The comparative foraging ecology of Royal *Eudyptes schlegeli* and Rockhopper *E. chrysocome* Penguins

by

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Declaration

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgment is made in the text of the thesis.

Cindy Hull

Authority

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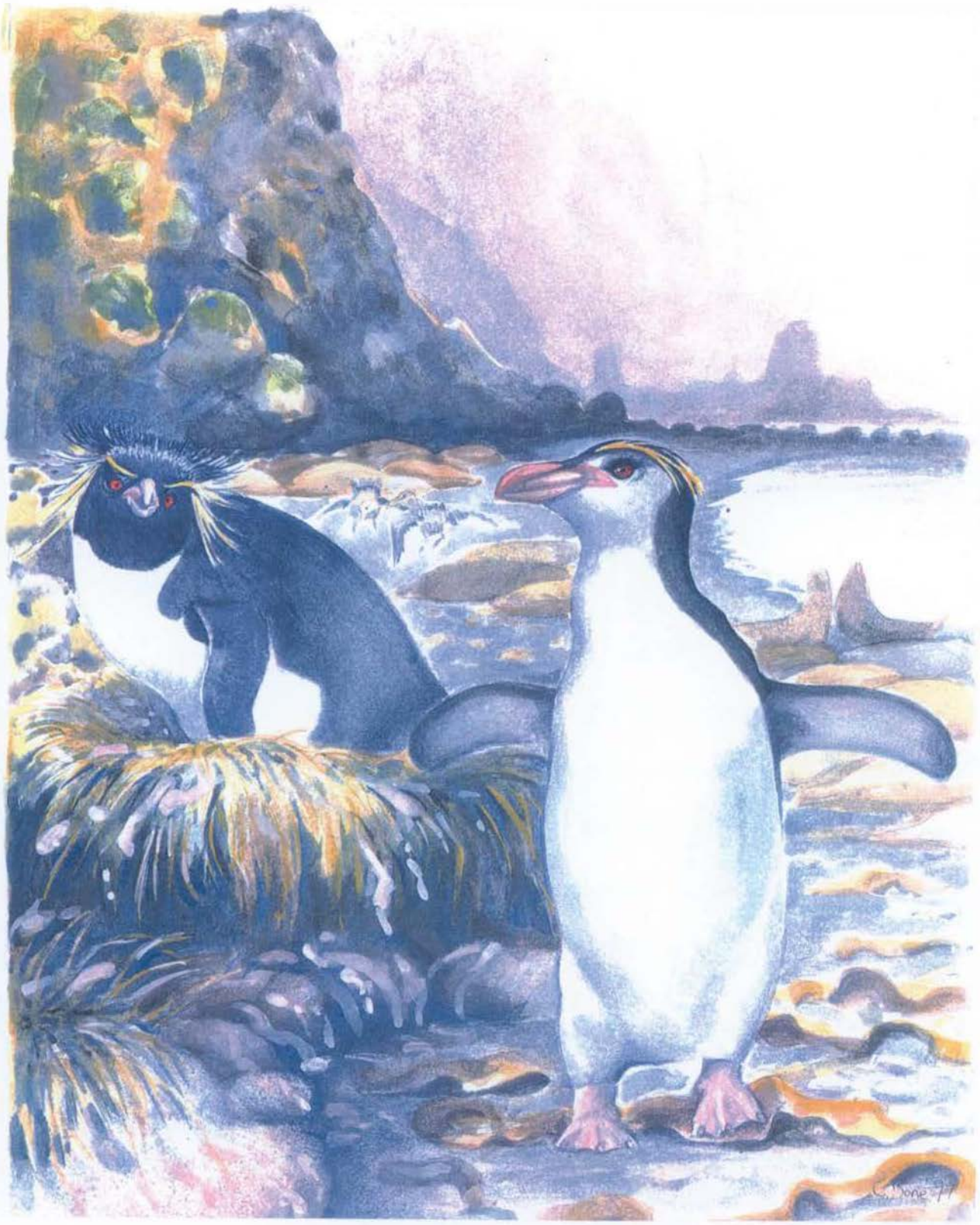


Frontispiece

Watercolour inspired by Royal and Rockhopper Penguins at Macquarie Island.

Catherine Bone, May 1997

Abstract

Penguins are well adapted to the marine environment, spending the majority of their time at sea. Whilst their ecology is intrinsically linked to this environment, details of how they interact with biotic and abiotic aspects of it are not well known for most species. The majority of penguins have a limited breeding season, and commitments at the nest necessitate that their foraging ranges are restricted, presumably placing pressure on prey resources around nesting colonies. Sympatrically breeding species are thought to compete for these resources, and their co-existence is thought possible by the segregation of aspects of their ecologies, in particular foraging zones, diet or the asynchrony in breeding timetables. Royal and Rockhopper Penguins both belong to the *Eudyptes* genus, are ecologically very similar, and breed sympatrically on Macquarie Island. This similarity provides the opportunity to explore the issue of ecological segregation in these two species. The purpose of this study was to describe the foraging ecology of Royal and Rockhopper Penguins and to determine the degree of overlap in resource use. It was undertaken over three years (1993/4, 1994/5 and 1995/6) to examine inter-annual variability.

The thesis is divided into two parts, the first dealing with methodological aspects. Morphometric indices were determined for externally sexing birds in the field. Bill length and depth were found to be reliable measures for sexing individuals of both species. Experiments assessing the impact of investigators on breeding success found no significant effects, provided care was taken when working in the colony. The

deployment of external devices (transmitters and Time Depth Recorders, TDRs) was an integral part of data collection in the study, and the impact of these on Royal Penguins was examined. No effects were found in birds carrying the small, streamlined VHF transmitters, but the attachment of the larger, unstreamlined TDRs decreased the likelihood that penguins would return from a foraging trip, increased foraging trip duration, increased water influx rates, and decreased accumulated fat levels. The different impacts of the devices was related to their size and streamlining most likely affecting drag. Some aspects of the foraging ecology of penguins carrying TDRs were therefore not entirely representative of unencumbered birds.

The second part of the thesis examined the foraging ecology and degree of overlap in resource use in Royal and Rockhopper Penguins. Aspects examined were: foraging zones (using satellite telemetry, TDRs which estimated positions using geolocation, sea surface temperature, and foraging trip durations); diving behaviour; diet; and breeding biology.

Both species foraged offshore, to the southeast of Macquarie Island in the polar frontal zone, further than had previously been estimated (Royal Penguins 600 km and Rockhopper Penguins 480 km). Foraging zones changed with stage in the breeding season, with their extent being related to foraging trip durations, determined by commitments at the nest. The sea surface temperatures in which both species travelled were the same (6.8 - 10.8° C), and constant between years and stages in the breeding season. The position of the polar frontal zone changed during this period, suggesting

that the species targeted a specific part of the zone.

Royal and Rockhopper Penguins were predominantly diurnal foragers, with most diving between the hours of 04:00 and 21:00. They spent 38.9% and 36.6% of a 24 hour period respectively, diving. Both species were capable of diving to over 100 m, but spent the majority of their time at depths less than 60 m in dives of less than 2 minutes duration. This emphasis on shallow, short dives probably maximised foraging efficiency by reducing the degree of anaerobic metabolism, with its associated cost of removing respiratory byproducts, and reduced time spent descending and ascending in the water column, which is presumably less profitable foraging time.

The diet of both species was dominated by small, gregarious pelagic prey, particularly euphausiids (dominated by *Euphausia vallentini*), and myctophid fish (dominated by *Krefftichthys anderssoni*). Diet varied between years, but was constant across the breeding season, although fewer taxa were consumed before, compared to after, the hatching of chicks.

The breeding biology of both species was similar and synchronous between individuals and years of the study, which is most likely related to the limited temporal window these species have in which to breed. The investment in clutches was low (6.3% in Royal Penguins and 7.0% in Rockhopper Penguins), and breeding success was constant between species and years (on average 53.3% in Royal Penguins and 47.3% in Rockhopper Penguins). Most breeding failures occurred during incubation, with

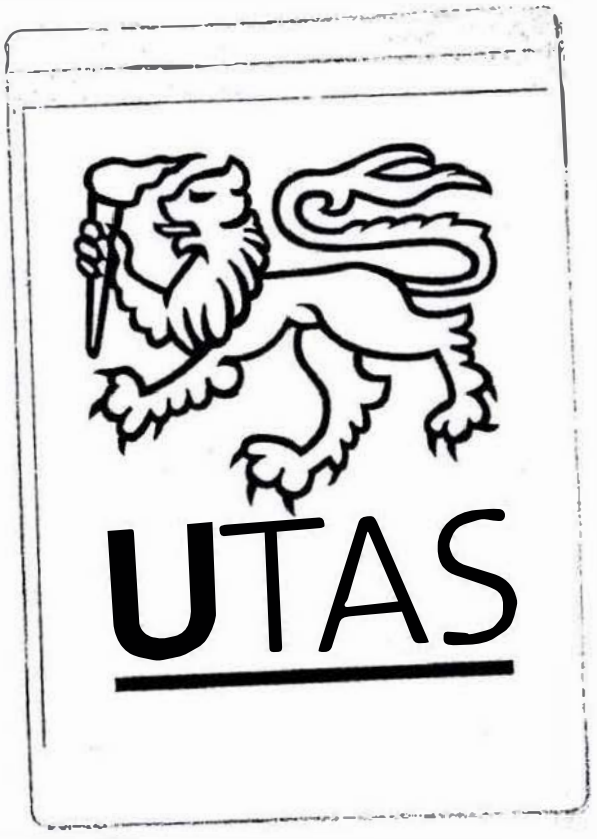
failures in Royal Penguins due to the late return of mates from foraging trips, and in Rockhopper Penguins, predation by skuas. It was speculated that the two species differed in the degree of being "capital" versus "income" breeders.

Inter-annual differences were only found in diet, and Rockhopper Penguin fledging masses, but foraging behaviour of both species was constant, suggesting that prey resources were variable and the species opportunistically consumed those which are encountered. The consistently high breeding success during the study suggests that these years were probably all "good" years in terms of the abundance and accessibility of prey.

Although Royal and Rockhopper Penguins exhibited many similarities in their foraging ecology, the overlap in resource use was not high. The mechanisms (particularly in combination with each other) minimising overlap were differences in: (1) Foraging zones (taking into account the three week asynchrony in the breeding timetables of the two species); (2) Diet, with Royal Penguins consuming larger and more myctophid fish, and fewer euphausiids than Rockhopper Penguins. Further, differences in the degree of digestion of prey suggested that the species foraged on different prey cohorts; (3) Asynchrony in the breeding season, reducing the overlap in peak food demands and the duration of foraging trips (which determined the extent of foraging zones).

This study determined that the foraging ecology of Royal and Rockhopper Penguins was intrinsically linked to the polar frontal zone and regulated by commitments at the nest.

Although these species were similar in aspects of their ecology, the overlap in resource use was less than has been suggested previously.



Acknowledgments

The opportunity to work on Royal and Rockhopper Penguins at Macquarie Island was provided by Mark Hindell, for which I am grateful. Macquarie Island is one of the more fascinating and exciting places in which I have been fortunate to spend considerable amounts of time. The choice of the Sandy Bay site was fortuitous, being arguably one of the more beautiful bays on the east coast. The milder, albeit slightly, climate on the east coast made the long hours working outside easier, and the site abounds with examples of most fauna and flora of the island. Sandy Bay and all Macquarie Island were a constant source of interest as there were also new things to explore and observe. The hut at Sandy Bay was an aircraft engine packing crate established as a field hut in the 1950's. After the initial shock at its small size and basic commodities, and with the help of a number of people to improve the comfort factor, it became home. Its character and charm will always remain with me and it is sad to consider that it is now out of service. Working on Royal and Rockhopper Penguins was another delightful aspect of this project. They are both fascinating and immensely comical species which were a delight to simply observe. Long hours of observation during the project provided the opportunity to watch the antics of these and other species, which provided a great deal of pleasure.

Whilst I have made specific acknowledgments at the end of each chapter, there are some I wish to reiterate. Field assistance during the three years of the project was provided by Mary-Anne Lea, Jane Wilson, Kirsten Le Mar and Paul Scofield. I am grateful to

each of these people who spent extended times at Macquarie Island, being dragged out on those unbearably windy and wild days that Macquarie is capable of. They all showed great tenacity and tolerance. I would particularly like to thank Jane Wilson who spent one and a half seasons on the island for the project. She was great support during the numerous equipment breakdowns and glitches in the project, a great friend and constant source of fun and entertainment.

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biological projects, instilled an interest in all the community which made for a cohesive and co-operative summer station. I am grateful to them all for their help and enthusiasm.

A number of people in Tasmania assisted with parts of the program which I greatly appreciate. Rod Ledingham from the Australian Antarctic Division always had great ideas for solving some of the logistic difficulties and was always generous and helpful when lending equipment. Don Reid was forever helpful and supportive, as was Warren Papworth. Assistance with identifications was provided by Steve Nichol, Graham Hosie, Dick Williams and Dave Slip, all of whom I thank.

From the Zoology Department, University of Tasmania, Richard Holmes adeptly built a number of pieces of equipment including the nets and some of the dummy packs, and Barry Rumbold handled the purchasing and management of accounts. Alan Dumphy was always helpful when finding and lending microscopes and various other pieces of laboratory equipment, and Sherrin Bowden was her usual incredibly efficient, helpful and reliable self in the department. Kit Williams was a wonderful source of help preparing electronic equipment for the vagaries of the Macquarie Island climate, and repairing numerous things after each field season. He also rescued me on a number of occasions from computers and programs that seized, for which I am grateful. Thanks to them all.

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