

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Aspects of the Breeding Biology of the
Black shag (*Phalacrocorax carbo
novaehollandiae*) at Pencarrow,
Wellington, with special reference to
Diet.

Hilary Lorna McKinnon

October 2000

A thesis in partial fulfilment of the requirements for the degree of Masters of Science in Zoology at
Massey University, Palmerston North.



Frontispiece: (Top photo) Fledged bird Pencarrow colony. (Bottom Photo) Breeding pair at nest. Photos courtesy of Peter Reese.

Aspects of the Breeding Biology of the
Black shag (*Phalacrocorax carbo
novaehollandiae*) at Pencarrow,
Wellington, with special reference to
Diet.

Hilary Lorna McKinnon

October 2000

A thesis in partial fulfilment of the requirements for the degree of Masters of Science in Zoology at
Massey University, Palmerston North.

To Jeff

Acknowledgements

Many thanks are due to the following people for their unconditional support and assistance.

Associate Professor Dr Robin Fordham, my supervisor, for all of his guidance, support and ideas throughout this thesis. Ian Latta my co-supervisor who assisted with extracting otoliths.

Dr Ralph Powlesland who originally suggested the topic. Ralph never failed to offer support and assistance with field work and showed a keen interest in all aspects of the study.

Mr and Mrs Curtis for allowing access to they farm where the Pencarrow Black shag colony is located and for recovering some of my stolen gear.

To Gill McKinnon, my mother, who proof read drafts of my thesis and provided many editorial ideas.

To Jeff Dewhurst my partner for all his assistance with computer work especially with pictures. I would also like to thank him for putting up with my constant absence during the year when I was doing field work.

David Hargest and the Hutt City Council for the permit needed to gain access to Pencarrow Coast Road, and Scott of the Eastbourne Police for his concern for my safety throughout the study.

Dr Chris Lalas whose knowledge of Black shag diets and assistance on some measurements made the section on diet that much more significant, and Dr Chris Paulin, Te Papa, for his help with fish problems.

Members of the Wellington branch of the New Zealand Ornithological Society, especially Alan Munro and Dave Sim, for their assistance in locating fledged young in the Wellington region.

Peter Recse, Te Papa for providing a number of the photographs used in this thesis.

I would also like to thank Reg Cotter and Gail Abel of Wellington, Sharyn Garner, Jarn Godfrey, Paul Barrett, Sara Treadgold, Tracy Harris, Cathy Lake, Hayden Hewitt, Robin Fordham and all other Ecology Group staff and students who assisted with field work, especially banding chicks. Thanks also to Barbara Just who helped to keep my expenses on track.

To my family and friends who have been so supportive and encouraging during the past few years, who have made this task so much easier to accomplish. I would like to apologise sincerely to anyone I have overlooked as I found everyone's contribution to this thesis invaluable.

Abstract

Aspects of the breeding biology, diet and movements of Black shags (*Phalacrocorax carbo novaehollandiae*) were studied at Pencarrow Colony, Lake Kohangatera, Wellington.

The breeding behaviour of adult birds did not differ from that described in overseas research. Both parents were involved in all aspects of incubation and rearing young, but males collected material for the nest, and females remained at the nest site to build the nest, often with the assistance of the males. Agonistic behaviour was most often shown in the defense of the nest site and mostly involved warning than direct attack. Inter-bird competition within the colony most often involved the displacement of roosting birds by birds returning to the colony.

Eighteen pairs were successful in laying eggs and a total of 39 chicks hatched. For the broods that survived to fledge one had 1 chick, nine had 2, and one had three young. Breeding success, as measured by the number (2.1 ± 0.1) of fledged young per nest, was higher than that recorded (Powlesland & Reese 1999) between 1993-98. However the rate of nest failure was twice as high. The variation in breeding success observed at the Pencarrow colony also occurs in Black shag populations in other counties.

Black shags at Pencarrow colony are primarily marine foragers. Only one instance of freshwater foraging was identified in 1999. Half of the diet identified in regurgitated pellets comprised one fish species, Wrasse (spotty). Twenty-two different prey items were found in the 121 pellets recovered from the ground underneath the colony. Fish are the predominant prey with 17 different species confirmed. There was no significant difference ($p > 0.1$) in the number of prey items per pellet over the eight months they were collected.

Movements of adults and fledged young appear to be partially dispersive. The continued presence and return of birds banded since 1990 also suggests a sedentary core population at the colony. The daily presence of adults engaged in foraging

activities along the eastern side of Wellington harbour suggests that this area is the preferred foraging area during the breeding season. The number of adult Black shags seen throughout the year in marine areas was significantly higher than in freshwater areas. Young birds did not permanently disperse away from the colony immediately after fledging but returned to the colony to roost overnight. Their most preferred daytime roost in the first few months after fledging was the Mai Mai on Lake Kohangatera 1 km from the colony. The first fledged bird seen roosting overnight away from the colony was on 1 January 2000 (c. 7 months and 2 weeks old).

<u>Contents</u>	<u>Page</u>
ACKNOWLEDGEMENTS	IV
ABSTRACT	VI
LIST OF FIGURES	XI
LIST OF TABLES	XIII
LIST OF PLATES	XVI
1.0 GENERAL BIOLOGY	1
1.1 Taxonomy	1
1.1.1 Origins	1
1.1.2 Classification	1
1.1.3 Distribution.....	2
1.2 Description of <i>Phalacrocorax carbo</i>	3
1.2.1 Measurements	3
1.2.2 Breeding adult.....	4
1.2.3 Post-breeding adults and immature shags.....	4
1.2.4 Juvenile.....	6
1.2.5 Nestlings	6
1.3 Aims of study	8
1.3.1 Measurement of breeding output.....	8
1.3.2 Diet	8
1.3.3 Dispersal	9
1.4 Thesis Layout	9
2.0 STUDY AREA	11
2.1 Location	11
2.2 History of colony	16
2.3 Weather	16
3.0 BREEDING BEHAVIOUR	19
3.1 Introduction	19
3.2 Methods	20
3.3. Results.....	20
3.3.1 Nest building.....	20
3.3.2 Courtship	22
3.3.3 Incubation	24
3.3.4 Chick rearing	26

3.3.5 Fledged young	27
3.3.6 Territorial Behaviour	28
3.3.7 Aggression towards chicks	29
3.3.8 External threats	29
3.4 Discussion	30
3.5 Conclusion	32
4.0 BREEDING SUCCESS	33
4.1 Introduction	33
4.2 Methods	34
4.2.1 Eggs and Chicks	35
4.2.2 Banding	35
4.3 Results.....	37
4.3.1 Egg stage.....	37
4.3.2 Chick stage	38
4.3.3 Fledged Young stage	44
4.3.4 Effect of age on breeding output.....	45
4.4 Discussion	45
4.6 Conclusion	48
5.0 DIET	50
5.1 Introduction	50
5.2 Methods	54
Pellets	54
5.3 Results.....	58
5.3.1 Composition of Diet	58
5.3.2 Pellet Contents	60
5.3.3 Length and Mass of Prey	61
5.3.4 Change in adult diet over breeding season.....	63
5.4 Discussion	65
5.5 Conclusion	69
6.0 DAILY MOVEMENTS & DISPERSAL	71
6.1 Introduction	71
6.2 Methods	74
6.2.1 Eastbourne transect - Adults	74
6.2.2 Wellington City transect	75
6.2.3 Wainuiomata River Estuary & Orongorongo River Estuary transect	77
6.2.4 Eastbourne transect - Fledged young	77
6.3 Results.....	77
6.3.1 Daily movements of adults	77
6.3.2 Activities.....	80

6.3.3 Interaction with other shag species	81
6.3.4 Fledged Young - Daily movements	82
6.3.5 Flight path from the colony to Lake Kohangatera and the coast	83
6.3.6 Activities.....	84
6.3.7 Departure from the colony.....	86
6.4 Discussion	87
6.5 Conclusion	90
7.0 GENERAL CONCLUSION.....	92
APPENDIX: 1. TAXONOMY	94
APPENDIX: 2. NEW ZEALAND DISTRIBUTION	95
APPENDIX: 3. WEATHER.....	96
APPENDIX: 4. SUNRISE AND SUNSET.....	98
THESIS REFERENCES	99

List of Figures

<u>Figure</u>	<u>Page</u>
1.1. Distribution and movement of Black shags in Australia and New Zealand.	3
2.1. North Island New Zealand. Insert: Wellington region containing study site.	12
2.2. Lake Kohangatera and Pencarrow Black shag colony.	13
2.3. Average rainfall for 1990-98 and 1999 from March – November in the Wellington area.	17
2.4. Average temperature for 1990-98 and 1999 from March – November in the Wellington area.	18
2.5. Maximum wind speed (m/s) for 1990-98 and 1999 from March – November in the Wellington area.	18
3.1. Male wingwaving display.	23
3.2. Numbers of males displaying (mate attraction) from March – September at Pencarrow 1999.	23
3.3. Two types of male gargling display.	23
3.4. Percentages of types of changeovers observed with incubating at Pencarrow 1999.	25
3.5. Feeding times of Black shag nestlings and fledged young at Pencarrow 1999.	25
4.1. Photo of upper colony showing nest sites that succeeded in laying eggs (showed signs of incubation).	39
5.1. Diagram of fish to show fish range. TL = Total length, from snout to end of tail. FL = Fork Length, from snout to fork in tail.	56
5.2. Diagram of Wrasse dentition showing length measurements for 1 – 5 equations.	57
5.3. Comparisons of mass against length for Wrasse (spotty) and Rock cod.	62
6.1. Map of Wellington harbour and southern coastline, showing Wellington, Eastbourne, Wainuiomata River Estuary and Orongorongo River Estuary transects.	76

6.2. Mean (\pm S.E.) morning and afternoon population size from March – September, Pencarrow, 1999.	79
6.3. Percentage of adult Black shags at daytime freshwater and marine roosts on Eastbourne transect from February to November 1999.	79
6.4. Mean (\pm S.E.) of adult Black shag activities on Eastbourne transect from February to November 1999.	80
6.5. Daily movements of Black shag fledged young along the Eastbourne transect from July to November 1999.	83
6.6 Lake Kohangatera and Black shag colony, showing outgoing flightpath and most often the return flight path.	84
6.7. Mean (\pm S.E.) of newly fledged young Black shag activities on Eastbourne transect from July 1999 to February 2000.	85
6.8. Sightings of daily movements and dispersal of Black shag fledged young away from Pencarrow colony 1999.	86

List of Tables

<u>Table</u>	<u>Page</u>
1.1. Taxonomic classification taken from the Checklist of the birds of New Zealand.	2
1.2. Measurements in millimetres of non-juvenile birds.	3
1.3. Weights of non-juvenile birds in grams.	3
3.1. Mean (\pm S.E.) feeding times of chicks and fledged young Black shags at Pencarrow 1999.	27
3.2. Age of fledged young (\pm 7) days when nests were abandoned by both parents and young, Pencarrow 1999.	28
4.1. Estimated laying dates of nests, numbers of eggs laid, and survival of young to fledging at Pencarrow colony 1999.	38
4.2. Calendar of dates (\pm 7) days for Laying = L, Hatching = H, chicks first seen in the nest = C, and nest = (), at Pencarrow colony 1999.	41
4.3. Chick banding dates, identification, gender and weight at Pencarrow colony 1999.	42
4.4. Brood size and percentage at fledging at Pencarrow colony 1999.	43
4.5. Age of brood (\pm 7) days when hopping out of nest and wing flapping first observed Pencarrow colony 1999.	43
4.6. Age, identify and gender of fledged young, as well as young first observed flying, Pencarrow colony 1999. Chick removed from colony (nest 13) not included.	44
4.7. Banded adults breeding success at Pencarrow colony, 1999, where success is defined as raising one or more chicks to fledge.	45
5.1. Foraging habitats of New Zealand shag.	53
5.2. Equations of otolith measurements for mass and length of fish prey.	56
5.3. Equations of Wrasse and Butterfish dentition, measurements for mass and length of fish prey.	57
5.4. Prey of Black shags found in regurgitated pellets at Pencarrow colony 1999.	58

5.5. Stomach contents of four chicks aged between 10 & 11(\pm 7) days. All chicks had been dead 1-2 days prior to being found.	59
5.6. The frequency of prey in egested pellets, and diet composition at Pencarrow colony 1999.	59
5.7. Mean number of prey items per pellet February – October 1999.	60
5.8. Frequency of number of prey found in 119 regurgitated pellets.	60
5.9. Mean dry weights (g) of pellets February – October 1999.	61
5.10. Mean length (mm) and mass (g) of eleven frequently occurring fish prey at Pencarrow colony 1999.	61
5.11. Means of ‘fish prey mass (grams) & length (mm)’ collected from chicks and adults at the Pencarrow colony, 1999.	63
5.12. Fish mass, Prey items per pellet and dry weight of pellets over autumn, winter and spring, Pencarrow colony, 1999.	63
5.13. Length and mass of eleven fish species in egested pellets over autumn, winter and spring, Pencarrow colony, 1999.	64
5.14. Means and standard errors of lengths and mass for all fish species for the three seasons autumn, winter and spring at Pencarrow colony, 1999.	65
5.15. Differences between the means of mass and length for all fish species combined for the three season’s autumn, winter and spring at Pencarrow colony, 1999.	65
6.1. Movements of New Zealand shags.	72
6.2 Description of Eastbourne and Wellington transect points.	75
6.3. Counts of Black shags on the Eastbourne transect 1999.	78
6.4. Average number of Adult and Fledged young every two kilometres on the ‘Wellington City’ and ‘Eastbourne’ transects, October & November 1999.	78
6.5. Activities (%) of adult Black shags with totals (n) and means (\pm SE) from February – November 1999.	80
6.6. Counts of Little Black shags and Little shags on the ‘Eastbourne’ transect, April – September 1999.	81

6.7. Sightings of fledged Black shags on the 'Eastbourne' transect July - November 1999.	82
6.8. Activities (%) of newly fledged young Black shags with total (n) and means (\pm SE) from July 1999 - February 2000.	85

List of Plates

<u>Plate</u>	<u>Page</u>
Frontispiece: Fledged bird & Breeding adult pair at nest.	ii
1.1 Adult in full breeding plumage.	5
1.2 Plumage of post breeding adults & immature Black shags.	5
1.3 Juvenile banded in 1995. (c. 12 to 18 months)	7
1.4 Nestlings (c. 6 days old)	7
2.1 Lake Kohangatera. looking north up Gollans valley from the coast of Fitzroy Bay.	14
2.2 West face of Link Ridge where the colony is located.	14
2.3. Main area of the Pencarrow Black shag colony in a stand of Karaka trees from the primary hide.	15
2.4 Swamp area at northern end of Lake Kohangatera, looking north up Gollan valley. Fitzroy Bay is 2km to left of photo.	15
3.1 Primary hide, the colony is behind the photographer.	21
3.2 Adult feeding nestlings (c. 3-5 days old)	21
4.1 Preparing to weigh chick (14 – 21 days old)	36
4.2 Ralph Powlesland returning newly banded chick to nest (14 - 21 days old)	36
5.1 Looking for regurgitated pellets under colony	55
5.2 Regurgitated pellet	55