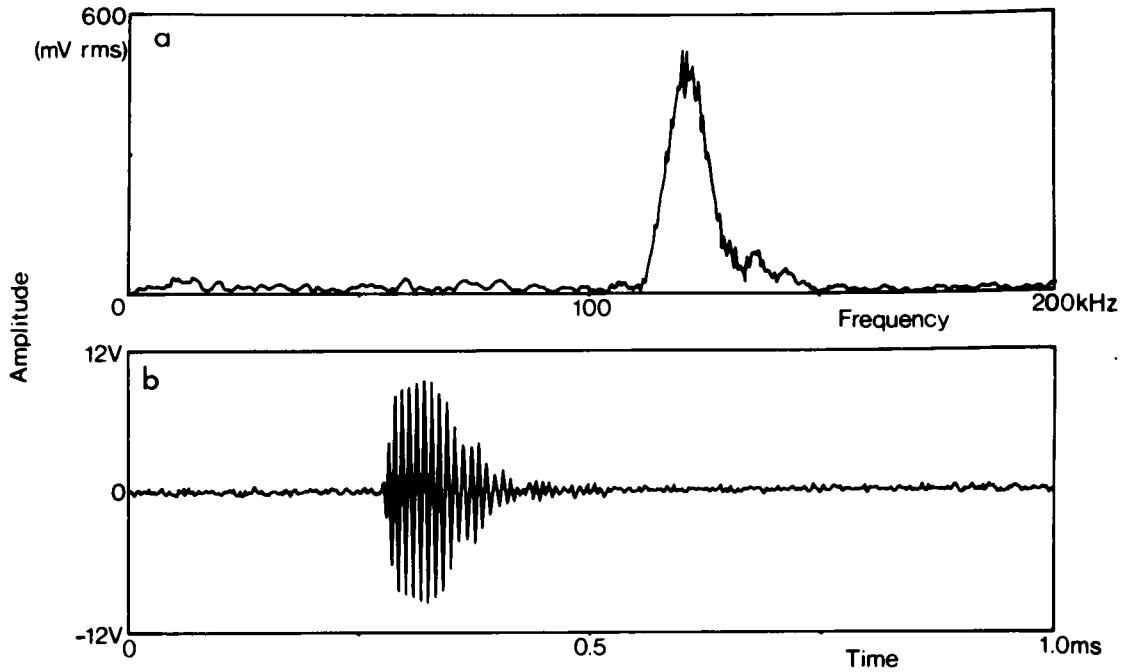

Fig. 2 Frequency spectrum (2a) and amplitude envelope (2b) of a single pulse.

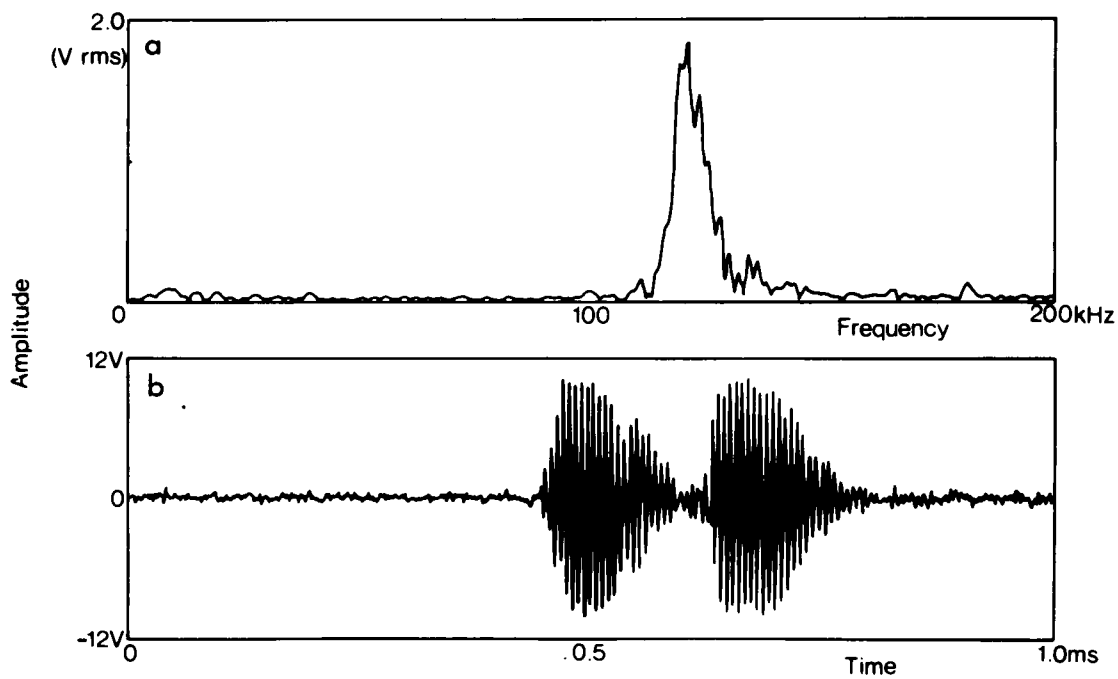

Fig. 3 Frequency spectrum (3a) and amplitude envelope (3b) of a double pulse.

DISCUSSION

While it seems certain that these high-frequency signals are used in echolocation, there is no *a priori* reason why this type of signal could not be used in intraspecific communication. Indeed the two aspects of echolocation and communication seem likely to be coupled, perhaps inseparably.

Kamminga and Wiersma (1981) showed that *Phocoena phocoena* and *Delphinapterus leucas* emit two-component sonar pulses consisting of a high-frequency and a low-frequency component. They, and Dudok van Heel (1981),

suggest that the high-frequency component functions in food finding, while the low-frequency component may function in coastal navigation. Although Shochi *et al.* (1982) did find a weak low-frequency component in the clicks of *C. commersonii*, the work of Evans *et al.* (1988) and Kamminga and Wiersma (1982) indicates that the sonar pulses of *Cephalorhynchus commersonii* are single-component pulses. As in *C. hectori*, the energy within the pulses is concentrated in a narrow, high-frequency band, with almost no energy at lower frequencies. This would appear to be the basis of a sonar system tuned for fine discrimination and food-finding. Such a sonar system would be of limited value in coastal navigation, where a much lower dominant frequency, such as in the low-frequency components of *Phocoena* and *Delphinapterus*, would provide appropriate resolution and better range (Dudok van Heel, 1981). Hector's dolphins are non-migratory and individuals typically range over small areas close to the coast (Slooten and Dawson, 1988) which they probably know in great detail. In this habitat these dolphins would seem to have little need for the low-frequency navigational components.

In an evolutionary sense, the non-migratory coastal niche of this species (and probably all the *Cephalorhynchus* species) and the lack of a low-frequency navigational component in the sonar are possibly related. Although it could be that the niche of this species did not favour the evolution of a navigational component, it is equally possible that the non-migratory coastal niche was dictated by the lack of a low-frequency navigational component in the sonar system.

Double pulses similar to those emitted by *C. commersonii* were commonly recorded from *C. hectori*. In general, the double pulses are approximately twice as long as single pulses and appear to be formed by two single pulses of normal length (150–200μs), with the second pulse immediately following the first. This contrasts with the double pulses which Evans *et al.* (1988) described from *C. commersonii*, in which each pulse of the double pulse is approximately half the length of a single pulse. There are some discrepancies in the length of high-frequency pulses reported from *C. commersonii*. The single pulses described by Evans *et al.* (1988) are at least twice as long (350–500μs) as those reported by Kamminga and Wiersma (1982) and Shochi *et al.* (1982).

The annual incidental catch of Dall's porpoise, *Phocoenoides dalli*, in monofilament gillnets runs into thousands and is the best-known marine entanglement problem (e.g. Jones, 1984). Evans and Awbrey (1984) and Evans *et al.* (1988) have shown the clear similarities between the high-frequency pulses of *C. commersonii* and *P. dalli*, and suggested that these pulses appear to be well suited to finding targets on the bottom among clutter. They further suggest that monofilament gillnets might be disregarded as clutter by echo-locating dolphins and predict that entanglement in such nets is likely to be a problem for Commerson's dolphin and perhaps all of the *Cephalorhynchus* species.

Recent work has shown that Hector's dolphin is often entangled in monofilament gillnets (Slooten and Dawson, 1988; Cawthorn, 1988) and that in some areas this may give cause for concern. An understanding of the sonar system of Hector's dolphin is crucial to the development of management strategies to reduce the impact of net entanglement.

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