Biology and Conservation of the

Cape (South African) fur seal

Arctocephalus pusillus pusillus
(Pinnipedia: Otariidae)

from the Eastern Cape Coast of South Africa

A thesis submitted for the degree of
Doctor of Philosophy from the
Australian National University

Carolyn Louise Stewardson
November 2001

The Australian National University

About 200 years ago, the great Swedish naturalist, Carl Von Linné, described the animal group Phoca (=seals) as follows:

> *"This is a dirty, curious, quarrelsome tribe, easily tamed, and polygamous; flesh succulent, tender; fat, and skin useful. They inhabit and swim underwater, and crawl on land with difficulty, because of their retracted fore-feet and united hind-feet; feed on fish and marine productions, and swallow stones to prevent hunger, by distending the stomach".*

Linné, Carl von (1802). *A general system of nature.....*Vol. 1. London: Lackington, Allen. p. 38.

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I declare that the research described in this thesis is my own original work except where otherwise acknowledged. Ten of the thirteen papers presented here are authored jointly with one or more authors. In each case, I am the senior author and the principal contributor to all aspects of the work.

The contribution/s of the co-authors are stated below.

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Discussion of ideas presented and use of facilities (Chapter 8).

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Ansie de Kock and Cecilia Saunders
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Analysis of blubber samples for heavy metals and pesticide concentrations (Chapter 12).

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Positive identification of seal parasites (Chapter 13).

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Preface

This thesis is written as a series of thirteen papers (Chapters 2–8, 10, 12–14), plus an introduction (Chapter 1), two unpublished chapters (Chapters 9 and 11) and a conclusion with ideas for future research (Chapter 15). This method of presentation maximises brevity; however, some repetition of methodology and references is inevitable.

Chapters 9 and 11 are currently being prepared for publication. I was unable to finish these two papers in time for inclusion in this thesis.

SUMMARY

Chapter 1: In 1990, the commercial harvest of seals in South Africa was postponed indefinitely until sufficient scientific information was available to make informed management decisions on the issue. Consequently, various programs were initiated on the south-east Atlantic coast, with little work, other than estimation of seal numbers, undertaken on seals of the south-west Indian ocean coast, particularly Algoa Bay, the eastern most boarder of the seals breeding range. Despite the small size of the seal population in this area there is a continuing and increasing interaction between fishermen and seals for available resources. The effects of this on the local seal population are unknown, but unlike the west coast seal population, that on the Eastern Cape coast is not increasing. Subsequently, the World Wide Fund for Nature initiated a study investigating the biology and conservation of Cape fur seals in Eastern Cape waters, to assist in the formulation of policy on seal conservation and management (WWF-South Africa project ZA–348). Specific objectives were to gather information on the: (i) general biology of the species; (ii) impact of commercial harvest; (iii) actual/potential threats that may affect the local seal population; (iv) nature and extent of sea-fisheries interactions; and (v) population size.

Chapter 2: The gross and microscopic anatomy of the Cape fur seal heart, lung, liver, spleen, stomach, intestine and kidneys (n = 31 seals) was described. Data indicate that body weight increased by 23% per annum until at least 9–10 y of age. Organ weight increased at a rate of between 25% and 33% per annum until at least 9–10 y of age, with the exception of the intestines, where exponential increase appeared to have ceased by about 7 y. Most organs increased in proportion to the body. However, the heart, liver and spleen appeared to increase at a faster rate than the body. The basic anatomical features of the viscera were similar to those of other pinnipeds, with some exceptions, including the arrangement of the multilobed lung and liver. Apart from the large liver and kidneys, relative size of the organs did not differ greatly from similar sized terrestrial carnivores. The histological features of the organs were generally consistent with those previously described for this species and other otariids.

Chapter 3: Morphology (n = 12 linear variables), relative size and growth of the male Cape fur seal was described. At birth, males are 35% (*c.* 69 cm) of their mean adult size. At puberty, they are 57% (*c.* 113 cm). The foreflippers are relatively long measuring 25–26% (*c.* 18 cm) of standard body length (SBL) in pups, and 24% (*c.* 48 cm) of SBL in adults. The hind flippers are considerably shorter measuring 19% (*c.* 13 cm) in pups, and 14.5% (*c.* 29 cm) in adults. Axillary girth is usually about 57–67% of SBL. Growth of SBL was rapid during the early postnatal period with a significant growth spurt occurring at the onset of puberty (2–3 y). The rate of growth slowed significantly between 6 and 7 y. A weak growth spurt was observed at 9 and 10 y (social maturity). Growth slowed thereafter, i.e., the mean for males > 10 y was 199 cm. Relative to SBL, facial variables and the fore/hind limbs scaled with negative slope relative to SBL or were negatively allometric; axillary girth scaled with positive slope; and tip of snout to anterior insertion of the foreflipper was positively allometric. Relative to age, body variables scaled with negative slope or were negatively allometric. In animals 1–10 y, SBL was found to be a very 'rough indicator' of age and age group.

Chapter 4: Morphology (n = 32 variables), relative size, and growth of the skull was described. Condylobasal length (CBL) was highly, positively correlated with SBL and age. Overall, skull variables grew at a slower rate than SBL, apart from height of mandible at meatus and angularis to coronoideus, which expressed isometry relative to SBL. CBL continued to increase until at least 12 y, with no obvious growth spurt between 8–10 y, when social maturity is attained. Mean CBL was 19.4% of SBL in yearlings; 15.5% in subadults, and 13.7% in adults. Apart from the dentition, all variables of the facial skeleton followed a somatic growth trajectory. Most of these variables expressed positive allometry relative to CBL, with greatest growth occurring in the vertical part of the mandible. Mastoid breadth, and gnathion to middle of occipital crest, expressed a strong secondary growth spurt at 10 y. Breadth of braincase, and basion to bend of pterygoid, followed a neural growth trajectory, scaling with negative slope relative to CBL. Condylobasal length was found to be a 'rough indicator' of SBL and age group (adult, subadult), but not of absolute age.

Chapter 5: Morphology (n = 8 linear variables and mass), relative size and growth of the baculum was described. The baculum continued to increase in size until at least 10 y, with growth slowing between 8–10 y, when social maturity is attained. Growth in bacular length, distal height and bacular mass peaked at 8 y; middle shaft height and distal shaft height peaked at 9 y; proximal height, proximal width, distal width and proximal shaft height peaked at 10 y. In the largest animals (age unknown), maximum bacular length was 139.3 mm and mass 12.5 g. Relative to SBL, bacular length increased rapidly in young animals, peaked at 9 y (6.9%), and then declined. Bacular mass and distal height expressed greatest overall growth, followed by proximal height, proximal shaft height and bacular length. At 9 y, mean bacular length and mass was 117 mm and 7 g; growth rates in bacular length and mass were 311% and 7125% (relative to age zero), and 5% and 27% (between years); and bacular length averaged 6.9% of SBL. For all males ≥ 12 months, most bacular variables grew at a faster rate than SBL and bacular length. Exceptions included proximal width which was isometric to SBL; distal width and distal shaft height which were isometric to bacular length; and proximal width which was negatively allometric relative to bacular length. Bacular length was found to be a 'rough indicator' of SBL and seal age group (pup, yearling, subadult, adult), but not of absolute age.

Chapter 6: Suture age as an indicator of physiological age in the male Cape fur seal was investigated. The sequence of partial suture closure differed from the sequence of full suture closure, with fusion beginning at different ages and some sutures taking longer to close than others. In animals ≤ 12 y, the sequence of full suture closure was the basioccipito-basisphenoid, occipito-parietal, interparietal, coronal and finally the squamosal-jugal. Suture age was found to be an unreliable indicator of chronological age. However, the basioccipito-basisphenoid can be used independently as an indicator of age, i.e., suture open, ≤ 3 y

old; suture fully closed, 3–4 y or older and male has reached puberty.

Chapter 7: Differences in body size and skull morphology (*n* = 31 variables) of male and female Cape fur seals were investigated. Males were found to be significantly larger than females in SBL. Principal component analysis (covariance matrix) showed that the underlying data structure for male and female skull variables was different, and that most variance between the sexes was expressed in overall skull size rather than shape. Males were significantly larger than females in 30 of the 31 skull variables. Breadth of brain case was the same for the genders. Relative to condylobasal length, males were significantly larger than females in 13 of the 30 skull variables. These were gnathion to posterior end of nasals, breadth at preorbital processes, least interorbital constriction, breadth at supraorbital processes, greatest bicanine breadth, breadth of palate at postcanine 1 and 3, calvarial breadth, mastoid breadth, gnathion to anterior of foramen infraorbital, gnathion to posterior border of preorbital process, height of skull at base of mastoid and height of mandible at meatus. In males, these variables were associated with the acquisition and defence of territory (e.g., large head size and mass; increased structural strength of the skull; increased bite capacity). Females were found to be significantly larger than males, relative to condylobasal length, with respect to breadth of brain case and length of upper postcanine row.

Chapter 8: Reproduction in the male Cape fur seal was investigated. The presence of sperm in the seminiferous and epididymal tubules indicated that males attain puberty between 3 and 4 years of age. Although some males may remain in breeding condition until March, the absence of spermatozoa in the epididymis during February to June, when mean testis mass and mean tubule diameter reached a minimum, clearly showed reproductive quiescence following the rut. Four stages of spermatogenesis were observed: (i) inactive (February/March–June); (ii) early spermatogenesis (July); (iii) late spermatogenesis (July/August–December/January); (iv) epithelial regression (February–June). Individual variation between males, possibly differences in social status and body condition, may influence the duration of spermatogenesis, hence the overlap in duration between epithelial regression and inactivity.

Chapter 9: The diet and foraging behaviour of Cape fur seals from the Eastern Cape coast was investigated. It was shown that Cape fur seals are opportunistic feeders and take predominantly benthic prey. Prey species included 37 species of fish, 7 species of cephalopods, a small number of crustacea (mostly decapoda) and other miscellaneous items. Analysis of faecal samples at the Rondeklippe colony suggested that the most numerous and most frequently occurring prey species were *Cynoglossus zanzibarensis/ capensis* and *Austroglossus pectoralis*. Analysis of faecal samples (and regurgitates) at Black Rocks seal colony suggested that the most numerous and frequently occurring prey species were *Loligo vulgaris reynaudii* and *Trachurus trachurus capensis*. Analysis of stomach contents from stranded seals suggested that the most important prey species based on percent total mass were *L. vulgaris reynaudii, T. trachurus capensis*, *Pagellus bellottii natalensis*, *Etrumeus whiteheadi* and *C. zanzibarensis/capensis*. Analysis of stomach contents from animals incidentally entrapped in trawl nets suggested that the most important prey species based on percent total mass were *Lepidopus caudatus*, *M. capensis/paradoxus*, *T. trachurus capensis* and *Octopus magnificus*. The model size of *M. capensis, M. paradoxus, T. trachurus capensis, A. pectoralis* and *L. vulgaris reynaudii* consumed by Cape fur seals fell within the range of local commercial catches, indicating potential competition between seals and the fisheries in this region. A bimodal distribution in the frequency of diving at different hours of the day was observed, with most dives occurring near dawn (± 3 hours) and dusk (± 3 hours) (*n* = 2 females). This overlaps with the time of day when important prey species such as *M. capensis, M. paradoxus, T. trachurus capensis* and *L. vulgaris reynaudii* have moved upwards in the water column (away from the sea bed) and are subsequently more accessible to seals. Female Cape fur seals can dive > 160 m, and can remain submerged for at least 3–5 minutes (*n* = 2 females).

Chapter 10: The impact of the fur seal industry on the current distribution and abundance of Cape fur seals in the Eastern Cape coast was investigated. On the Eastern Cape coast, Cape fur seals inhabited six islands in Algoa Bay (Stag, Seal, Black Rocks, St. Croix, Jahleel and Brenton) and two sites in Plettenberg Bay (Seal Point on the Robberg Peninsula and Beacon Island). Soon after British settlement of Algoa Bay in 1820, the St. Croix and Bird Islands were leased to individuals by the governor of the Cape Colony (Lord Charles Sommerset) at an annual rental, for fishing and sealing purposes. Available evidence suggests that seals had been extirpated from St. Croix, Jahleel and Brenton Islands in the late 1850s; Seal Point between 1857 and 1890; Stag Island in the mid/late 1800s; Seal Island in the early 1900s; and Beacon Island in the late 1800s/early 1900s. Black Rocks was the only colony on the Eastern Cape coast to survive commercial sealing operations. Access to Black Rocks is difficult and for that reason sealing activities were irregular. Sealing operations on Black Rocks were terminated in 1949. At present, Black Rocks supports *c.* 700 seals. In the last 12 years the population has decreased by 82%. By destroying seal herds through commercial harvesting, and confining the population to Black Rocks, the population is unable to build up its numbers sufficiently to stimulate colonisation on neighbouring islands. Limited space for breeding seals on Black Rocks, and the influence of storms (gale force winds and high swells) restricts the number of pups that can be reared successfully. It is unlikely that the Black Rocks population can increase quickly enough to flow onto Seal and Stag Island, without being depleted by storms.

Chapter 11(a): An evaluation of operational interactions between the trawl fishing industry and Cape fur seals, in waters off the Eastern Cape coast was conducted. Information was obtained from independent observation aboard commercial trawl vessels. Observations indicated that the annual number of seals entrapped and brought aboard by commercial trawlers was estimated to be 997 (0.258 seals per trawl). The annual mortality rate of seals due to drowning was estimated to be 529 (0.137 seals per trawl). The annual overall mortality rate was estimated to be 549 (0.142 seals drowned/deliberately killed per trawl). Drowned animals were predominantly males, ≥ 5 y. Although the seal population on the Eastern Cape coast remains viable, the long term effects of changing the population structure, by removing males ≥ 5 years, are unknown.

Chapter 11(b): An evaluation of operational interactions between the squid jigging/line fishing industry and Cape fur seals, in waters off the Eastern Cape coast was conducted. Information was obtained from questionnaire surveys, with limited independent observation aboard commercial chokker squid vessels. Fishermen interviewed used various methods to discourage seals from interfering in fishing operations including firing a shot near the seal to frighten it; using clubs; gaffing/hooking the seal; using knives; throwing objects (e.g., sinkers, stones); using a catapult; feeding the seal with mackerel; catching the seal; loud noises; starting of engines; banging gaffs on the water surface; waiting for some other fishermen to shoot the seal; and moving to another area. Some fishermen deliberately kill (shoot) seals in order to reduce their perceived impact. More than 1 000 are illegally shot in this area each year. At sea, it is not always possible to achieve a clean head shot, therefore, many seals are shot in the stomach or back, and die a slow, painful death. Considering that large numbers of seals are being shot in this area, ongoing monitoring of the seal population is required.

Chapter 11(c): The incidence and nature of entanglement of Cape fur seals off the Eastern Cape coast was investigated. Observations during the 1993 pupping season at Black Rocks indicated that the minimum estimated frequency of entanglement was *c.* 0.11–0.22%. Examination of stranding records, animal hospital files, and direct observation at seal colonies, suggested that mono-filament line accounted for 28% of entanglements, trawl net fragments accounted for 36%, and rope accounted for 36% (n = 26 entangled seals). Although debris-related mortality does not appear to impact significantly on the local seal population, much of the materials which entangles seals is highly durable, and floats at the water surface for long periods. Such material is likely to accumulate in areas of up- or down- welling where the animals feed. As the fishing industry continues to expand, more synthetic material will accumulate, and the incidence of entanglement in this area will subsequently increase. Therefore continued monitoring of the population, and the nature of entanglement, is essential.

Chapter 12: The concentration of heavy metals (Cd, Cu, Pb, Ni and Zn) and organochlorine contaminants (PCBs, DDT, DDE and DDD) in the blubber of 12 adult male Cape fur seals was investigated. The median and range of concentrations of metals were, in µg/g wet weight: Cd, 0.4 (<0.04–0.53); Cu, 2.6 (2.17–7.43); Pb, 0.7 (0.54–0.99); Ni, 17.7 (9.39–23.18) and Zn, 11.5 (3.14–16.65). Dry weights were: Cd, 0.5 (<0.04–0.59); Cu, 2.9 (2.47–8.45); Pb, 0.6 (0.54–1.14); Ni, 17.0 (10.79–28.22) and Zn, 12.8 (3.61–20.26). Concentrations of Cd, Pb and Zn were in the limits of reported values; however Cu and Ni levels were considerably higher. There was no evidence that the elevated levels of Cu and Ni reported in this study would pose a serious threat to the health of individual animals; however, high concentrations of these metals may be sufficient to result in some additional stress to animals when they mobilise their lipid reserves during illness or starvation. Concentrations of organochlorines (µg/g wet weight) were below the limit of detection.

Chapter 13: Endoparasites recovered from the blubber and stomach of Cape fur seals were documented. Forty three (81%) of the 53 seals examined harboured stomach parasites, and 13 (25%) harboured blubber parasites. Nine parasite taxa were identified. Helminth species included adult cestodes *Diphyllobothrium* sp., larval cestodes, *Hepatoxylon trichiuri* and *Phyllobothrium delphini*; nematodes, *Anisakis physeteris*, *Anisakis simplex*, *Contracaecum ogmorhini*, *Contracaecum* sp. and *Hysterothylacium* sp. and an acanthocephalan, *Corynosoma* sp. Three of these taxa, *Hepatoxylon trichiuri*, *Anisakis physeteris*, and *Hysterothylacium* sp., were accidental parasites. Scanning electron microscope examination confirmed the identity of *Contracaecum ogmorhini* and suggests that earlier studies may have incorrectly identified this nematode as *Contracaecum osculatum*. The endoparasites found in the present study did not appear to contribute to the mortality of Cape fur seals, at least in the population from which the examined specimens were taken. Although the anisakine nematodes, *Contracaecum* sp. and *Anisakis* sp., are potentially pathogenic, severe pathological changes were limited to small gastric lesions in the stomachs of three individuals.

Chapter 14: Preliminary studies investigating the nature and extent of shark predation in Eastern Cape waters were conducted. In Eastern Cape waters, potential shark predators include the white (*Carcharodon carcharias*), broadnose sevengill (*Notorynchus cepedianus*), bluntnose sixgill (*Hexanchus griseus*), shortfin mako (*Isurus oxyrinchus*), bull (*Carcharhinus leucas*), tiger (*Galeocerdo cuvier*), and dusky (*Carcharhinus obscurus*). Only the white and broadnose sevengill shark have been observed actively feeding on Cape fur seals. Shark bitten seals were observed throughout the year, with coastal records peaking in the autumn/winter period. Adult animals were observed with shark bite wounds more often than young. Wounds were usually located on the lower body, suggesting that attacks were made from behind. Fresh shark bite wounds were found on a minimum of 3.4% of seals found stranded on local beaches, and 0.3% of seals observed at the Black Rocks colony during the breeding season. Although predatory encounters appear to be common, long term studies are required before we can fully assess the extent of shark predation along the Eastern Cape coast.

Chapter 15: Immediate threats to the local seal population include deliberate shooting of seals; incidental catch in commercial fishing gear; and storms (gale force winds and high swells) during the pupping/mating season. Commercial harvest was a major threat to the survival of the local population up until 1949. Entanglement in man made debris was identified as a potential threat. Other potential threats, not examined in the present study, included disturbance (e.g., the planned deep sea port and industrial zone within Algoa Bay by Coega Development Corporation), habitat degradation, and episodic mass mortalities. Future research should concentrate on: (i) monitoring of seal numbers; (ii) ways to minimise negative interactions between seals and fisheries; and (iii) monitoring the population for signs of disease. In order to conserve seals in Eastern Cape waters, a comprehensive seal conservation and management plan is required which addresses the following key issues: incidental catch in commercial fishing gear, deliberate shooting of seals, entanglement, disturbance caused by human activity, habitat degradation, episodic mass mortalities, education and marine protected areas.

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