RETENTION AND CONDITION OF CEPHALOPOD BEAKS IN THE STOMACH OF AN AUSTRALIAN SEA LION (*NEOPHOCA CINEREA*)

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Australian sea lions (*Neophoca cinerea*) prey upon fish, cephalopods, crustaceans and sea birds (Marlow 1975; Walker and Ling 1981; Gales and Cheal 1992; Kemper and Gibbs 1997; McIntosh et al. 2006). However, quantitative assessments of diet are limited and little is known about the digestive properties of wild *N. cinerea* (Richardson and Gales 1987; Bodley et al. 1999). Variation in passage of prey through the digestive tract has been shown in *N. cinerea* (Gales and Cheal 1992; Bodley et al. 1999) and other pinnipeds (Cottrell et al. 1996; Fea and Harcourt 1997; Bowen 2000; Staniland 2002; Tollit et al. 2003; Yonezaki et al. 2005) and passage rate may vary by prey type *e.g.*, squid vs. fish, leading to bias in quantitative dietary analyses (Staniland 2002).

Neophoca cinerea undertakes foraging trips of approximately two days followed by some days ashore (Higgins and Gass 1993) therefore it is important to consider variation in rates of passage when studying diet by methods where samples are collected when the animal is ashore, e.g. scats, stomach contents.

Gales and Cheal (1992) undertook experimental feeding studies with captive *N. cinerea* and demonstrated that scat analysis is unreliable for determining dietary intake due to larger cephalopod beaks being more likely to be retained in the gastrointestinal tract (GIT). While experimentation with captive animals has an important role in determining the validity of wild studies, it is also subject to biases inherent in the constraints of captivity.

Opportunistic reports, such as the present one, with information that corroborates tightly controlled captive studies and descriptive work from free-ranging animals, is likely to enhance our understanding of the validity of these processes. This note reports on an opportunistic observation of digestive rates of prey in a wild free-ranging *N. cinerea* that was brought into captivity for 14 days and subsequently died. Differences are described between food given while in captivity and remains found in the stomach during post-mortem examination.

On 7 October 2000 an injured adult male *N. cinerea* was reported to the Royal Society for Prevention of Cruelty to Animals (RSPCA) to be at Point Davenport, SA (Latitude 35° 09´S, Longitude 137° 20´E) (GDA94). The animal had extensive injuries believed to be the result of a shark attack. Approximately half of the rear left flipper was missing and an open wound and other lacerations were present on the lower abdomen. The sea lion was admitted to the RSPCA seawater facility where it was housed alone in an enclosure with free access to swimming pool and dry pen areas. The sea lion remained at the facility for 14 days during which time it was fed up to 12 kg of fish per day (total 142.1 kg) and treated daily with antibiotics (Clavulox) administered within fish cavities (RSPCA case notes Sea-lion 272).

There were faeces in the enclosure each day but these were not collected. No regurgitates were noted. Fish species fed were *Arripis truttacea* (maximum length of 41 cm), and *Sardinops neopilchardus* (maximum length of 29 cm). Remains of these two species have been identified in the stomach contents of carcasses of free-ranging wild *N. cinerea* analysed by the author at the South Australian Museum (SAM). All fish offered were consumed. The sea lion was described as interested in eating, active, alert and using both the pool and dry areas each day. After 13 days RSPCA veterinary staff determined that partial amputation of the flipper was the best option. The sea lion was fed 6 kg of fish the evening of 20 October, and then was not fed the next morning due to impending anesthetic. At 1409 hrs, 21 October, the sea lion was sedated and then died under anesthesia at 1435 hrs. The body (weight 151 kg, total length 2270 mm) was brought to the SAM for post-mortem examination, after which the skeleton was entered into the collection (M22083). The GIT was excised and the stomach and intestinal contents removed separately and flushed with water through a 1.0 mm sieve. Hard remains of prey were identified to the lowest taxonomic level possible and measured to the nearest 0.1mm using the methods of Clarke (1986).

The only food items remaining in the stomach were 63 cephalopod beaks (Table 1), including *Octopus sp.*,

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Beak ID	UCL (mm)	UHL (mm)	LCL (mm)	LHL (mm)
Sepia sp. upper	14.3-15.1 n=2			
Sepia sp. upper	16.4-31 (21.5) n=21			
Sepia sp. lower			7.9-20.5 (13.1) n=24	
Octopus sp. upper	13.3-18.1 (15.8) n=3			
Octopus sp. lower			9.6-15.4 (12.1) n=3	
Sepioteuthis australis upper		*5.5–12.5 (8.2) n=5		
S. australis lower**			14	2.8-5.1 (4.1) n=5

Table 1. Measurements to nearest 0.1mm (mean length in mm) of cephalopod beaks found in the GIT of a *Neophoca cinerea* 22 hours after its last feed of fish and at least 14 days after access to cephalopod prey. U = upper, H = hood, C = crest, L = length (Clarke 1986), * Reliable UCL were unobtainable, UHL is shown, ** Reliable LCL was obtainable in one beak, LHL is shown.

Sepia sp. and *Sepioteuthis australis*, with two upper *Sepia* sp. beaks found in the intestine. Stomach stones are common in *N. cinerea* (Wood Jones 1925; Marlow 1975; Needham 1997) but were not present in this specimen. There were no fish remains, indicating that these must have passed through or been completely digested within hours as demonstrated in some phocid seals (Murie and Lavigne 1986).

The condition of the beaks varied within and between cephalopod species. Octopus upper beaks were generally intact, with little cracking and chipping confined to the posterior edge of the hood and posterior and ventral edges of the lateral walls. In lower octopus beaks the bottom portion of wings were worn off to evenly rounded edges just below the junction of the lateral wall on both sides. The posterior and ventral edges of the lateral walls were cracked and chipped. The posterior edges of all crests were deeply chipped and/or cracked.

Sepia sp. beaks, which are the most robust of the genera found in the stomach, had the least damage but damage varied considerably. Upper beaks were generally intact, with most damage limited to the posterior edge of the hood and posterior and ventral edges of the lateral walls. Lower beaks were more variable, with two lower beaks exhibiting very little damage while the remaining 22 had the bottom portion of the wings worn off to evenly rounded edges near the junction of the lateral wall. The posterior and ventral edges of the lateral walls showed little cracking and chipping.

Beaks of *Sepioteuthis australis* were the most damaged. Beaks of this species retain a large transparent margin when fully mature and are not as robust as *Octopus* or *Sepia* beaks. The upper and lower beaks had various amount of damage, larger beaks were less damaged. The smallest of the upper beaks was worn to the darkly pigmented portion of the rostrum and shoulder with very little of the transparent part remaining. The largest upper beak had deep cracking and chipping to the posterior edge of the hood with the lateral walls broken of at the junction of the wing. Three intermediate sized beaks showed progressive damage according to size. Lower beaks' wings were worn off to a rounded edge near the junction of the lateral wall where the darkly pigmented strip ends. The smallest of the lower beaks was worn to the darkly pigmented part of the rostrum and shoulder with a small portion of transparent crest and lateral wall remaining. The free corners of the lateral walls were missing in all but the largest specimen.

Differences in the condition of beaks indicate that damage may occur at different rates and areas for various species and demonstrates the importance of choosing beak measurements appropriate for each species of prey to yield the most accurate back-calculations for prey size.

A notable difference between this study and Gales and Cheal (1992) was the number of upper to lower beaks. The present study found equal numbers of upper and lower beaks for octopus and *S. australis* and one less upper than lower *Sepia* sp. beaks. There was an apparent lack of upper beaks (only three of a total of 65 beaks) found in the stomachs of five sea lions studied by Gales and Cheal (1992).

All beaks recovered were within the sizes (table 1) reported by Gales and Cheal (1992) from *N. cinerea* stomach contents, and larger than octopus beaks they recovered from scats. However, the presence of beaks in the intestine at least two weeks after being consumed indicates that some beaks eventually pass through. Two upper *Sepia* sp. beaks found in the intestine were of similar size and robustness to those in the stomach, and not the smallest in the GIT, indicating that small size does not necessarily bring about passage into the intestine. Perhaps smaller beaks become interlocked with other beaks to form a mass and during a period of fasting some of these beaks may become loose and pass through. The condition of the beaks found in the stomach indicates that some species and beak sections are more vulnerable to damage, in particular the free ends of the wings.

The *N. cinerea* in this study was fed 6 kg fish approximately 22 hours before death and had not consumed cephalopods for at least the previous 14 days. Passage through the GIT was less than 24 hours for the two fish species fed, while beaks remained for at least two weeks. This is consistent with feeding studies of captive *N. cinerea* where fish and squid marked with titanium dioxide had a mean transit rate of 14.9 hours (Bodley et al. 1999), and where items of low digestibility, including beaks, remained in the alimentary tract for more than six days Richardson and Gales (1987).

Bias in diet studies can occur when different rates of passage through the digestive tract apply to different prey. Fish otolith and cephalopod beak variation in passage time resulting in bias has been reported for many pinniped species e.g. (Cottrell et al. 1996; Fea and Harcourt 1997; Bowen 2000; Tollit et al. 2003). The present observations corroborate previous studies (Gales and Cheal 1992; Bodley et al. 1999) in that bias due to relatively rapid passage of fish prey and retention of cephalopod beaks also occurs in *N. cinerea.* Although injury and adjusting to a captive environment may have compromised the digestive processes, the disparity between prey that were known to have been consumed and the remains in the stomach was great, with no overlap. This variation highlights possibilities for bias in diet studies based on GIT content, regurgitate and scat analysis, particularly for samples that are sourced from land. Only some fish prey consumed during the latter part of foraging trips, more likely to be coastal species consumed when returning to land, may be present. Cephalopod prey may be over or under represented depending on the method of sample collection. In conclusion, caution should be exercised when employing methods using hard part analysis for diet studies of *N. cinerea,* as the time period prey items have accumulated cannot be confidently estimated, and prey consumed during the same time period that have already passed through will be missed.

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