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SHORT NOTE

Dive duration and some diving rhythms of the New Zealand king shag (*Leucocarbo carunculatus*)

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The New Zealand king shag (*Leucocarbo carunculatus*) is a threatened species, with a total population of 524 (Schuckard 1994). It is endemic to the Marlborough Sounds, at the northern end of the South Island, New Zealand (Heather & Robertson 1996). There has been only 1 previous account of dive duration (Nelson 1971) and none on diving rhythms of king shags. Stonehouse (1967) recorded the diving rhythms of some New Zealand shag species but none for any of the genus *Leucocarbo*. Lalas (1983) examined dive rhythms of the closely related Stewart Island shag (*Leucocarbo chalconotus*), in the only detailed study of diving behaviour for any species of the genus.

Anecdotal observations of foraging king shags were recorded wherever they were sighted throughout their range from 14 Apr 1988 to 9 Mar 2000. Most observations were made in the outer Pelorus Sound. If a shag was seen to dive, the surface nearby was scanned until the shag reappeared. If possible, the boat was kept at least 200 m away from the bird to avoid disturbance. Times were recorded for dive duration and for the surface rest time between dives, rounded to the nearest 5-s period. Dive times were rounded downward only, to take account of a known source of error in over-estimating dive duration (Stonehouse 1967; Lalas, 1983).

On 10 occasions, sequences of 2-15 dives were observed, with dive times and rest time between dives being recorded. The duration of 12 other single dives are also reported (Table 1).

Fifty-three individual dives were timed, for 22 different shags on 14 different days, from 19 Sep 1990 to 9 Mar 2000. Individual dives occupied 65-190 s (mean 127 s). Rest times between dives (n=38) averaged 157 s (range 55 – 745 s). The mean dive duration was considerably longer than the dive times (mean 45 s, max. 90 s) suggested by Heather & Robertson (1996), based on observations of 22 dives by 6 individual shags (Nelson 1971). Foraging strategies may be different in other areas within the species' range, and it is known that dive time varies with water depth for bottom-foraging shags (Stonehouse 1967; Lalas, 1983). Diving behaviour of shags can also vary according to prey availability (Kato *et al* 1992). Alternatively, I have observed several escape dives of up to 55 s when a king shag dove to avoid a boat approaching too closely. Such displacement dives were determined by the activity of the shag – they swam rapidly away from the approaching boat, with the head turning animatedly from side to side, before hurriedly diving. In normal foraging dives the shag appears 'at rest' on the water surface and the dive appears to be much more leisurely. I have found king shags to show signs of displacement behaviour at a range of 200 m from a boat, and sometimes more. Escape dives mistaken for foraging dives could affect mean dive times.

King shags are known to dive in waters of depths up to 90 m, but tend to favour water depths of 20-40 m (Schuckard 1994). A study of king shag diet in the Pelorus Sound found they were feeding on benthic fish (Lalas & Brown 1998).

Dive duration may be affected by success of the dive. One of the shortest dives recorded, near Maud Island on 18 Jan 1991, involved a shag surfacing after 70 s with an unidentified flatfish species (estimated length 15 cm) in its beak. It is thought most prey are consumed underwater but larger or more difficult prey are brought to the surface.

Further evidence of the species diving capability is provided by 2 other observations of shags surfacing from known depths with flatfish. One surfaced near Oke Rock in the outer Pelorus Sound in an area of relatively

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Table 1 Dive and rest times (s) of king shags (*Leucocarbo carunculatus*), Pelorus Sound, New Zealand. us, bird unsighted at time of diving or surfacing; *, surfaced with flatfish.

Date	Location	Bird	Rest	Dive	Rest	Dive	Rest	Dive	After observations
7 Feb 1992	Maud Island	A	us	**130**	470	**115**	200	**120**	Continued diving
			315	**115**	745	**145**	us		
18 May 1999	Te Puraka	B	70	**180**	85	**170**	75		Flew away
18 May 1999	Ouokaha	C	us	**140**	85	**115**	120	**100**	Lost from sight
			125	**125**	85	**160**	us		
17 Feb 1999	Forsyth Bay	D	us	**190**	260	**125**	245	**190**	Roosted; mussel farm
26 Aug 1999	Port Ligar	E	us	**125**	125	**115**	250	**170**	Lost from sight
			320	**us**					
16 Feb 2000	Wynens Bay	F	155+	**145**	210	**165**	135	**155**	Continued diving
			110	**us**					
16 Feb 2000	Forsyth Bay	G	us	**120**	60	**95**	55	**125**	Continued diving
			65	**105**	65	**125**	75	**135**	
			75	**140**	70	**135**	70	**130**	
			130	**140**	80	**us**	us	**170**	
			140	**160**	155	**us**	us	**us**	
20 Jan 2000	Brightlands Bay	H	140	**120**	145	**us**			Continued diving
9 Mar 2000	West of Duffers Reef	I	us	**125**	100	**125**	110	**us**	Continued diving
9 Mar 2000	Ketu Bay	J	us	**120**	130	**115**	120	**130**	Continued diving
			135	**110**	105	**125**	us		
No date	Various (single dives)	K-V		**110**		**75**		**70**	
				105		**115**		**70***	
				65		**120**		**135***	
				90		**130**		**90**	

uniform 60 m depth, and 1 on 17 Sep 1999 near Tapapa Point, east of Maud Island, in the same water depth. For both dives, bottom depths were measured on a depth sounder, but dive duration was not recorded.

Only 1 of the 10 dive sequences observed was a complete set with the bird seen arriving, performing a full sequence (2) of dives, and then seen departing. The other sequences (2-15) were incomplete, as I was not able to observe both the start and end of each series. Most shags appeared to continue diving but were lost sight of some point before they left.

Where the precise position of the shag could be obtained, or where seafloor depth was constant over the general area, I could compare dive times with depth. Lalas (1983) found that dive time and water depth for *L. chalconotus* were significantly correlated, but no relationship was found here. This is probably resulted from the small sample size (33 dives) and to most timed dives being in relatively similar depths (25-40 m).

The results provide evidence of dives of longer duration than previously recorded for king shags. The maximum dive length of 190 s is similar to the 169 s recorded for *L. chalconotus* (Lalas 1983). Extended sequences of at least 15 dives (see bird G, Table 1) and of at least 45 min in duration were recorded at times, again being similar to records for *L. chalconotus* (Lalas 1983) in water of similar depth.

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