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THE EFFECTIVENESS OF AN ESTABLISHED SANCTUARY ZONE FOR REDUCING HUMAN DISTURBANCE TO AUSTRALIAN SEA LIONS (*NEOPHOCA CINEREA*) AT CARNAC ISLAND, WESTERN AUSTRALIA

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This study tested the effectiveness of a recently established sanctuary zone on Carnac Island (Western Australia) in reducing human disturbances to Australian sea lions (*Neophoca cinerea*). Several methods of recording behaviors were also tested to clarify their adequacy for detecting human disturbances. Observations made between March 2005 and September 2006 (98 observations over 16 days) indicated that a wireless camera was effective for monitoring sea lions unobtrusively, and continuous and instantaneous observations were both generally effective in monitoring levels of human disturbance. The sanctuary zone was ineffective in that sea lions hauled out more often in the adjacent recreational zone, even though the sanctuary was established based on previous observations. This study concluded that sea lions are more likely to haul out where environmental attributes along a beach are suitable. Because environmental conditions are variable over time, a fixed sanctuary zone will only aid in reducing impacts when conditions are suitable in that zone. The authors recommend that future sanctuaries should include entire stretches of useable beach to be effective.

Key words: Australian sea lion; Western Australia; Sanctuary zone; Observation methods; Wildlife tourism

Introduction

This study investigated impacts from human presence associated with recreation and tourism on the Australian sea lion (*Neophoca cinerea*) while hauled out on Carnac Island Nature Reserve (Western Australia) after the establishment of a sanctuary zone. Wildlife tourism is ever expanding across Australia and, given that the city of Perth has the highest per capita boat ownership in Australia, Carnac Island provides an ideal site to study the effects of marine mammal tourism on Australian sea lions (Orsini, Shaughnessy, & Newsome, 2006; D. I. Walker, Lukatelich, Bastyan, & McComb, 1989).

The Australian sea lion (*Neophoca cinerea*, family Otariidae) is an endemic species, restricted to southern and southwestern Australia (Shaughnessy, Dennis, & Seager, 2005; Gales, Cheal, Pobar, & Williamson, 1992). This species suffered past population decline during the 19th and early 20th century from

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commercial harvesting (for meat and leather), from which it has not been able to fully recover (Gales, Haberley, & Collins, 2000; Ling, 1999; Shaughnessy, 1999). According to G. Walker and Ling (1981), the range of the Australian sea lion distribution in the past extended from the Abrolhos Islands (28°S, 114°E) right around to the east coast of Australia at Queenscliff (38° 17′S, 144° 42′E) in Victoria (Fig. 1). The current range extends from the Abrolhos islands to just east of Kangaroo Island (35° 47′S, 138° 17′E) (Ling & Walker, 1978). Since protection in 1892 (Gales et al., 2000), colonies of fur seals have been recovering successfully (from 7,100 animals in 1990 in Western Australia to 15,100 in 2000) (Gales et al. 2000), but there is no evidence for a similar increase of Australian sea lions (total population estimated at 9,300–11,700 animals in 2005) (Department of Conservation and Land Management [CALM], 2004; Shaughnessy et al., 2005; Gales et al., 2000;), and in fact it is not known whether the population may in fact be declining. Because of its small population size and endemicity the species was listed as rare by the Seal Specialist Group of the Species Survival Commission in 1993 (Shaughnessy et al., 2005), and because of the small breeding population has been suggested to be highly vulnerable to local extinctions (Orsini, 2004), and in fact is listed as "vulnerable" under the Commonwealth's Environment & Biodiversity Protection Act (Department of the Environment, Water, Heritage and the Arts, 2008).

Current pressures that affect the Australian sea lion and many other pinniped species are generally from

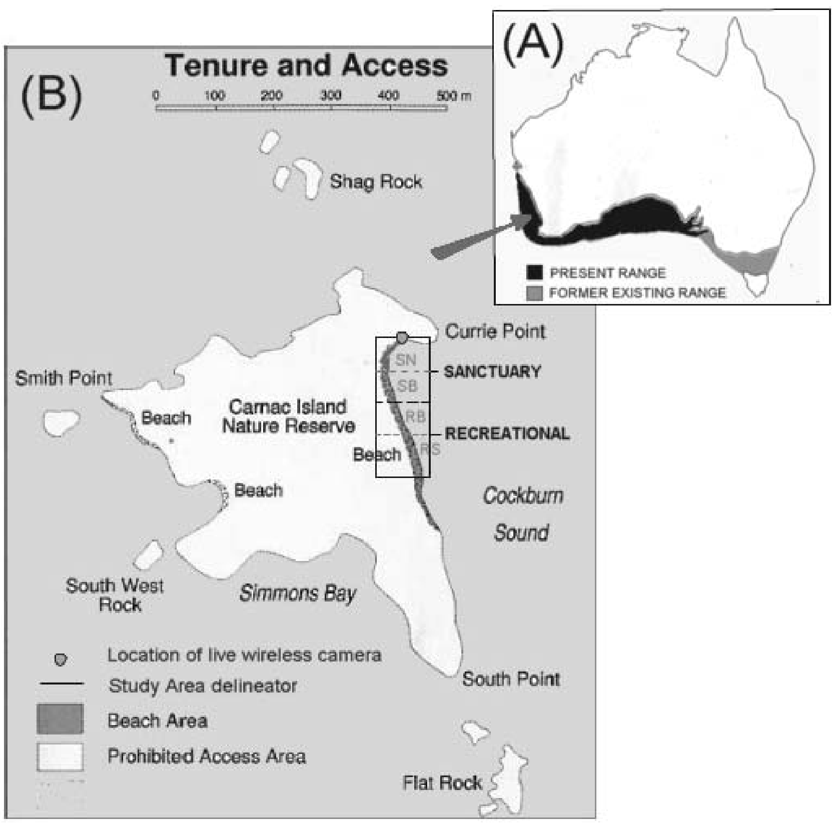

Figure 1. Approximate past and present distribution of the Australian sea lion (A) (DEC, 2004; modified from Ling & Walker, 1978); and study area, showing the sanctuary and recreational zones (B) (adapted from the Carnac Island Management Plan; CCWA & CALM, 2003). SN: Sanctuary north zone, SB: Sanctuary boundary zone, RB: Recreational boundary zone, RS: Recreational south zone.

indirect factors, which are often associated with industries such as fisheries and tourism (Kirkwood et al., 2003). Although today's fisheries do not directly target seals or sea lions, impacts occur as a consequence of poor fishing practices that result in bycatch, entanglement of waste from boats such as synthetic material, nets, and lost fishing gear (Page et al., 2004). Other indirect effects apart form tourism include depletion of sea lions' natural diet such as fish and crustaceans, or impacts causing an alteration in their natural behavior (relying on food from trawling nets to feed), and impacts caused by low flying aircrafts over breeding and haul-out sites (Shaughnessy, 1999). Observed responses to this type of disturbance include animals fleeing to the sea, which could cause trouble during the breeding season as mothers may not be able to relocate their pups (Shaugnessy, 1999). Also instances of sea lion pups drowning in lobster pots (Gales et al., 1992), boat-caused injuries and deaths (Orsini, 2004), and in more extreme cases instances of spearing or shooting (CALM, 1992) have been documented. Only recently have impacts from underwater man-made noise been included in studies on impacts to marine mammals (Salgado Kent & McCauley, 2006).

With respect to ecotourism, the industry has increased rapidly in recent years (Kirkwood et al., 2003). Tourism can be seen as both beneficial and detrimental. Beneficial effects occur from creating greater public awareness and instilling a public desire to conserve (Gales, Hindell, & Kirkwood, 2003). However, tourism can be detrimental as it can degrade the ecological value of a site and may cause the wildlife to move away from a site or decrease in number (Gales et al., 2003). Tourists feeding animals, for example, disrupts natural behavior of sea lions. When tourists feed animals they feel they are communicating with nature (Orams, 2002). Orams, (2002) found that feeding marine mammals on the West Coast of the US could lead to animals becoming dependent upon being fed and has in fact resulted in numerous pinniped attacks on humans. With more specific relevance to the Australian sea lion, CALM (1992) reported that scuba divers were hand feeding sea lions on Seal Island (Western Australia) to encourage them into the water. Beach visitors on the Island were also feeding animals in order to interact with the sea lions (CALM, 1992).

Pinniped tourism is also usually associated with large numbers of tourists visiting sea lion (or seal) haul-out sites (Cassini, 2001). The most popular site in Australia for pinniped tourism is at Seal Bay on Kangaroo Island, where visitation has increased from 20,000 tourists per annum in the 1970s to over 100,000 per annum in the late 1990s (Gales et al., 2003). Because accessibility to viewing sites is a major factor for successful pinniped tourism, the most common tourist destinations are those with close proximity to human population centers. CALM (1992), Orsini (2004), and Orsini et al. (2006) found this was the case at islands around Perth (Western Australia), where, for example, approximately 70,000 people visiting Penguin Island. The island is only 12.5 ha in size and experiences 3,500 people on the island on the busiest days (CALM, 1992). Orsini et al. (2006) also found high visitation occurring on Carnac Island (Fig. 1), which has an area of 19 ha. For such a small area Carnac Island receives approximately 13,000 visitors on land per year and 20,000–30,000 in the eastern bay (Orsini, 2004; Orsini et al., 2006).

Many preferred sea lion haul-out sites tend to be located at beaches on offshore islands, which is often due to the absence of human impacts and terrestrial predators (Stevens & Boness, 2003). Tourism, however, often targets pinniped haulout sites (shore areas—beaches, rocky shores—that sea lions use consistently throughout the year to come to shore), and consequently there is increasing competition for space between tourists and sea lions. Seal Island (in the Shoalwater Island chain, Western Australia), for example, may have from 2 to 35 animals including adult and subadult males (CALM, 1992). The island is less than 3 ha in size and therefore has very limited beach area (~40 m in length). Before closing public access to the island, CALM (1992) recorded high numbers of people and sea lions using the beach simultaneously (e.g., up to 60 people and 16 boats on the beach area with 22 sea lions at one time) (CALM, 1992). The seriousness of the effect of tourism on sea lions resulted in closure of public access to Seal Island (CALM, 1992).

Similar disturbance to sea lions from human visitation has been confirmed at Carnac Island (Orsini, 2004; Orsini et al., 2006). Carnac Island has a limited beachfront area, hence large numbers of boats and human visitors have the potential to cause competition for space. This potential became evident when sea lions were observed to leave the beach or reduce their time spent hauling out when humans were close in proximity (Orsini, 2004; Orsini et al., 2006). Orsini (2004) suggested that in the longer term there could be a risk of sea lions abandoning the site altogether. As a result, a sanctuary zone was established by DEC (the Department of Environment and Conservation in Western Australia—formerly known as the Department of Conservation and Land Management or CALM) on the northern end of the beach, restricting human visitation to the southern end (the recreational zone).

For informed management decisions regarding the protection of key haul-out sites, not only is an understanding of the ecology and behavior of sea lions important, but so is an understanding of the effectiveness of sanctuary zones. This study aimed at testing the effectiveness of the sanctuary zone established on Carnac Island. Specifically, it aims to address the following question: Is the establishment of the sanctuary zone resulting in significantly decreased human disturbance to sea lions at Carnac Island? For the establishment of a sanctuary to be effective: firstly, human activity in the general area where the sanctuary zone is located must be high enough to be causing human disturbances to sea lions; secondly, the zone must be largely left undisturbed by human presence or activity; and thirdly, a significant proportion of sea lions must use the zone. Hence, we examined the effectiveness of the sanctuary zone by testing the following hypotheses:

1. There are fewer humans using the sanctuary zone established on Carnac Island than the recreational zone (regardless of time of day or month).
2. The number of sea lions is greater within the sanctuary zone than in the recreational zone (regardless of time of day or month).
3. Sea lion responses to human disturbance (measured by the number and duration of behavioral events associated with vigilance) are higher within the recreational zone than in the sanctuary zone during high human visitation periods, but are low inside the sanctuary zone regardless of human visitation period.
4. The time sea lions spend resting is less outside of the sanctuary zone during high human visitation periods than during low human visitation periods, but is low inside the sanctuary zone regardless of human visitation period.

To test these hypotheses, several methods for collecting data (on numbers and behaviors of sea lions) were tested and compared to identify the most useful for the purposes of this study. The first of these included a comparison of behavioral data based on continuous observations with those based on instantaneous observations. Continuous observations involve recording the duration of behaviors, while instantaneous observations result in a count of behavioral events, the number of times a behavior was instigated (Terhune & Brillant, 1995). Currently, there are no data to indicate that these two types of observations are interchangeably or whether one is more suited for recording human disturbance to sea lions than the other. The second set of methods tested included a comparison of data collected by in situ field observations with those made remotely using a wireless video camera, and a comparison. In situ field observations have the advantage of close proximity to the subjects under observation, but may cause artifacts to be introduced into the data, from the presence of the observer (Tershy, Breese, & Croll, 1997). Furthermore for studies on islands or remote areas, remote observations using a camera are more cost-effective for long-term studies, because they do not require travel to the site (by boat or car).

The Study

General Methods

Study Site. Carnac Island is one of six islands off the coastline around Perth (WA) where male Australian sea lions are known to haul out. The island (Fig. 1) is located 8 km southwest of Fremantle, and is an A class nature reserve (Abbot, Marchant, & Cranfield, 2000). The management purpose of the reserve is "the conservation of flora and fauna and recreation" by "ensuring that the passive recreation activities that are permitted on the island do not compromise the island's conservation purpose" (Conservation Commission of Western Australia and Department of Conservation and Land Management [CCWA & CALM], 2003). Carnac Island provides an ideal site to study Australian sea lions and possible effects from human interaction because of its close proximity to Perth (the largest city in Western Australia). Also, the recently established sanctuary zone created on the northern end of the beach (~120 m of beach), restricting human visitation to the southern end (recreational zone; ~150 m of beach), allows comparison of human disturbance between protected and nonprotected areas.

Data Collection and Analysis. All observations during the study were conducted between 0900 and 1600 hours on days between March 2006 and September 2006, depending upon weather and logistics. Field observations were conducted at a distance greater than 15 m from the sea lions, using binoculars to ensure that observer presence did not introduce significant artifacts in the data (Orsini, 2004; Orsini et al., 2006). Data were recorded both on a spreadsheet and voice recorder to ensure accuracy. Replicates for each experiment were variable and dependent on time available on the island (see Fesults section for information on replicates). All statistical analyses were done using Statistica 5.5 (© StatSoft Inc.). Analyses included ANOVAs (repeated-measures ANOVAs where levels of factors were considered nonindependent) for factor analysis, paired *t*-test for comparison of nonindependent means, and simple regression analysis for testing the significance of correlations between variables (details of each analysis are in relevant Results sections below). The assumption of homogeneity of variance for parametric statistics was tested using Levene's test, and normality was tested using the Kolomogrov-Smirnoff test. In cases where data were heterogeneous, they were log or square root transformed until the test of homogeneity was not significant ($p > 0.05$). For repeated-measures ANOVAs, in the few cases where the assumption of homogeneity of variances was still not met after transformation, data were checked for sphericity with Machley's test, and the Greenhouse Geisser correction factor was applied (StatSoft, Inc. 1984–1994).

Behavioral Observations. For behavioral observations throughout this study, sea lions were selected randomly within each of the zones (sanctuary or recreation). Random selection was done by counting the total number of sea lions on the beach at the time of observation, designating a number to each animal, and then using a random number generator to select a sea lion. No sea lion was sampled twice. Behaviors recorded included "look," "lift head," "sit up," "rest," and "readjustment." Time spent at rest (not doing any of the other behaviors) was also recorded. Behavioral observations were made over 20-minute periods. Behaviors were defined in the following way:

- "Look": a sea lion looked directly at the stimulus without lifting its head off the sand,
- "Lift head": a sea lion lifted its head off the sand to look at the stimulus,
- "Sit up": a sea lion sat upright facing the stimulus or near it,
- "Rest": a sea lion was observed lying motionless with its head resting on the sand and eyes closed,
- "Readjustment": a sea lion showed slight movements such as raising a flipper (for thermoregulation) or a slight roll or turn to readjust its posture, or when a sea lion performed an action such as a look, lift head, or sit up, but no stimulus causing disturbance was present or noticeable.

Comparison of Methods for Collecting Data

Comparison of Instantaneous and Continuous Behavioral Cbservations. Sea lion behaviors were recorded using instantaneous and continuous observations simultaneously during high visitation periods in the recreational and sanctuary zones. Continuous observations involved recording the cumulative time spent doing behaviors, while instantaneous observations involved counts of the number of times behaviors were initiated (over each 20-minute period). Behaviors recorded included "look," "lift head," and "sit up."

Comparison of Remote Observations Using a Wireless Camera to Field-Based Observation. Data were collected using two methods: 1) direct observation in the field, and 2) observation from a monitor based at the DEC (Fremantle, WA) fed real-time video from a wireless camera (an Axis 213 PTZ network camera with 4× zoom) based at Carnac Island (the distance between the camera and the opposite end of the study area was approximately 270 m; see Fig. 1 for location). One observer was based at the island, while the other was based at the DEC office. Simultaneous observations were coordinated by following a timetable and communicating by mobile phone. Data were collected on numbers of sea lions and their behaviors ("lift head," "sit up," "rest," and "readjustment") using both continuous and instantaneous methods. Abundance was recorded in the recreational and sanctuary zones every 30 minutes after arrival to the island, and behavioral observations were made between counts of sea lions.

Assessment of the Effectiveness of the Sanctuary Zone

Abundance, distribution, and behavioral data were collected within the sanctuary zone and in the recreational zone, as well as at high and low human visitation times. To distinguish between high and low visitation the number of people on the beach and number of boats present were recorded. Low visitation was defined as the presence of less than 10 boats and no humans on the beach, while high visitation was defined as human presence on the beach and greater than 10 boats within approximately 50 m of the beach. The numbers of sea lions sampled within the recreational zone and within the sanctuary zone, and during high and low visitation, were kept balanced so that sufficient replicates were collected for analyses.

Sea Lion Abundance and Distribution. Two sets of data were collected. The initial collection was for assessing distribution in terms of presence of sea lions within the sanctuary versus recreational zone (field based), while the subsequent collection was more detailed so that numbers were recorded in four similarly sized sections along the beach (referred to as sanctuary north, sanctuary boundary, recreational boundary, and recreational south; Fig. 1). These subsequent observations were done using the wireless camera and were only done during low visitation periods (due to limited time). Counts of animals and their locations were made every 0.5 hour (consistent with previous counts).

Number and Distribution of Human Visitors and Their Relationship to Sea Lion Abundance and Distribution. Field-based counts of the number of people on the beach and numbers of boats present within approximately 50 m of the beach were made every 0.5 hour throughout each day of field observations during low and high human visitation periods in the recreational and in the sanctuary zone. Counts were consistent with those for sea lions so that numbers of human visitors could be related to numbers of sea lion using the beach.

Disturbance of Sea Lions by Human Visitation. To assess the impact of human presence on sea lions, four behaviors ("rest," "look," "lift head," and "sit up") were monitored using continuous and instantaneous observations, and the stimulus for the behavior noted (human disturbance, another sea lion, seagulls, or no apparent cause).

Results

Comparison of Methods for Collecting Data

Comparison of Instantaneous and Continuous Behavioral Observations. Results from 13 independent 20-minure observations made between March 19 and September 29, 2006 showed that a significant linear correlation was found between the two techniques with respect to the behavior "look" [$r=0.89$, $F(1,10)=44.13$, $p<0.001$] (Fig. 2). A power (chi-square) fit was slightly better, but an exponential fit was worse [$r=0.92$, $F(1,10)=270.73$, $p<0.001$; and $r=0.70$, $F(1,10)=22.86$, $p<0.01$, respectively]. Because continuous observations were measured as cumulative duration over 20-minute periods, the better fit using a power function indicates that an increase in the number of looking events was related to an increased duration of looking events. One observation was particularly high (18 events, 254 seconds), which appeared to be influencing the correlation; however, deleting it from the data set did not significantly change the strength of the correlation (linear $r=0.77$). A significant linear correlation was not found between the two techniques for the behavior "lift head" [$r=0.26$, $F(1,11)=0.83$, $p>0.05$] (Fig. 2), and "sit up" [$r=0.26$, $F(1,5)=0.35$ $p>0.05$] (Fig. 2). Power and exponential fits for "look" and "lift head" were as poor as linear fits, indicating that duration of behaviors was simply more variable.

Comparison of Remote Observations Using a Wireless Camera to Field-Based Observation. Data were collected on a single day (June 21, 2006) due to limited access to the island on other days. However, because observations using the two techniques were simultaneous and of the same subjects (individual sea lions), 1 day of observations was deemed adequate. Based on 20 observations (10 using each method), there were no significant differences in the number of sea lions counted using the camera and in the field in any of the tests (total number of sea lions, sea lions only in the sanctuary, and sea

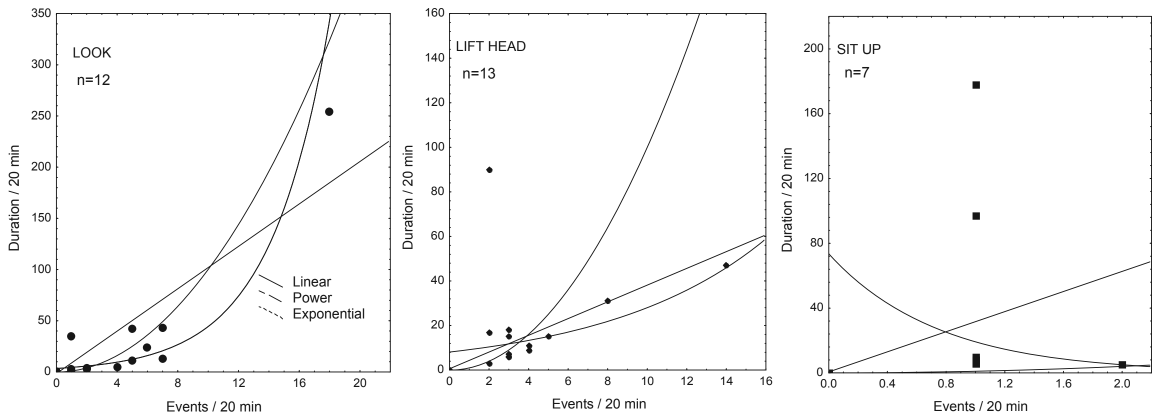

Figure 2. Relationship between continuous (cumulative duration/20 minutes) versus instantaneous observations (number of events/20 minutes) of Australian sea lions conducting the behaviors "look," "lift head," and "sit up" (some data points on the figure overlap each other).

lions only in recreational zone). Similarly, there were no significant differences between wireless camera and field measurements of instantaneous and continuous observations in the number of times sea lions performed the behaviors "rest," "readjust," "lift head," and "sit up" (Table 1). The behavior "look" was too subtle to be detected with the wireless camera.

Assessment of the Effectiveness of the Sanctuary Zone at Carnac Island

Sea Lion Abundance and Distribution. A total number of 64 counts of sea lions over 17 days was made between March 1 and September 29, 2006. Replicates for analysis were mean counts per day to ensure independence of the data. The mean number of sea lions per day was greater in the recreational zone than in the sanctuary zone [three-factor ANOVA with visitation level, time block and zone as factors: $F(1,10)=20.94, p<0.001$] (Table 2-A), regardless of human visitation level or time period (in blocks from 0900–1100, 1100–1300, and 1300–1500 hours), and regardless of month [two-factor ANOVA with month and zone as factors: $F(1,10)=31.97, p<0.001$] Table 2-B, Fig. 3).

A total of 14 counts were made over a period of 7 days September 9 through September 29, 2006 within four zones along the beach ("recreation south," "recreation border," "sanctuary border," and "sanctuary north") (Fig. 4). Numbers of sea lions differed among the four zones [$F(3,5)=15.24$, $p<0.001$] Table 2-C), with numbers significantly higher in the recreational south zone (Tukey's post hoc test).

Table 1

Comparison Between the Mean Number of Australian Sea Lions Counted Using the Wireless Camera and In-Field Observations (Total Number, Number in Recreational Zone, and Number in Sanctuary Zone) Using Paired *t*-Tests

	Technique	Mean	*t*-Value ($df=9$)	*p*-Value
Numbers of sea lions				
Total number	camera	21.6	–1.00	ns
	field	21.7		
Recreation	camera	12.2	0.00	ns
	field	12.2		
Sanctuary	camera	9.40	–1.00	ns
	field	9.50		
Instantaneous behavioral observations				
Readjustment	camera	5.9	–0.69	ns
	field	6.1		
Lifting head	camera	1.1	1.00	ns
	field	1.0		
Sit up	camera	10.0	0.00	ns
	field	9.50		
Continuous behavioral observations				
Rest	camera	94.36	–1.04	ns
	field	95.14		
Readjustment	camera	3.53	1.12	ns
	field	2.74		
Lift head	camera	0.44	1.17	ns
	field	0.38		
Sit up	camera	1.70	0.26	ns
	field	1.68		

Table 2

Summary of Significant Effects for ANOVAs of Numbers of Sea Lions (Humans for the Fourth Analysis) and Their Behaviors

Effect	*df*	*F*-Value
A. Number of sea lions		
Visitation level (high, low)	1, 10	ns
Time block (0900–1100, 1100–1300, 1300–1500)	2, 10	ns
Zone (recreational, sanctuary; repeated measure)	1, 10	20.94***
Visitation level × Time block	2, 10	ns
Visitation level × Zone	1, 10	ns
Time block × Zone	2, 10	ns
Visitation level × Time block × Zone	2, 10	ns
B. Number of sea lions		
Month (March, April, June, July, August, September)	5, 10	ns
Zone (recreational, sanctuary; repeated measure)	1, 10	31.97***
Month × Zone	5, 10	ns
C. Number of sea lions		
Month (August, September)	1, 5	ns
Zone (recreational south, recreational mid, sanctuary mid, sanctuary north; repeated measure)	3, 15	15.24***
Month × Zone	3, 15	ns
D. Number of humans		
Time block (0900–1100, 1100–1300, 1300–1500)	1, 15	11.93***
Zone (recreational, sanctuary; repeated measure)	1, 15	22.38***
Time block × Zone	1, 15	ns
E. Time spent resting		
Visitation level (low, high)	1, 48	15.50***
Zone (recreational, sanctuary)	1, 48	ns
Visitation level × Zone	1, 48	ns
F. Number of instantaneous events[a]		
Zone (recreational, sanctuary)	1, 26	33.69***
Disturbance type (human, other; repeated measure)	1, 26	14.27***
Behavior (look, lift head, sit up; repeated measure)	2, 38.9	18.97*
Zone × Disturbance type	1, 26	17.67***
Zone × Behavior	2, 38.9	ns
Behavior × Disturbance type	1.6, 41	ns
Zone × Behavior × Disturbance type	1.7, 41	ns
G. Duration of continuous behaviors[a]		
Zone (recreational, sanctuary)	1, 25	6.81*
Disturbance type (human, other; repeated measure)	1, 25	4.73*
Behavior (look, lift head, sit up; repeated measure)	2, 29.5	ns
Zone × Disturbance type	1, 25	5.90*
Zone × Behavior	2, 29.5	ns
Behavior × Disturbance type	1.2, 29.8	ns
Zone × Behavior × Disturbance type	1.2, 29.8	ns

Replicates were mean observations per day. Repeated measures ANOVAs were used where levels of factors were considered nonindependent.
[a]Greenhouse Geisser correction applied (SoftCom Inc., 1984–1994).

Number and Distribution of Human Visitors and Their Relationship to Sea Lion Abundance and Distribution

Numbers of Human Visitors in the Sanctuary and Recreational Zones. Human visitors were counted on April 1, 2005, and between March 1 and April 30, 2006. There were more humans in the recreational zone than in the sanctuary zone [5.4 ± 1 and 2.3 ± 0.5 (mean ± SE), respectively; $F(1, 15) = 22.38$, $p < 0.001$] (Table 2-D), regardless of the time block, but more people were present in the afternoon between 1300 and 1500 hours than between 0900 and 1100 or 1100 and 1300 hours [two-factor ANOVA with time and zone as factors: $F(1, 15) = 11.93$, $p < 0.001$] (Table 2-D, Fig. 5). The number of human visitors was linearly related to the maximum number of boats anchored off the island [$r = 0.71$, $F(1, 24) = 24.87$, $p < 0.001$] (Fig. 6).

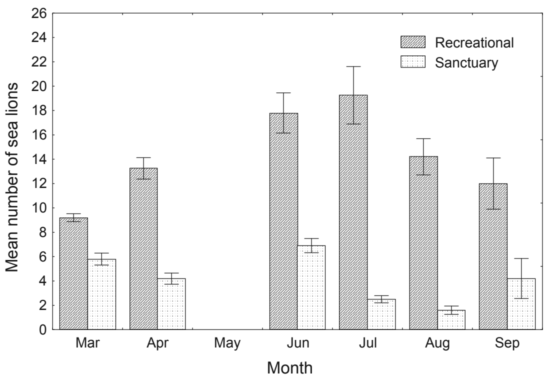

Figure 3. Mean number of Australian sea lions hauled out in the recreational and sanctuary zones per month in 2006 (mean ± 1 SE). No observations were made in May.

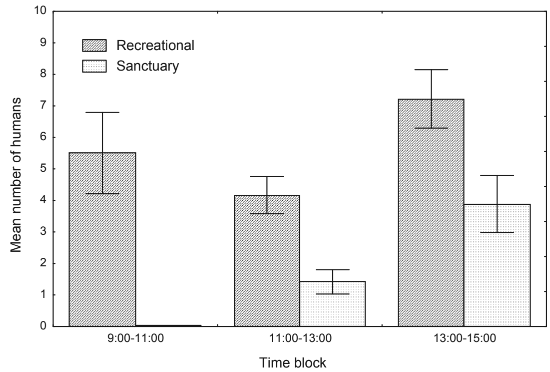

Figure 5. Mean number of human visitors during time blocks between 0900 and 1500 hours during high human visitation in March and April in the sanctuary and recreational zones at Carnac Island (mean ± 1 SE).

Relationship Between Human and Sea Lion Presence. There was a positive relationship (although weak) between the number of visitors in the recreational zone and the number of sea lions within the sanctuary zone (which was reflected in significant relationships between the number of sea lions within the sanctuary zone and the total numbers of visitors and maximum number of boats) (Table 3). The relationship was not complemented with an equivalent negative relationship between the number of sea lions within the recreational zone, so a conclusion that sea lions were moving to the sanctuary as a result of human presence in the recreational zone cannot be supported. Furthermore, a positive relationship between the number of sea lions in the recreational zone and the number of humans in the same zone indicates that sea lions simply occurred in both zones during high visitor presence, but humans occurred to a lesser extent in the sanctuary zone.

Disturbance of Sea Lions by Human Visitation

Time Resting. The total number of observations made was 26 (13 in the sanctuary and 13 in the recreational zone) collected on days between the March 19 and September 29, 2006. The time sea lions spent resting was significantly lower during high human visitation periods than during low visitation periods, regardless of whether sea lions were in the sanctuary or recreational zone [two-factor ANOVA with visita-

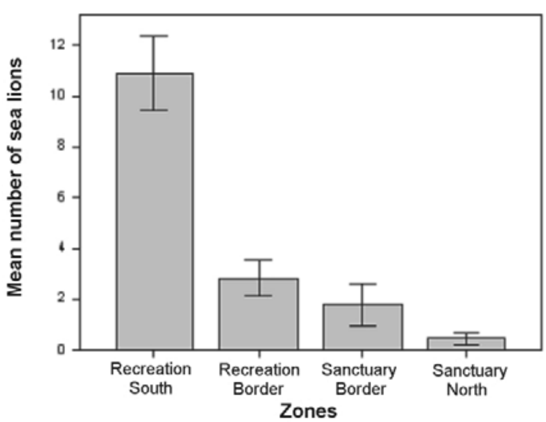

Figure 4. Haulout preference of Australian sea lions among the four zones on the main beach at Carnac Island (mean ± 1 SE).

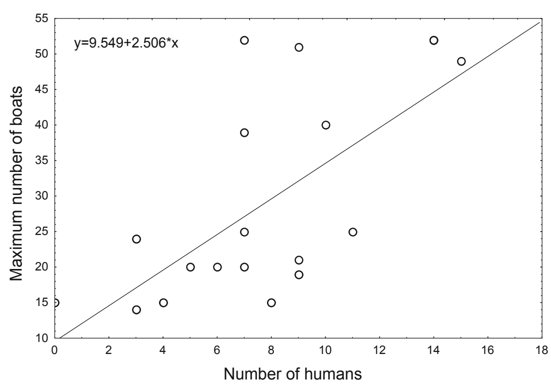

Figure 6. Relationship between human visitors and the maximum number of boats at Carnac Island.

Table 3
Summary of Correlations Between the Number of Human Visitors and the Number of Sea Lions

	Sea Lions in Recreational		Sea Lions in Sanctuary		Total Sea Lions	
No. of Humans	*r*	*F*(24)	*r*	*F*(24)	*r*	*F*(24)
Total visitors	0.11	ns	0.412	6.15*	0.23	ns
Recreational zone	**0.43**	**6.03***	**0.59**	**13.91*****	0.23	ns
Sanctuary zone	0.24	ns	0.12	ns	–0.28	ns
Maximum boats	0.23	ns	0.41	4.96*	0.01	ns

tion and zone as factors: $F(1,48) = 15.50, p < 0.001$] (Table 2-E, Fig. 7). Time spent resting was highly related (inversely) to time spent responding to human disturbance [$r = -0.96$, $F(1,60) = 780.35$, $p < 0.001$], but only weakly to time spent responding to other disturbances (sea gulls and other sea lions) [$r = -0.31$, $F(1,59) = 6.12$, p" 0.05]. On average sea lions spent $99.9 \pm 0.06\%$ of time resting during low visitation, and $95.8 \pm 1.09\%$ during high visitation periods.

Behavioral Responses to Disturbance at High Visitation. Due to the little disturbance that was occurring during low visitation, observations were focused only on high visitation periods for this part of the study. The mean number of behavioral events (instantaneous counts) in response to human disturbance was significantly greater than events in response to other disturbances (mainly seagulls and other sea lions) (Table 2-F, Fig. 8). Disturbances occurred more often in the recreational zone than in the sanctuary zone, and were mainly "look" and "lift head." Analysis of duration (based on continuous observations) of these behaviors reflected the same patterns as from instantaneous counts (between zones and between disturbance stimuli), but a significant difference in duration among the three behaviors ("look," "lift head," "sit up") was not evident (Table 2-G) because the variability was too high.

Discussion

Comparison of Instantaneous and Continuous Behavioral Observations

While instantaneous and continuous behavioral observations were related, this study demonstrates that the relationship between frequency and duration of behaviors was dependent on the behavior observed. There was a strong relationship between continuous and instantaneous observations with regard to the behavior "look," regardless of the function fit to the data. The strongest fit was the power function, however, which reflected an increasing in duration of this behavior with increasing number of events (because correlations were based on cumulative time over the 20-minure period). Observations made using the two methods for "lift head" and "sit up" were not related, which indicated that measures of frequency and duration for these behaviors were noninterchangeable. A larger sample size for these behaviors (particularly "sit up" because it occurred rarely) may have increased the power of the test. Behavioral studies conducted by many other authors have used both methods (Terhune & Brillant, 1995), but some have opted to use only one method (Terhune & Brillant, 1995 used continuous; and Cassini, 2000, and Orsini, 2004, used instantaneous counts). This study found that while changes in some behaviors were detected by both methods, changes in other behaviors were only detected by one

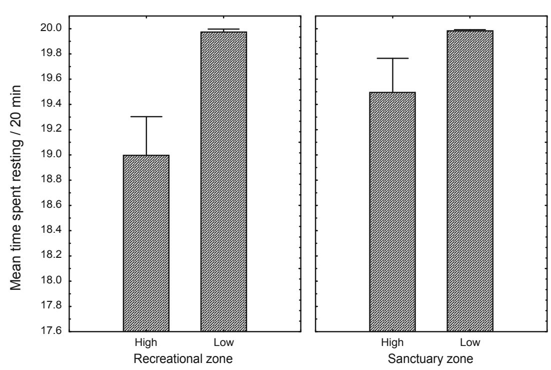

Figure 7. Mean time Australian sea lions spent resting/20-minute observation periods during high and low human visitation periods in the recreational and sanctuary zones (mean ± 1 SE).

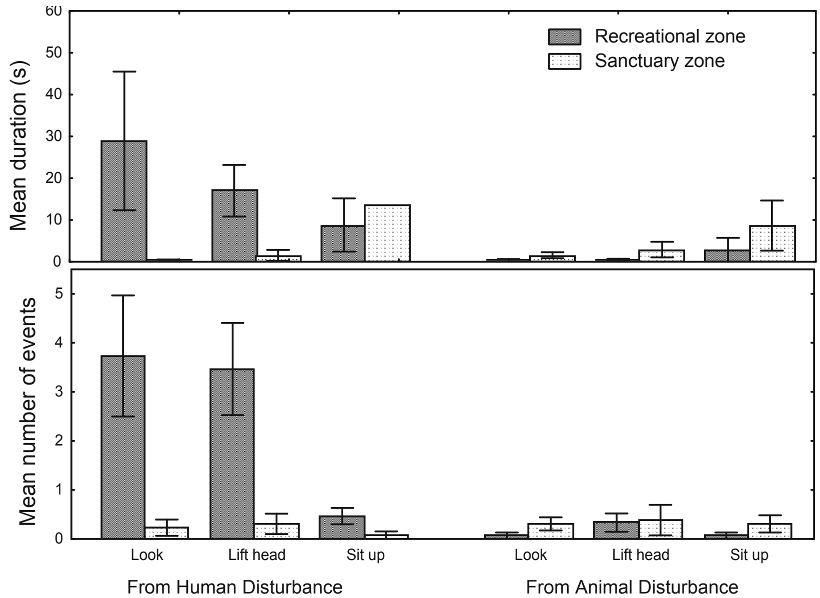

Figure 8. Mean number and duration of Australian sea lion behavioral events caused by disturbances from humans and other animals (seagulls and sea lions) in the recreational and sanctuary zones during high human visitation (mean ± 1 SE).

method and not by the other. As a result, in choosing behavioral observation methodology the objectives of a study should be evaluated carefully, and either instantaneous counts or continuous observations, or both, should be made accordingly.

Comparison of Remote Observations Using a Wireless Camera and Field-Based Observation

Remote observations using a wireless camera were accurate for monitoring the number of sea lions present on Carnac Island, as well as their behaviors. The small (and insignificant) variation that occurred was due to the camera's stationary position, hence at particular angles sand dunes or rock ledges prevented direct viewing of individual animals. During high wind conditions (generally greater than 15 km/h) the camera shook, causing blurring of video at high magnification so that more subtle movements could not be detected (such as "lift head").

Results from this study are consistent with the study by Sease, Taylor, Loughlin, and Pitcher (2001), who found that a video camera was a suitable method for recording steller sea lion numbers in Alaska (and specifically for providing back-up data records). The use of a wireless camera can be particularly advantageous to remove artifacts caused by observer presence. In a study by Tershy et al. (1997) in Mexico, high densities of sea lions on a small island responded to anyone who landed on the island (including researchers). The use of remote cameras in future studies will likely increase the accuracy of collecting representative sea lion behavioral data, and in fact could be useful for collecting unbiased typical tourist behavior (because researchers are not visible).

Assessment of the Effectiveness of the Sanctuary Zone at Carnac Island

The intention of the sanctuary zone created at the northern end of the beach on Carnac Island was to allow sea lions to haul out free from human disturbance in an area where the majority (71%) had been observed to haul out during Orsini's study conducted in 2003 (Orsini, 2004; Orsini et al., 2006). In this study the majority of sea lions observed used the southern recreational zone, regardless of visitation levels (77.51% in the recreational zone, compared to 22.49% in the sanctuary zone). In fact, the southern most end of the southern recreational zone was preferred (68.36% at the recreation south, 17.75% at the recreation border, 10.47% at the sanctuary border, and 3.42% at the sanctuary south). Orsini (2004) and Orsini et al. (2006) suggested that haul-out site preference observed during his study was likely linked to seaweed accumulation on the northern shoreline. This study demonstrates that areas of use are variable. Rather than the haul-out site depending upon spatial location, site choice is most likely linked to environmental factors.

During low human visitation, the percentage of time spent resting in the recreation and sanctuary zones was high—99.87% and 99.93%, respectively—and similar in both zones. The small numbers of disturbances recorded during low visitation periods were from other sea lions or seagulls. Sea lions spent approximately 4–6% less time resting during high visitation than during low visitation periods due to greater time spent responding to human disturbances. Greatest vigilance behaviors occurred during high human visitation periods and in the recreational zone, although significant disturbance also occurred in the sanctuary zone. Based on finding in this study, the sanctuary zone appears to be providing some level of protection (due to signs posted for visitors to read), although not complete protection. Responses to human disturbance appeared to be more consistent in frequency than in duration in both zones, which means that people that did not heed signs and entered the sanctuary zone disturbed sea lions for a similar period of time as those who remained in the recreational zone.

Disturbance were similar to those observed by Orsini (2004), where there was either ongoing low-level disturbances causing vigilance behaviors such as "look" and ``lift head'' (Fig. 9A) or higher level disturbances from closer interactions resulting in a ``sit up'' behavior (Fig. 9B), change of location, or in some circumstances an aggressive responses such as barking or lunging. Vigilance behaviors are defined as those where an animal seeks to investigate its surroundings, interrupting the ongoing activity in which it has already engaged in (Quenette, 1990). Orsini (2004) and Orsini et al. (2006) showed that ongoing low-level disturbances occurred within 15 m causing vigilance associated behaviors such as looking in the direction of source of disturbance, lifting their heads (usually associated with a visual scan), or sitting upright to gain height (Orsini, 2004). The higher level responses were a result of direct disturbances from inappropriate recreational activities close to animals or visitors trying to provoke responses from sea lions (which are usually resting or sleeping). These activities generally caused sea lions to retreat away from the disturbances or caused more aggressive behavior such as huffing, flaring nostrils, and lunging towards the stimulus (Orsini, 2004). Results from this study confirm previous findings related to impacts of tourism on pinnipeds in other areas of Western Australia and around the world. For example, Cassini (2001) observed strong responses (such as sit up or retreat) when tourists came within approximately 10 m of South American fur seals (*Arctcephalus australis*). Kovacs and Innes (1990) found that tourist presence significantly altered female harp seals' behavior, and human presence often resulted in harp seals leaving the area (retreating) and pups unattended.

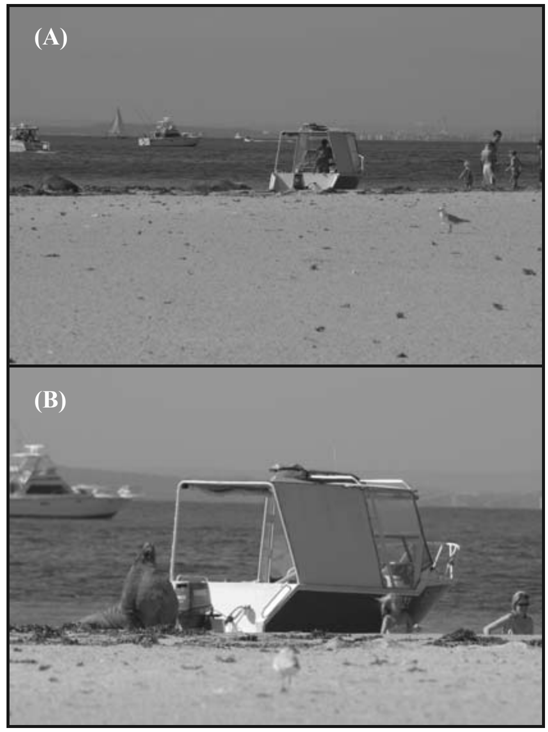

Figure 9. Disturbances occurring to a group of Australian sea lions: (A) low level in the recreational zone, and (B) high level in the sanctuary zone.

Human visitation on Carnac Island during this and previous studies (Orsini 2004) is changing the amount of time available for sea lions to recuperate significant energy lost while traveling to and from foraging grounds. The impact of human disturbance is ultimately related to energy recuperation requirements while hauling out. The Australian sea lion (*Neophoca cinerea*) is a generalist, meaning it is an opportunistic feeder. The sea lion's diet consists of fish, squid octopus, cuttlefish, lobster, and even occasionally birds and turtles (Gales & Cheal, 1992; Ling 1992). Prey is mainly found in the benthos, meaning that sea lions must spend a great deal of time diving deep, and require high oxygen exchange to achieve this. In contrast, epipelagic (middle to surface) feeders spend less time (and energy) diving than benthic feeders. According to Costa, Carey, Kuhn, Weise, Shaffer, and Arnould (2004), Australian sea lions at Seal Bay (Kangaroo Island, South Australia) expended more energy than most other otariid benthic feeders when foraging at sea, and concluded that Australian sea lions were close to exceeding their physiological dive limit. A follow-up study confirmed the idea that these sea lions have to work hard to exploit benthic habitats in waters around their breeding site (Costa & Gales, 2003). The authors concluded that the Australian sea lion is at the limit of its natural foraging capacity. These findings point to the fact that the species is highly sensitive to pressures on daily activity, including significant time spent recuperating depleted energy while hauled out on land resting. Hence, haul-out sites are considered vital to pinnipeds that spend a lot of time foraging for energy recuperation (Orsini, 2004).

At Carnac Island, a sanctuary zone established to limit the impacts of tourism (and maximize time spent resting) appeared to result in some reduction in human visitation within that area, but overall the sanctuary was not effective in that preferred haul-out locations changed since the establishment of the sanctuary zone. The authors recommend that sanctuary zones in the future should include entire stretches of useable beach to be effective. Furthermore, to maximize the chances of providing adequate protection for a population, a broad understanding of the general ecology and behavior of sea lions continues to be necessary. Implementing effective sanctuary zones can help to limit some pressures, but ultimately their contribution in protecting a population is not known, especially given that the effects of cumulative impacts (across all sources) have not been ascertained. Commitment to work on a multilevel scale is critical for allowing a broader understanding of the problem. For example, an assessment of sea lion movement patterns and energy budgets will provide an understanding of the extent to which the species is being stretched to its limit energetically. As a result, the extent to which protection needs to be applied can be determined and implemented, so that population recovery becomes possible.

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Biographical Notes

Chandra Salgado Kent completed her doctorate in Marine Biology at Charles Darwin University in Darwin, Australia in 2004 after having moved from the United States in 1998. Chandra has been working in the field of environmental management and wildlife conservation over the last 10 years. Currently she holds a Research Fellow position at the Centre for Marine Science and Technology at Curtin University, with main research interests in anthropogenic impacts on marine animals (including noise); vocalization, distribution, and migration patterns of marine mammals; and conservation of marine mammals.

Brett Crabtree grew up in a small coastal town on the South Coast of Western Australia, and as a result the environment, and in particularly the marine environment, has always been a strong passion. To pursue this passion, Brett undertook a double degree in Environmental Biology and Geography at Curtin University in 2003, which he successfully completed in 2007. Brett has since continued his interests, and is currently undertaking a Masters in Urban and Regional Planning to gain a holistic approach to Environmental Management.

References

Abbot, I., Marchant, N., & Cranfield, R. (2000). Long-term change in the floristic composition and vegetation structure of Carnac Island. *Journal of Biogeography Western Australia, 27*(2), 333–346.

Cassini, M. (2001), Behavioral responses of South American fur seals to approach by tourists a brief report. *Applied Animal Behavioural Science. 71*(4), 341–346.

Conservation Commission of Western Australia & Department for Conservations and Land Management. (2003). *Carnac Island Nature Reserve management plan* (Management Plan No. 47). Perth: Authors.

Costa, D., & Gales, N. 2003, Energetics of a benthic diver: Seasonal foraging of the Australian sea lion, *Neophoca cinerea*. *Ecological Monographs, 73*(1) 27–44.

Costa, D. P., Carey, E., Kuhn, M. A., Weise, M. J., Shaffer, S. A., & Arnould, J. P. Y. (2004). When does physiology limit the foraging behavior of freely diving mammals? *International Congress Series, 1275*, 359–366.

Department for Conservations and Land Management. (1992). *Shoalwater Bay Island management plan 1992–2002* (unpublished report). Perth: Author.

Department for Conservations and Land Management. (2004). *Sea lions and fur seals*, Brochure. Perth: Author.

Department of the Environment, Water, Heritage and the Arts. (2008). *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).* Retrieved March 2008, from http://www.environment.gov.au/epbc/about/history/index.html

Gales, N. J., & Cheal, A. J. (1992). Estimating diet composition of the Australian sea lion *Neophoca cinerea* from scat analysis: An unreliable technique. *Wildlife Research, 19*, 447–456.

Gales, N. J., Cheal, A. J., Pobar, G. J., & Williamson, P. (1992). Breeding biology and movements of Australian sealions, *Neophoca cinerea*, of the west coast of Western Australia. *Wildlife Research, 19*, 405–416.

Gales, N., Haberley, B., & Collins, P. (2000). Changes in the abundance of New Zealand fur seals, *Arctocephalus forsteri*, in Western Australia. *Wildlife Research, 27*, 165–168.

Gales, N., Hindell, M., & Kirkwood, R. (2003). *Marine mammals fisheries, tourism and management issues*. Collingwood, Australia: CSIRO Publishing.

Kirkwood, R., Boren, L., Shaughnessy, P., Szteren, D., Mawson, P., Hüchstädt, L., Hofmeyr, G., Oosthuizen, H., Schiavini, A., Campagna, C., & Berris, M. (2003) Pinniped-focused tourism in the Southern Hemisphere: A review of the industry. In N. Gales, M. Hindell, & R. Kirkwood (Eds.), *Marine mammals fisheries, tourism, and management issues*. Collingwood, Australia: CSIRO Publishing.

Kovacs, K. & Innes, S. (1990). The impact of tourism on harp seals (*Phoca groenlandica*) in the Gulf of St Lawrence Canada. *Applied Animal Behavioural Science, 26*(1–2), 15–26.

Ling, J. K. (1992). *Neophoca cinerea*. *Mammalian Species, 392*, 1–7.

Ling, J. K. (1999). Exploitation of fur seals and sea lions from Australian, New Zealand and adjacent subantarctic islands during the eighteenth, nineteenth and twentieth centuries. *Australian Zoologist, 31*(2), 323–350.

Ling, J. K., & Walker, G. E. (1978). An 18 month breeding cycle in the Australian sea lion? *Search, 9*, 464–465.

Orams, M. (2002). Feeding Wildlife as a tourism attraction: A review of issues and impacts. *Tourism Management, 23*, 281–293.

Orsini, J. P. (2004). *Human impacts of Australian sea lions,* Neophoca cinerea, *hauled out on Carnac Island (Perth, Western Australia): Implications for wildlife and tourism management*. Master's thesis, Murdoch University, Perth, Western Australia.

Orsini, J. P., Shaughnessy, P. D., & Newsome, D. (2006). Impacts of human visitors on Australian sea lions (*Neophoca cinerea*) at Carnac Island, Western Australia: Implications for tourism management. *Tourism in Marine Environments, 3*(2), 101–115.

Page, B., McKenzie, J., McIntosh, R., Baylis, A., Morrissey, A., Calvert, N., Hasse, T., Berris, M., Dowie, D., Shaughnessy, P., & Goldsworthy, S. D. (2004). Entanglement of Australian Sea Lions and New Zealand fur seals in lost fishing gear and other marine debris before and after Government and industry attempts to reduce the problem. *Marine Pollution Bulletin, 49*, 33–42.

Quenette, P. Y. (1990). Functions of vigilance in mammals: A review. *Oecologica, 11*, 801–818.

Salgado Kent, C. P., & McCauley, C. S. (2006). *Underwater noise impacts from dredging*. CMST Report No. 2006-19.

Sease, J. L., Taylor, W. P., Loughlin, T. R., & Pitcher, K. W. (2001). *Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1999 and 2000*. US Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-122.

Shaughnessy, P. (1999). *The action plan for Australian seals*. Canberra: Environment Australia (Natural Heritage Trust).

Shaughnessy, P., Dennis, T., & Seager, P. (2005). Status of Australian sea lions, *Neophoca cinerea* and New Zealand fur seals, *Arctocephalus forsteri*, on Eyre Peninsula and the far west coast of South Australia. *Wildlife Research, 32*, 85–101.

SoftCom, Inc. (1984–1994). *Statistica for Windows: Statistica II*. Centreville, VA: Author.

Stevens, M., & Boness, D., (2003). Influence of habitat and human disturbance on use of breeding sites by a declining population of southern fur seals (*Arctocephalus australis*). *Journal of Zoology, London, 260*, 145–152.

Terhune, J., & Brillant, S. (1995). Harbor seal vigilance decreases over time since haul out. *Animal Behavior, 51*, 757–763.

Tershy, B. R., Breese, D., & Croll D. A. (1997). Human perturbations and conservation strategies for San Pedro Mártir Island, Islas del Golfo de California Reserve, México. *Environmental Conservation, 24*(3), 261–270.

Walker, G., & Ling, J. (1981). New Zealand sea lion *Phocarctos hookeri*. In S. H. Ridgeway & R. J. Harrison (Eds.), *Handbook of marine mammals volume 1: The walrus, sea lions, fur seals, and sea otter*. London: Academic Press.

Walker, D. I., Lukatelich, R. J., Bastyan, G., & McComb, A. J. (1989). Effect of boat moorings on seagrass beds near Perth, Western Australia. *Aquatic Botany,* (36), 69–77.