

NEW ZEALAND SHAG (*LEUCOCARBO CARUNCULATUS*) ON DUFFERS REEF, MARLBOROUGH SOUNDS.

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ABSTRACT

The total population of New Zealand King Shag (*Leucocarbo carunculatus*) was counted for the first time during the 1992 breeding season. At 524 birds, numbers were almost twice as high as estimated previously. The daily rhythm, foraging range and feeding location of King Shags from the Duffers Reef colony in the Marlborough Sounds were studied in 1991 and 1992. The mean (\pm s.d.) foraging range was 8.2 ± 4.1 km (maximum 24 km) from the colony. Most (74%) fed in 31% of the study area, 20-40 metres below the surface on a mainly flat bottom, within the confines of the outer Marlborough Sounds. During the six months courtship/breeding period, daily rhythm of the colony was different from the rest of morning and afternoon. It is assumed that females left to feed in the morning and males in the afternoon to feed and collect nesting material. No double peak was seen during the non breeding period.

INTRODUCTION

The King Shag (*Leucocarbo carunculatus*) is endemic to New Zealand and is restricted to the outer Marlborough Sounds. The only known colonies are at White Rocks, Sentinel Rock, Duffers Reef and the Trio Islands (Figure 1). The maximum distance between them (Trio Islands to White Rocks) is 40 km. These very small islands are used both for breeding and roosting.

Little information is available about the King Shag. Previous studies by Falla (1933) and Nelson (1971) dealt mainly with the breeding biology of the King Shag, and little is known of the rest of their ecology. Nelson (1971) gave an estimate of about 300 shags, including non-breeders as the total population. Previously published counts at individual colonies summarised by Butler (1987), do not mention the time of the day and so might be minimum counts, particularly if they were made near midday, when the number of birds at the colony is lowest.

In this study I made dawn counts of all four colonies in June/July 1992 to get an accurate population estimate and recorded the distribution, feeding range, diving depth and daily pattern of departure and arrival of King Shags at Duffers Reef.

STUDY AREA

Duffers Reef (40°57' S, 174°02' E) is the continuation of the main ridge of Forsyth Island at the entrance of Pelorus Sound (Figure 1). The reef extends about 1 km and consists of rocky islets up to 30 metres in height.

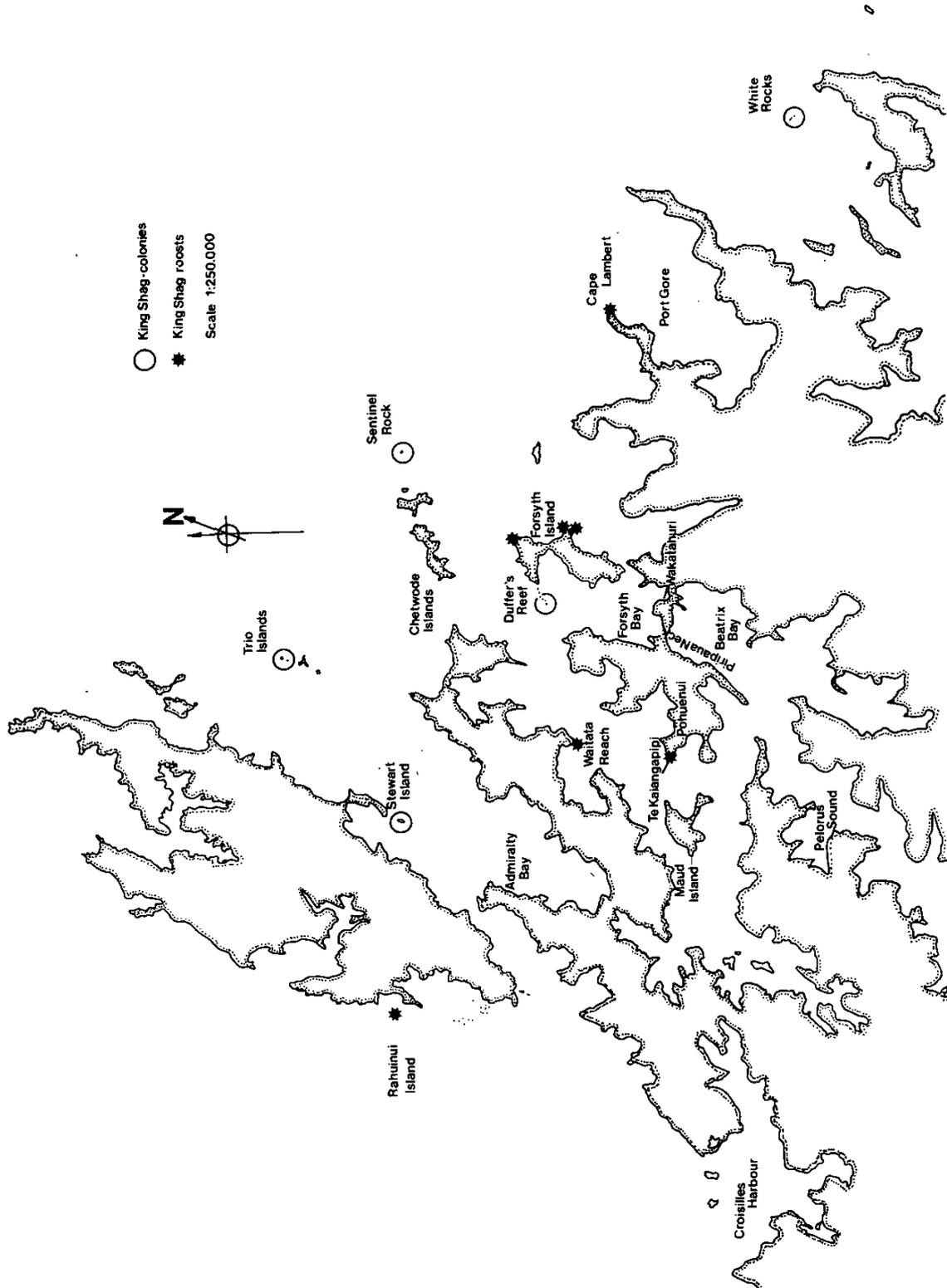


FIGURE 1 – Northern part of the Marlborough Sounds

The biggest rocks are covered in scrub. The King Shag colony, on the barren outermost rock, has been occupied since 1965/66 (Nelson 1971). The nests are on the southern side of the island, starting 3 metres above high water mark.

METHODS

King Shags are solitary feeders and disperse over a huge area. They fly low over the water straight to their feeding ground. Each month, I (a) recorded flight direction to give an indication where to find the feeding birds, and (b), plotted feeding areas by mapping the actual distribution of feeding birds.

Flight direction

I recorded the arrival and departure of shags at the colony to determine the direction in which they were feeding. Departing and arriving birds were counted during blocks of 5 minutes per sector (see Figure 2). Difficulties occurred in defining the boundary between northeast and north. I therefore extended sector north slightly and named all birds passing the knob of Forsyth Island as north and all birds staying on the inside of the island as northeast. Not all flights were feeding trips and separate notes were made of courtship related activities, such as "circle-flying" above the colony and "arriving with nesting material".

I always approached the colony before dawn, switched off the motor while well away from the colony and let the boat drift to a suitable mooring place. In this way I could approach to 100 metres without causing commotion. In daylight, moving to 100 metres away would cause substantial disturbance.

During 4 of 12 counts, the number of arriving birds exceeded the number of departing birds. Birds always leave the island upwind and so with a northerly wind and the boat on the south side of the island, some birds would have departed unnoticed. Because of this, the counts were split into "successful" and "less successful". This problem did not occur when birds arrived at the colony. They fly higher before landing and are easier to notice. The counts of circle-flying and arriving with nesting material are not affected by unnoticed birds.

Feeding areas

I defined a study area of 240 km of water (Figure 2) by the flight directions of birds leaving the colony and King Shag sightings of the past. The whole study area was visited every month by speedboat. This trip was done once most shags had left the colony between 10.00 hrs and 15.00 hrs. In the field I plotted the distribution of birds on the NZ Topographical Map (1:63,360) in squares of 100 by 100 yards. These plots were later related to water depth taken from a 1:30,000 bathymetric map of Pelorus Sound (DSIR 1987), distance and direction from the colony and slope of sea floor. The sea floor was classified as flat, moderately sloping (less than 5°), or steeply sloping (more than 5°).

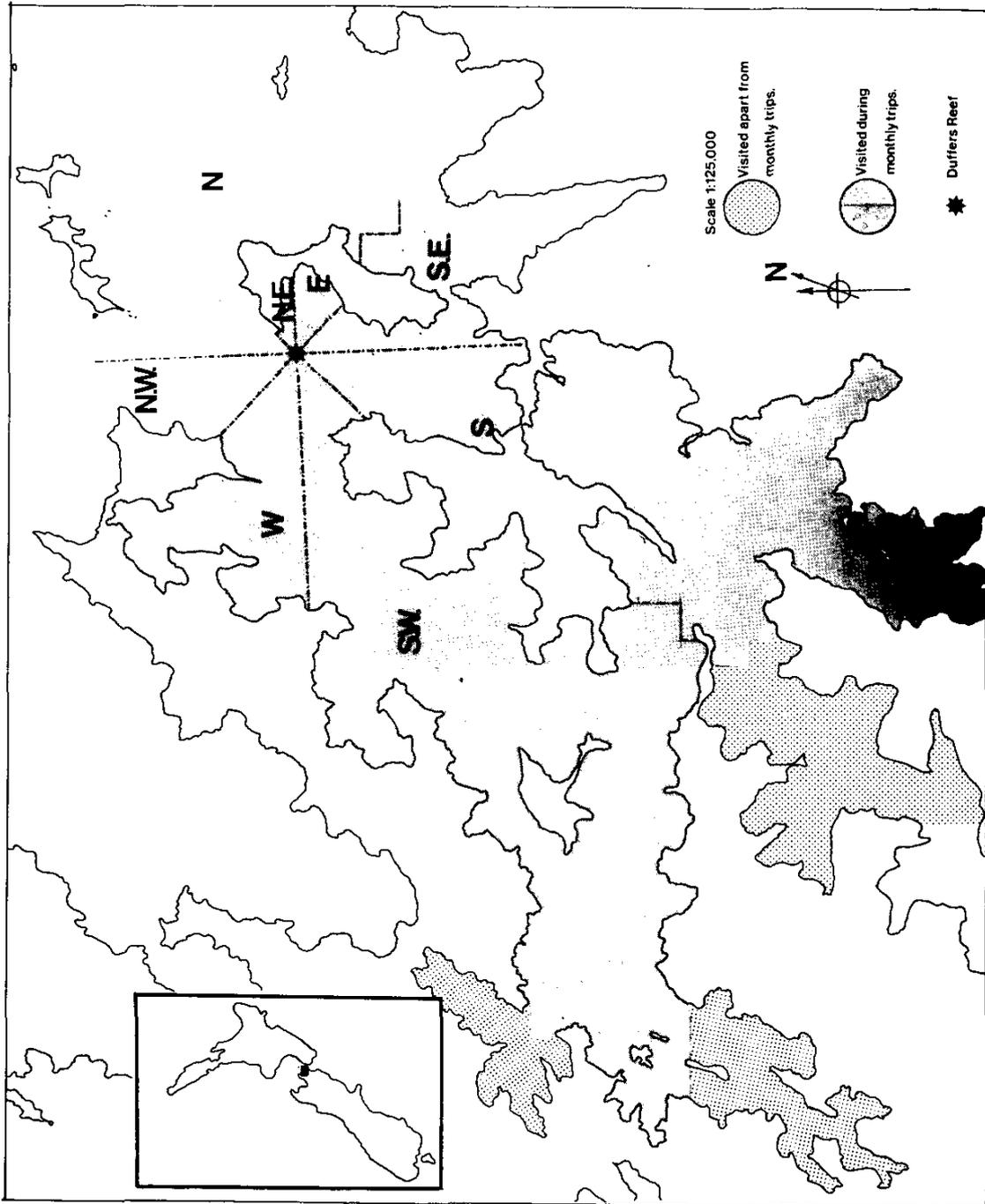


FIGURE 2 - Study area with flight directions

The study area fully covers the sectors south, southwest, west, northeast and east. Numbers shown for southeast and north sectors are a minimum because I visited the eastern side of Forsyth Island, a major part of these sectors, only from December onwards. Because of rough, open seas I had to largely ignore the northwest sector.

RESULTS

Population of New Zealand King Shags.

Between 21 June and 18 July 1992, I counted at all four breeding colonies before the dawn departure (Table 1). The totals were 524 birds and 166 occupied nests. Stewart Island, a rock at the southeastern side of D'Urville Island, was not included in this count. From 1960 to 1965 a small colony of King Shags with 5 to 13 nests was established on this island but it then disappeared. In 1981, J. Hawkins (pers. comm.) saw 4-5 birds on Stewart Island, together with one nest.

TABLE 1 – Total population and number of nests from all colonies of King Shags in 1992

Colony	No. of Birds	% Breeding	No. of occupied nests	Date (1992)
Duffers Reef	168	82	69	21/06
North Trios 1	120	58	35	25/06
North Trios 2	45	67	15	25/06
Sentinel Rock	68	50	17	26/06
White Rocks	123	49	30	18/07
Total	524	61	166	

TABLE 2 – Breeding populations in 1992 compared with Butler (1987)*.

Colony	Number of Birds		Number of Nests	
	1948-87*	1992	1948-87*	1992
White Rocks	20-90	123	14-40	30
Trios North	15-100	165	6-55	50
Sentinel Rock	2-78	68	2-18	17
Duffers Reef	11-150	168	20-80	69

Duffers Reef and White Rocks showed some nests with chicks visible. At other colonies, birds were sitting tight on their nests, which probably meant they had eggs or very small chicks. The timing of the breeding cycle of 1992 appeared similar at all colonies. Between 50 - 80% of the birds at the five colonies took part in breeding. The numbers of nests of White Rocks, Sentinel Rock and Duffers Reef in 1992 were within the range of numbers mentioned by Butler (1987), which suggests a stable population of King Shags over the last 45 years (Table 2).

Little is known about roosts of King Shag, away from their breeding sites. Most of my data refer to the Te Kaiangapipi roost where the number present was 5 or less. In April and May, the beginning of the breeding season, I found an increase of up to 22 birds but none was present in June and July. In January 1988, the Offshore Island Research Group (unpubl. report) found a new roost on Rahuinui Island, on the western side of D'Urville Island, with about 23 King Shags, including 18 newly fledged juveniles, but no obvious signs of nests. In February 1993, R. Taylor (pers. comm.) found another new roost of about 26 shags at Cape Lambert. These sightings of roosts with relatively high numbers of King Shags coincide with a period of low numbers at Duffers Reef. Between March and the end of October, numbers counted before the morning departure ranged from 143 to 168. During summer, from December to February, numbers ranged only from 83 to 91 (Figure 3). Only during this period did I notice birds in the early morning coming from, and in the late afternoon flying to, a northern location outside the study area.

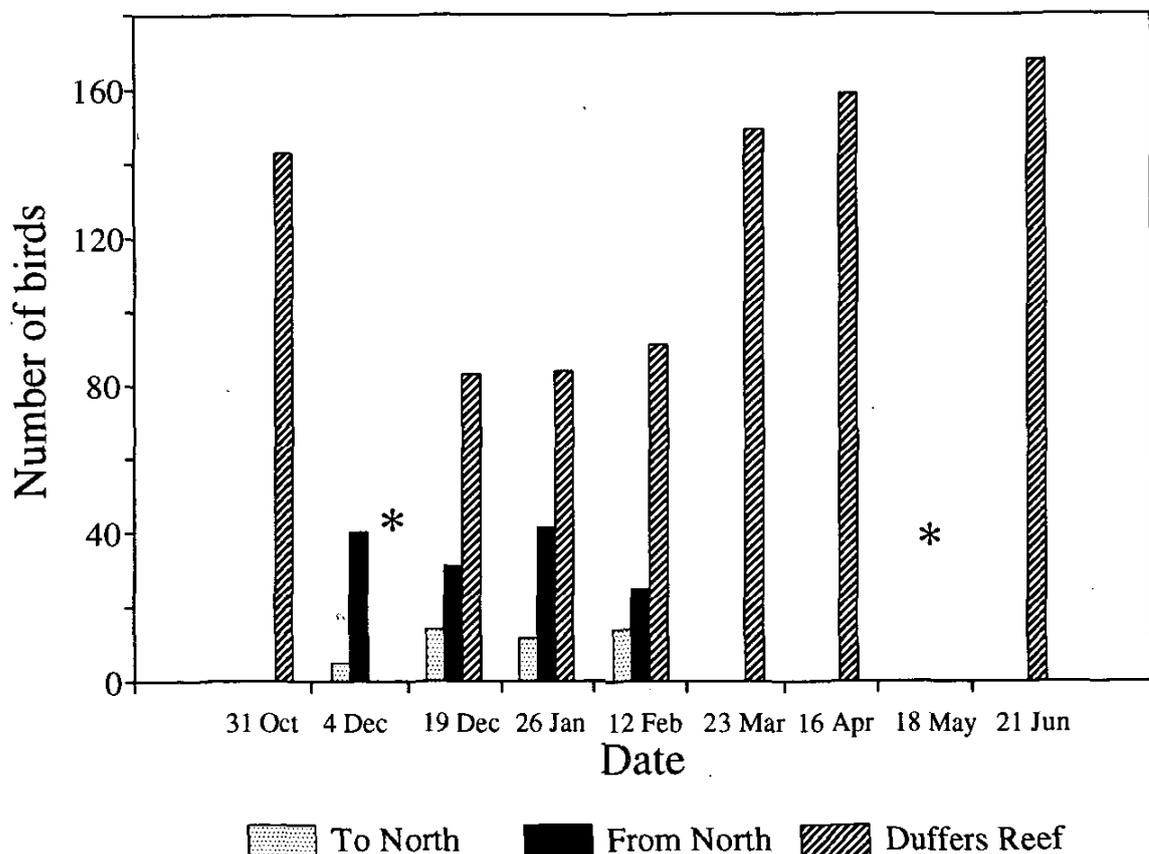


FIGURE 3 - Local migration of Duffers reef population during summer.

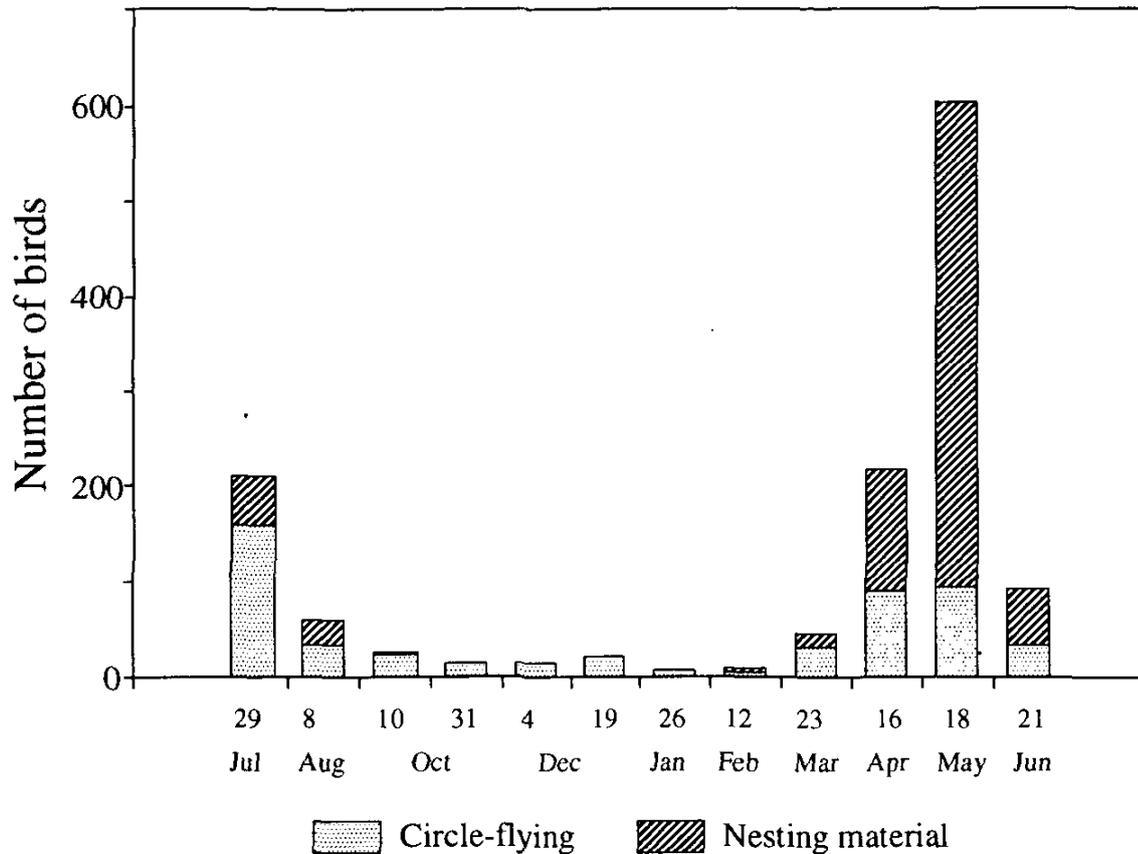


FIGURE 4 – King Shags engaged in two forms of courtship-related behaviour.

Courtship/breeding period at Duffers Reef

Circle-flying and collection of nest material are part of courtship behaviour among the whole family of Phalacrocoracidae (Marchant & Higgins 1990) and are used to define the courtship/breeding period (Figure 4). From March onwards collection of nest material rapidly increased. The birds made many short trips, mainly to the closest islands of Duffers Reef, Forsyth Island and maybe as far as the Chetwode Islands to the north and northeast of the colony. This activity reached a peak in May, when 62% (509) of the birds that arrived between dawn and 14:00 hrs carried nesting material. After 14:00 hrs the weather deteriorated and I had to abandon the count. After August, the number of birds flying with nesting material decreased rapidly. Circle-flying followed a similar pattern, with a peak of 158 birds in July. Between October and March, circle-flying was at its lowest (Figure 4).

Based on the timing of collection of nest material and circle-flying, I conclude that courtship/breeding lasts for 6 months from March to August. During this period, copulations, nest-building, egg-laying, breeding, hatching, feeding of juveniles and the first juveniles leaving the colony are taking place. An exception to this pattern was seen during the period of hatching in 1992 when a juvenile of the previous season was still being fed in the colony by a pair that did not take part in breeding. From January onwards all juveniles are flying.

Direction choice of departing and arriving birds

During days spent near the colony, I recorded flight directions of departing and arriving birds. Birds flew straight and low over the water. They avoided crossing over land, except for the low saddle of the Piripaua Neck between Pohuenui and Wakatahuri, which they crossed to reach Beatrix Bay.

To determine the birds directional choice, I used the successful counts of the whole year. After excluding the birds collecting nest material, no difference was found between the courtship/breeding period and non breeding period, so the counts were combined.

I have no evidence that birds move regularly between different feeding spots. I did not stay to observe complete feeding sessions between a bird landing at and leaving a certain fishing spot, although a few watches lasted at least 1.5 hours. All flying birds seen in the study area were heading for or coming from the colony.

Almost 75% of all departing and arriving birds used the south, southeast, west and southwest sectors (Figure 5). The King Shags of Duffers Reef are clearly inshore feeders, staying within the confines of the outer sounds.

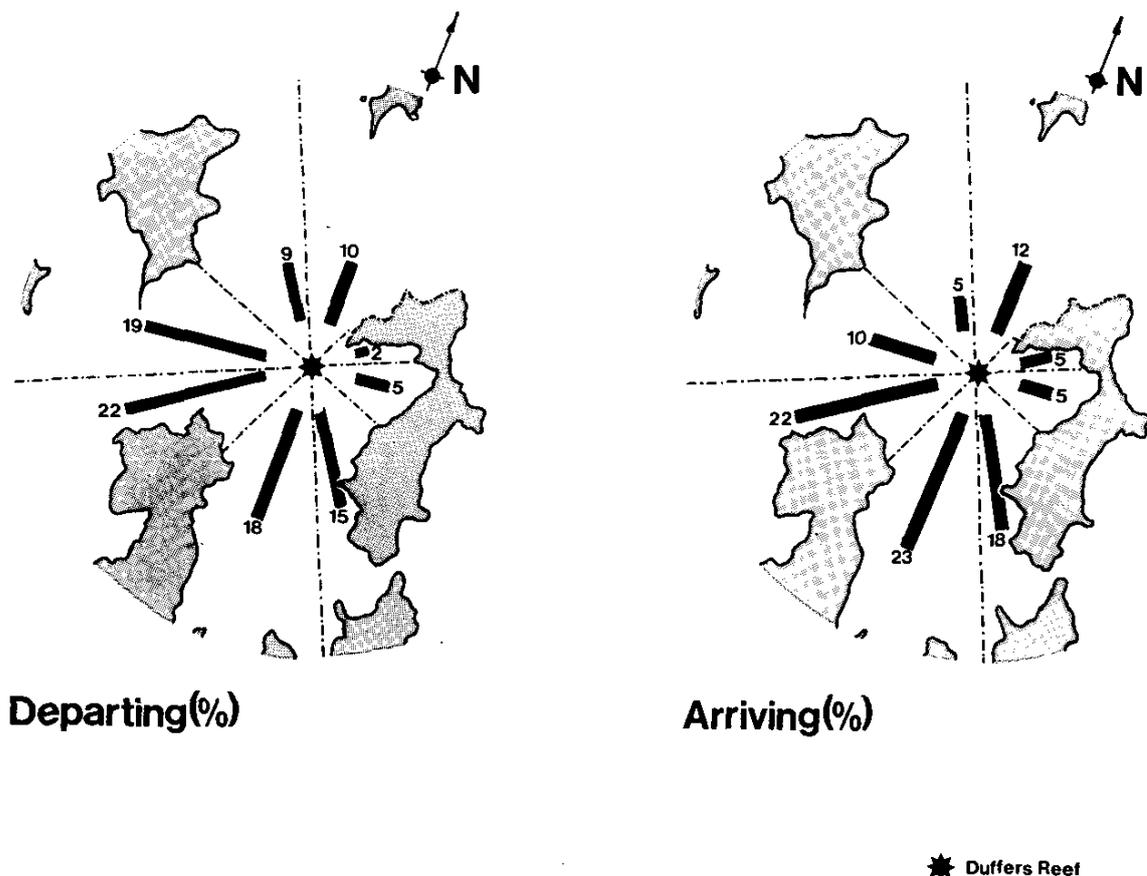


FIGURE 5 – Total of departing and arriving King Shags shown as a percentage of all successful counts.

Foraging range, distribution and diving depth of birds from Duffers Reef

During the monthly trips, 289 birds were seen in the study area of which 219 were fishing. The birds fed at an average distance of 8.2 km (s.d. \pm 4.1, n = 219), from Duffers Reef. The maximum distance between feeding birds and the colony was 24 km. This area, far into the Pelorus Sound, was not a part of the study area but was regularly visited by boat (Figure 2). There was no significant difference in feeding range between the courtship/breeding period (7.6 ± 4.1 km, n = 104) and the non breeding period (8.7 ± 4.0 km, n = 115).

Almost 66% of the birds from Duffers Reef search for food (Figure 5) in those sectors fully covered by this study, south, southwest, west, northeast and east. I therefore assumed that the study area does well represent the feeding areas of the Duffers Reef birds. Most fishing birds were seen in the sectors west, southwest and south of the colony (Figure 6).

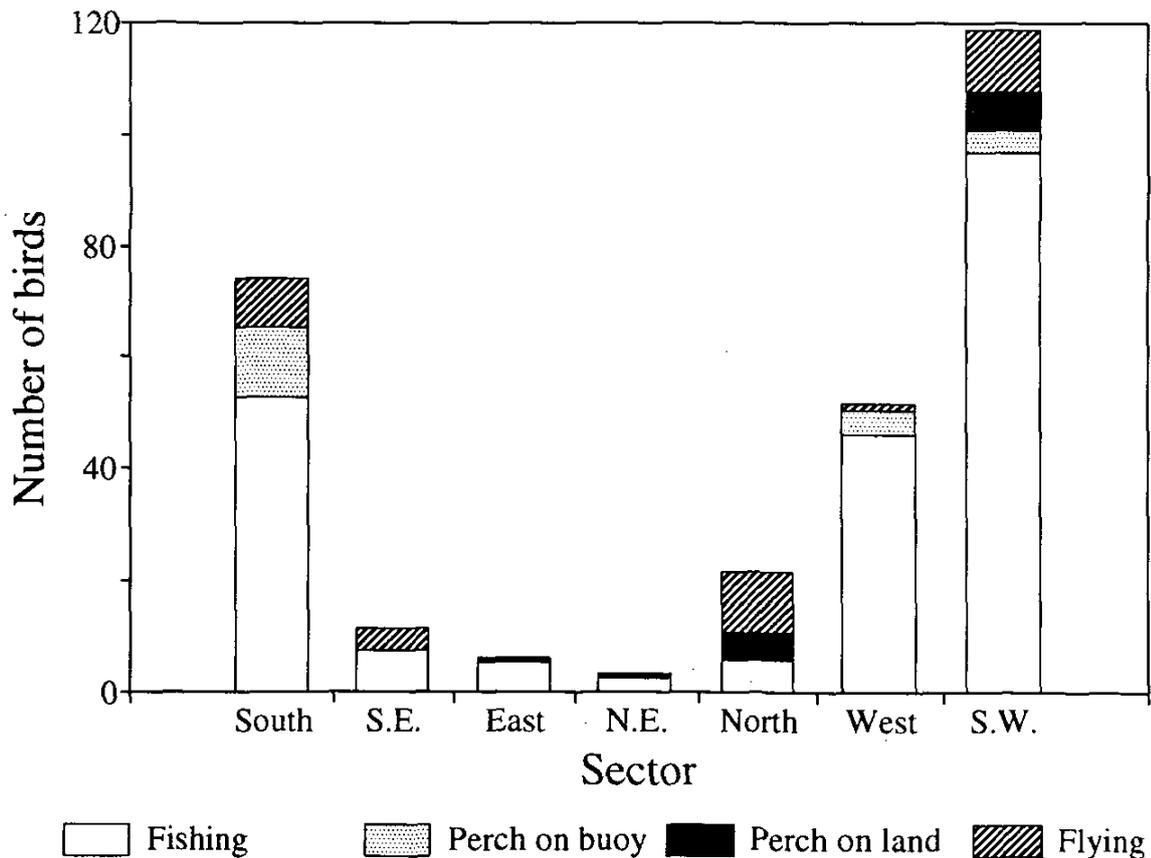


FIGURE 6 – Fishing birds per sector. N.W. not visited.

The high number of records around Duffers Reef were mainly of birds bathing shortly after take-off. Close to their feeding areas, birds often chose bouys of mussel farms as perching spots. Perching on land was less common, apart from the few roost sites. Water depth is important in determining where King Shags feed. Most (74%) fed where the bottom was 20 - 40 metres deep (Figure 7) whereas only 31% of the study area has waters of these depths. At depths of 20-40 metres the bottom is mainly flat (63%) or moderately steep (<5) (23%). Bays along Waitata Reach, waters around Maud Island, Beatrix Bay and Forsyth Bay and the eastern side of Forsyth Island which are not deeper than 40 metres attract most of the King Shags (Figure 8). Almost no birds fed in the centre of Waitata Reach, where depths are far beyond 40 metres and up to 70 metres.

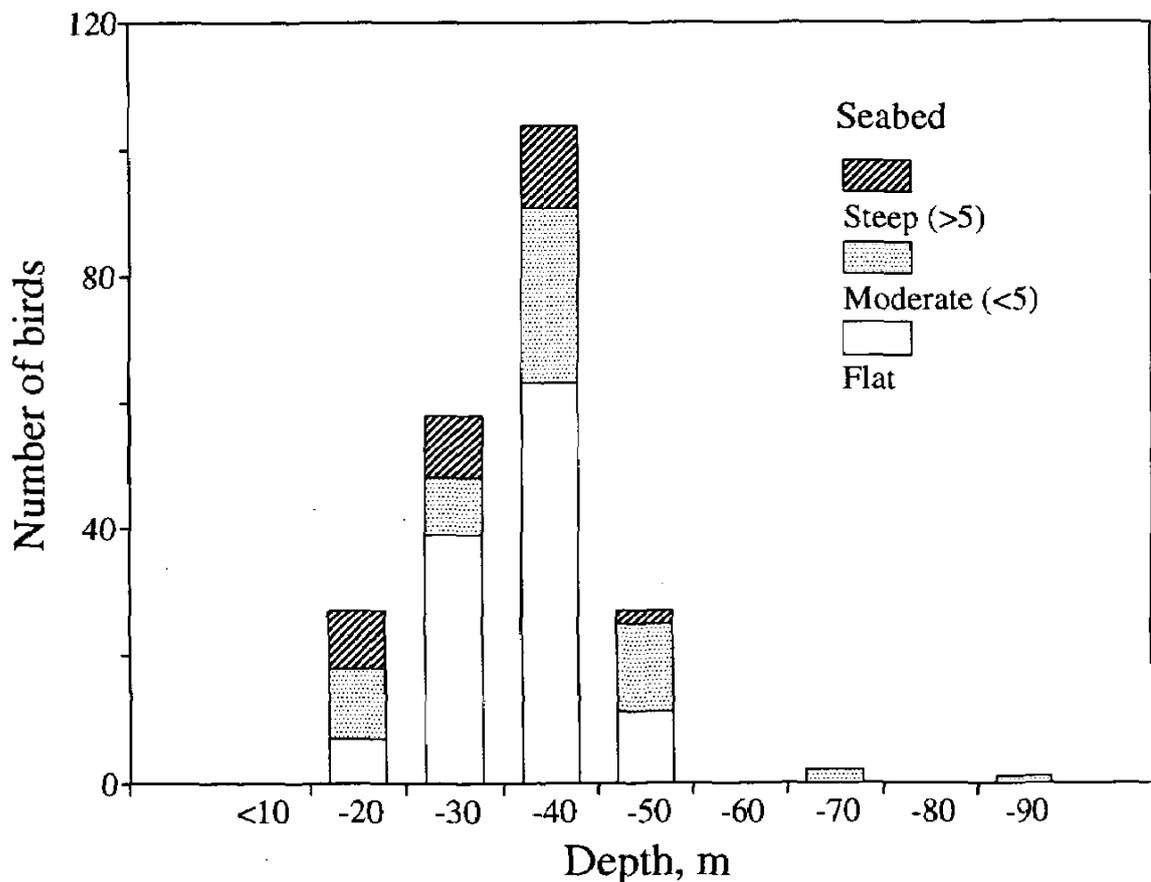


FIGURE 7 - Water depth and angle of seafloor below foraging birds (N = 219).

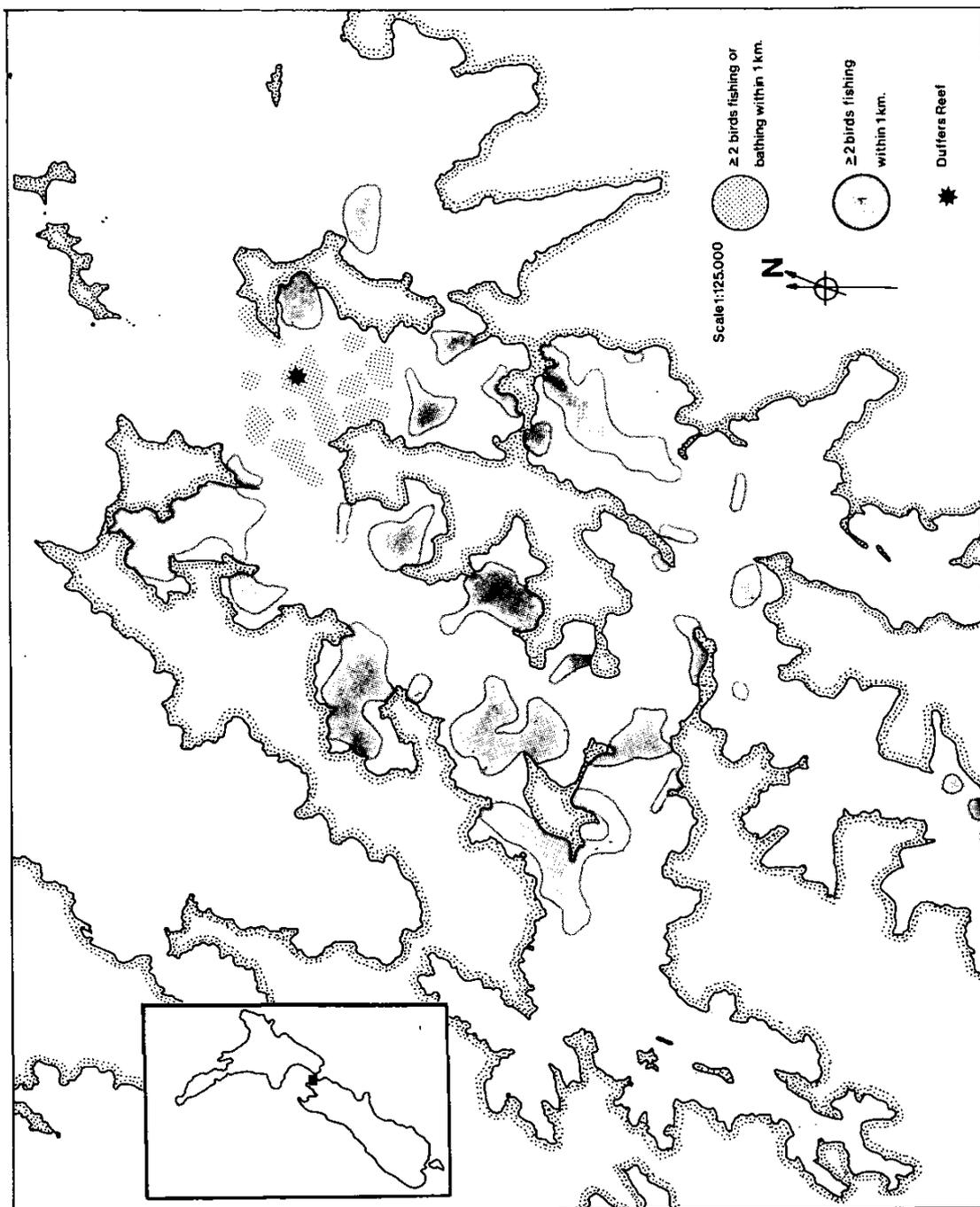


FIGURE 8 – Main feeding area of king shags from Duffers Reef.

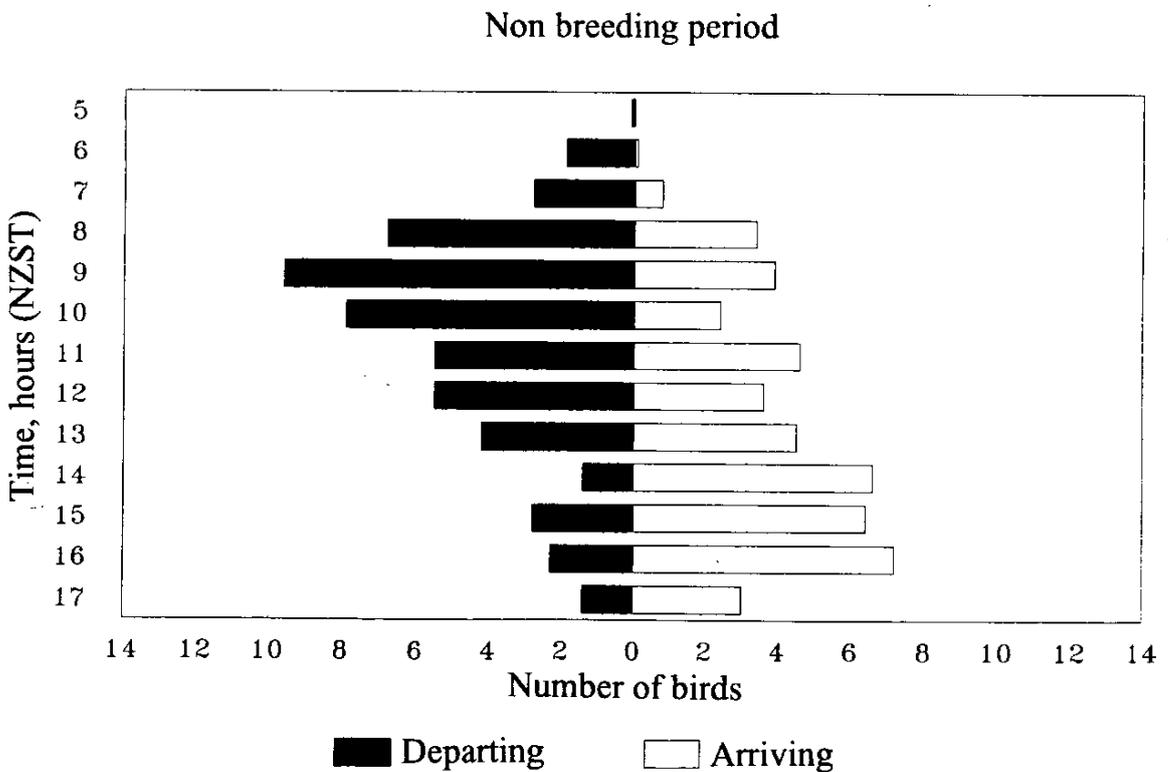
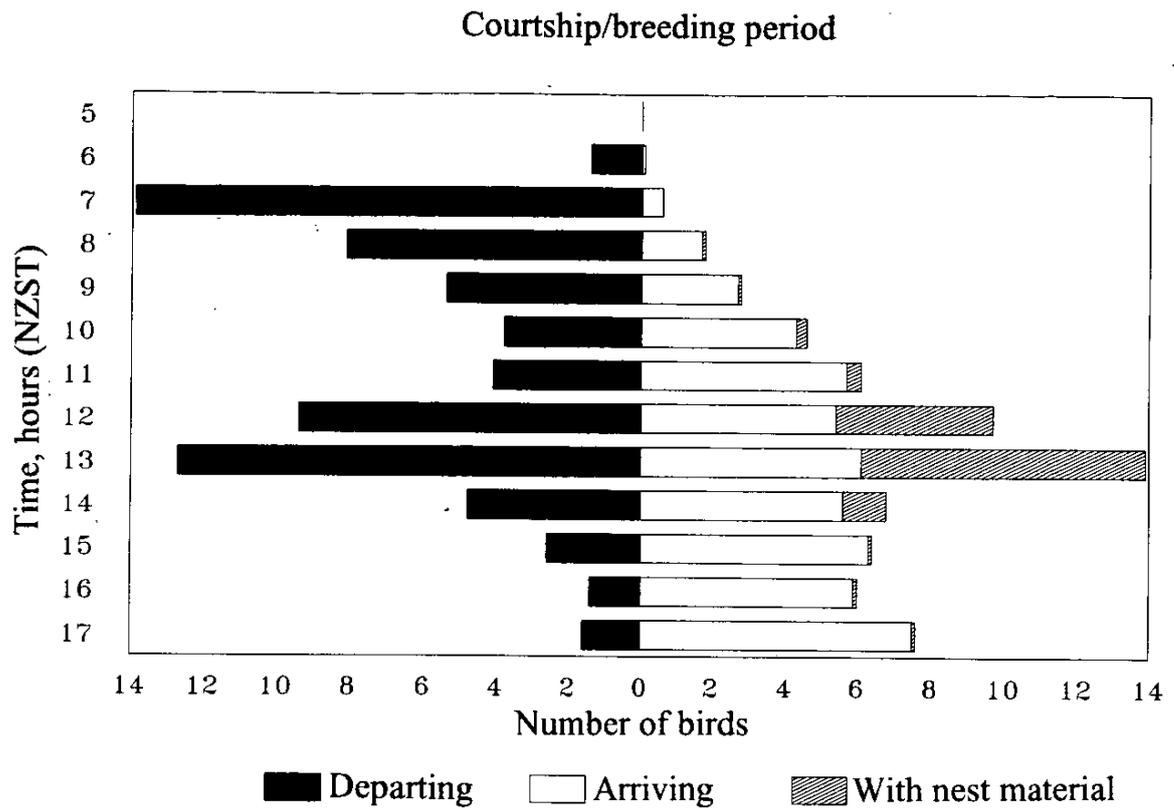


FIGURE 9 – Daily activity pattern during courtship/breeding period and non breeding period

Daily movements during courtship/breeding period and non breeding period

I used the successful counts at the colony to investigate daily movements of the Duffers Reef birds. Daily activity patterns differed between the courtship/breeding period and the non breeding period. During the courtship/breeding period many birds departed around 07:00 hrs, shortly before or at sunrise (Figure 9). A second mass departure took place around 13:00 hrs, caused by birds looking for nesting material nearby, and they arrived back within one hour. Between October and March, the non breeding period, the peak of departing birds was at 09:00 hrs, and the number of departures gradually declined during the rest of the day.

Figure 10 shows the annual pattern of departing birds in relation to sunrise. Time of first departure was taken as the first moment when two birds left within 15 minutes of each other. From the beginning of October onwards, first departures became increasingly later after sunrise and by mid-December, first departures were taking place 3 hours after sunrise. After December, the gap between sunrise and first departures declined and by the start of the courtship period, birds were departing around sunrise again.

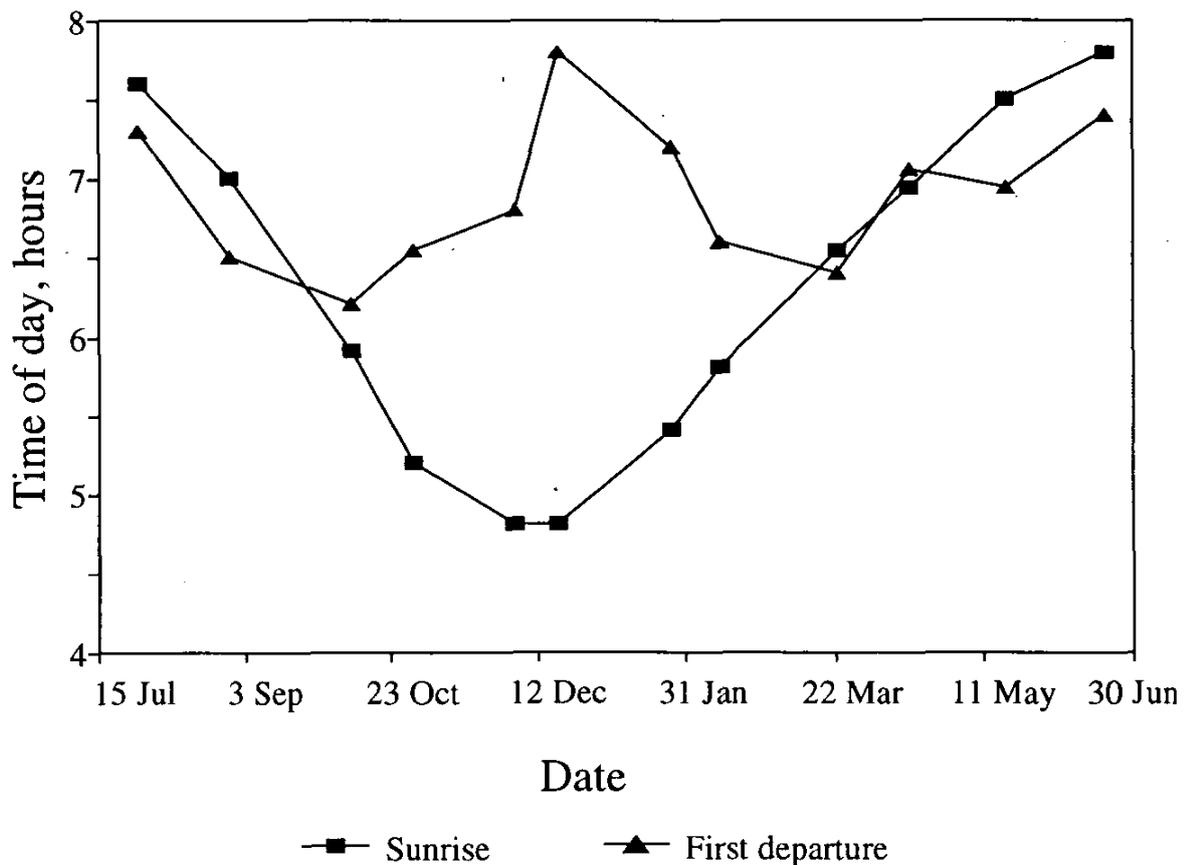


FIGURE 10 – First departing birds in relation with sunrise.

DISCUSSION

King Shags are sedentary and restricted to the outer Marlborough Sounds. For the King Shags from Duffers Reef the average distance to the feeding area is 8.2 km and the maximum is 24 km. *Phalacrocorax aristotelis*, a shag from Europe, has a similar feeding range of 7 to 17 km (Rees 1965, Pearson 1968, Wanless *et al.* 1991a) and among the Phalacrocoracidae, distances between colony and feeding area can be as much as 60 km (Bekhuis *et al.* 1987).

The diving depth among the Phalacrocoracidae varies from 1.5 m (*P. auritus*, Cooper 1986) to maxima of 116 - 125 m in *P. atriceps* (Williams *et al.* 1990, Wanless *et al.* 1991b). *P. aristotelis* showed much similarity with King Shags as they also fed close to the seabed between 21 and 40 m (max. 43 m), using <11% of the area available (Wanless *et al.* 1991b). The Stewart Island Shag, which is closely related to the King Shag, dives in waters up to 40 - 50 m deep (Lalas 1983). Lalas (1983) describes solitary shags as exclusively demersal feeders, taking solitary slow-moving prey at or near, the sea floor.

Little is known about the food of the King Shag. Juvenile as well as adult flatfish was the most important prey for the Stewart Island Shag (Lalas 1983), the closest relative of the King Shag, and so it seems likely that King Shags also feed on flatfish. Breeding in winter is probably related to food availability caused by seasonal patterns in Cook Strait. During winter, nitrate rich bottom water from the Cook Strait enters the bottom layer of the outer sounds and phytoplankton biomass in this layer reaches a peak in this period (Gibbs 1991). Flatfish migrate in winter to spawn in deeper waters and the peak in winter of phytoplankton is followed by an increase in free swimming flatfish larvae in late winter early spring. In summer small flatfish settle in shallow coastal waters and inlets, which are vital nursery areas. A recent study of pellets regurgitated by King Shag (Lalas in prep.) indicated that the food of King Shags is mainly bottom living fish. Illegally shot birds and regurgitations from disturbed birds contained only sole *Peltorhamphus novaezeelandiae*; other species recorded are: *Gonorynchus greyi* and *Parapercis colias* (Nelson 1971). Six species of flatfish from the Marlborough Sounds are known of which *P. novaezeelandiae* (common sole) *Pelotretis flavilatus* (lemon sole) and *Arnoglossus scapha* (witch) show overlap with King Shag feeding areas and activity pattern. Juvenile *P. flavilatus* is more numerous in the outer sounds because of constant salinity. Eggs of *P. flavilatus* are extremely buoyant and will not survive in the freshwater layer of the inner sounds, caused by the winter spring rains (Rapson 1940). In Otago, juvenile and adult *P. flavilatus* and *Peltorhamphus novaezeelandiae* are relatively common off-shore and avoid the shallow waters of inlets (Roper & Jillett 1981). *A. scapha* and *P. flavilatus* are visual diurnal feeders (Livingstone 1987) and a potential prey for the King Shag.

This study shows that King Shags from Duffers Reef use a specific area in the outer Pelorus Sound to feed; they feed individually, presumably on flat bottoms in waters between 20 and 40 m. Here they do not compete with the other two most common shags in the Marlborough Sounds, the Pied Shag and the Spotted Shag. Pied Shags breed throughout the Marlborough

Sounds. They are also solitary feeders, but fish close inshore, often in depths of 3 – 10 m at distances of 100 – 300 m from the shore (Stonehouse 1967). Spotted Shags are social feeders in flocks of up to 100 birds, often between 2 – 16 km from the coast (Stonehouse 1967). They feed on pelagic fish in deeper water (Lalas 1983) and breed in the outer sounds.

Activity patterns of King Shags vary with season and time of day. Marchant & Higgins (1990) describe a difference in time of departure for both sexes during the breeding period: "Where colonies far from feeding areas, females leave to feed in mornings, males in afternoon. Female build nest with material brought by male". Mass departures during the courtship/breeding period around sunrise and a second peak around 13:00 hrs might well be caused by the difference in sexes. During this period male and female have to stay alternately at the colony to attend to the nest site. Short daylight with only half a day for each mate to search for food will give a strong motivation to leave the colony very early in the morning. So it is assumed that females left to feed in the morning and males in the afternoon to feed and collect nesting material.

As King Shags have an average clutch size of 1.8 eggs (Nelson 1971), the 60 pairs that bred on Duffers Reef in 1991 would have laid about 108 eggs. A breeding success of 10 juveniles was 9.3% of the estimated number of eggs. This result is much lower than that of other shag species, e.g. *Phalacrocorax purpurascens* (57-61%), *P. melanogenis* (31-39%) *P. varius* (26.2%) and *P. punctatus* (54.4%) (Marchant & Higgins 1990). Still, there are no indications of a downturn in total number of nests since 1948. The low breeding success is suspicious and urgent study is needed to determine if this is typical. What affects breeding success and is there already a significant disturbance by visitors? New interest from tour operators in the King Shag and more human interference in general around the colonies need to be carefully managed. Though landing on the reef is not permitted, an agreement between charter-boat owners and the Department of Conservation to keep a distance of 50 – 100 metres away from the colony is not enough to protect the King Shags from considerable disturbance. This very timid bird deserts its nest easily when disturbed by recreational fishing, diving, aeroplanes and organised charters. I saw eggs taken by Black-backed Gulls and Red-billed Gulls and others lost by just rolling out of the nest during panic take-off when a boat passed close by. Another concern is the use of set-nets placed very close to the colony.

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