

SUMMARY OF NEW ZEALAND SEA LION RESEARCH

UNDERTAKEN ON MAINLAND, NEW ZEALAND

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This report is an attempt to summarise the research conducted on New Zealand sea lions (*Phocarctos hookeri*) on the mainland of New Zealand. This research has been undertaken by a large number of students and independent scientists over a period of approximately 25 years. Many of the projects have been of extremely short duration (2 weeks fieldwork), use a variety of techniques and have been undertaken by researchers with varying levels of skill and knowledge about sea lions. Some projects have produced conflicting results perhaps due to seasonal or methodological differences and the difficulty of separating out the many confounding factors that affect sea lion behaviour.

The report consists of three main sections:

- 1) Summary by topic. These summaries provide an overview of the main findings while sifting out dubious and conflicting conclusions. Statements are referenced to the appropriate researcher.
- 2) Bibliography. This is a list of all the research conducted whether referenced in the report or not. Please note, the related theses and projects included at the end of the report have been conducted by students at the University of Otago but were considered outside the scope of this report. They are either, proposals only (Gormley, 2000; Jackson, 2003; Williams, 2003; Osmand, 2005), or they relate to population modelling (Gormley, 2002; Samaranayaka, 2006) or the Auckland Island population (Dickie, 1995; Dickie, 1999). Copies of University theses and reports can be found at Otago University; SIT projects can be found at the Hocken library (University of Otago) or obtained from the New Zealand Sea Lion Trust.
- 3) Research Abstracts and Summaries. Abstracts and summaries provide extra detail for all research listed in the bibliography. These are presented according

to research type (ie publication, thesis etc). Abstracts are provided for all publications and University of Otago research. Summaries are provided for all School for International Training research as the abstracts were often poorly written.

1) SUMMARY BY TOPIC

POPULATION ESTIMATES

Sea lions have been reported regularly in Otago since 1984 (Hawke, 1986; McConkey et al, 2002b) though photographs have confirmed a sea lion present as early as 1954 (McConkey et al, 2002b). Population estimates for the Otago region have been calculated since 1994 using photographic identification and mark-recapture calculations based upon regular surveys of the main beaches (Lalas and McConkey, 1994; McConkey, 1999). Population estimates began with 20 sea lions for Otago Peninsula and 20 sea lions for The Catlins in 1994 (Lalas and McConkey, 1994; McConkey, 1994). Later Otago Peninsula estimates include 39 in 1996 (Ritchie, 1996), 41-48 sea lions in 1999 (McConnell, 2001), and 47 sea lions in 2001 (Ludmerer, 2002). Catlins population estimates increased to 50-62 sea lions in 1996 (McNally, 1996; Heinrich, 1998), 65 sea lions in 1998 (McNally, 2001) and 69-77 sea lions in 1999 (McConnell, 2001). One-off estimates were also calculated for Waipapa Point, Southland (eight sea lions) and Small Craft Retreat, Stewart Island (49 sea lions) in 1999 (McConnell, 2001). Sea lion numbers at The Snares were calculated at 234 for 1997 and 255 for 1998 with only one pup sighted in 1997 (McNally, 2001). Finally, Campbell Island pup production was estimated at 78 pups for the 1997/98 breeding season (McNally, 2001). Daily counts suggest that the Otago Peninsula population has continued to increase while The Catlins population has declined (Cook, 2002, New Zealand Sea Lion Trust unpublished data). A database is being compiled by the "New Zealand Sea Lion Trust" which will allow regular population estimates to be calculated.

MANAGEMENT

New Zealand legislation requires that threatened species of marine mammals must be managed to reduce human-induced mortality and achieve a non-threatened status within 20 years. The New Zealand Department of Conservation management plan for New Zealand sea lions specifies that to achieve a non-threatened status *P. hookeri* (1) at Otago must increase in the number of breeding females to ≥ 10 , and (2) must establish \geq two new breeding locations within the 20-year time frame, each with ≥ 10 breeding females (Lalas and Bradshaw, 2003). Lalas & Bradshaw (2003) suggest this is unlikely to occur naturally and some form of assistance is required for this goal to

be realistic. Many studies have reported deliberate harassment and killing of sea lions (McConkey, 1994; Heinrich, 1998; Ludmerer, 2002; McConkey, 2004). This will further reduce the chances of new colonies establishing and these events need to be stopped through education (interpretive signs, regular newspaper/magazine articles, school activities) and prosecution of offenders if necessary (Heinrich, 1998; Ludmerer, 2002; McConkey, 2004). More invasive management actions such as translocation of mothers and pups may also be required in situations where the mother and/or pup are threatened (McConkey, 2004). Greater levels of protection and monitoring may be required in locations where migrant females begin breeding to allow them to establish without undue disturbance (McConnell, 2001; McConkey, 2004).

DISTRIBUTION

Since the 1980's sea lions have been continually seen on parts of the New Zealand mainland (Wilson, 1979; McConkey et al, 2002b). Early sightings were largely restricted to the Otago Peninsula, The Catlins, and Stewart Island though regular sightings are now recorded at Waipapa Point (Wilson, 1979; McConkey et al, 2002b). Regular sightings over short periods have also been reported from North Otago at Shag River and Oamaru (Ludmerer, 2002). Most sea lions in Otago are immigrant males ≤ 2 years old at arrival, and include animals tagged as pups at Auckland Islands (McConkey et al, 2002b). Recruitment is variable between cohorts and high recruitment may be reliant on two consecutive seasons of high squid production at the Auckland Islands (Heinrich, 1998; McConkey et al, 2002b). These immigrant males usually remain and become resident (Beentjes, 1989a; McConkey, 1997; Heinrich, 1998; McConkey et al, 2002b; McConkey, 2004). Migrant females continue to be rarely seen and do not remain to breed (McConkey et al, 2002c). Some male sea lions based at Otago return to the Auckland Islands during the breeding season (McNally, 2001). Female foraging cycles at Otago (1.7-2.4 days) appear to be shorter than those at the Auckland Islands (2.6-5.4 days) (Auge, 2004; Eusden, 2004). Sea lions have favoured areas within their distribution which can change between years (ie west end of Surat Bay in 1996, east end of Surat Bay in 2001, Cannibal Bay in November 2003) and seasonally (ie more likely to use sand dunes in the winter) (Beentjes,

1989a; Heinrich, 1998; Hollingworth, 2001; Cook, 2002; Olesnycky, 2003; White, 2003; Auge, 2004).

BEHAVIOUR

Daily numbers of sea lions sighted in Otago vary seasonally with peak numbers in spring and autumn and lowest numbers in winter and summer (McConkey, 1997; Heinrich, 1998). Some adult males made use of much smaller favoured areas than subadults and juveniles, displaying a level of territoriality even in the absence of females (Krohn, 2003; Olesnycky, 2003). When female sea lions moved to a new beach the number of male sea lions at the beach was found to increase over time and they were found progressively closer to the location of the females (Schimanski, 2001). Mean arrival time is usually around mid-morning and mean departure time mid to late afternoon with peak numbers ashore early to mid afternoon (Beentjes, 1989a; Heinrich, 1995; Abrams, 1997; McConkey, 1997; Heinrich, 1998; Segarra, 2001). Adult male sea lions are more likely to be solitary and less likely to take part in social interaction than juvenile and subadult males (Heinrich, 1998; McConnell, 1998; Hollingworth, 2001; Samuelson, 2001; Chandler, 2002; Larimer, 2004; Ory, 2004). Adult and subadult males are more likely to join a group than remain solitary but adults were seldom seen close to other adults (McConnell, 1998; Olesnycky, 2003). The solitary nature of the adult males may therefore be due to the larger numbers of adult males and their aggressive, intolerant nature toward one another (Heinrich, 1998; Olesnycky, 2003). Larger sea lion group size also leads to increased social interaction (McConnell, 1998; Ory, 2004). Females and one-year old males were also often solitary, perhaps as a method of avoiding harassment (Heinrich, 1998). Females were also found to exhibit solitary breeding behaviour at Campbell Island rather than the gregarious colonies found at the Auckland Islands (McNally, 2001). Different peak periods of sea lion activity have been reported but generally seem to be around peak periods of arrival and departure (Heinrich, 1998; Chandler, 2002; Ory, 2004). Weather conditions have also been found to have an influence on behaviour and activity levels (less activity in extreme weather ie cold temperatures, direct sunlight, strong winds) (Beentjes, 1989a; Samuelson, 2001; Larimer, 2004; Ory, 2004).

FEMALE ATTENDANCE RATES

Several mother/pup pairs have been observed over a 10 year period from the first pup in 1994. These have all been short-term observational studies conducted during daylight hours. Attendance rates (time mothers spend with pup rather than time spent ashore) have ranged from 11% to 70% and individual attendance rates have varied widely between years (Borofsky, 1997; Parker, 1998; Schimanski, 2001; Hunt, 2002; McConkey et al, 2002c; Thibault, 2003; Eusden, 2004). Some of these differences may be due in part to different methods of observation. Only three of 28 pups (1994-2006) died while in their mothers care, all within the first three months, and only one possibly due to starvation (New Zealand Sea Lion Trust unpublished data). One additional pup died while being hand-reared after the death of her mother (New Zealand Sea Lion Trust unpublished data). Mothers that have not had a new pup in a breeding season have resumed attending their previous pup with attendance rates ranging from 19-62% (Hunt, 2002; McConkey et al, 2002c; Thibault, 2003). The presence of males reduces the amount of time mothers and pups spend in resting behaviours, disrupts suckling, and may cause separation of the mother and pup but has not yet resulted in noticeable injury to the mother or pup (Borofsky, 1997; Parker, 1998; Merrigan, 2002). Female tactics to deal with disruptive males include avoidance (choice of remote locations) and occasional aggression toward males (Borofsky, 1997; Parker, 1998; McConkey et al, 2002c; Merrigan, 2002; Thibault, 2003). One episode of cross-suckling (fostering) has been observed and one female has been observed suckling her yearling in the same year as her new pup (Parker, 1998; McConkey et al, 2002c; Eusden, 2004).

IMPACT OF TOURISM

Many researchers have investigated the impact of people on sea lion behaviour using a variety of methods and with sometimes conflicting results. Almost all researchers recorded an increase in sea lion activity in the presence of people (Heinrich, 1995; Heinrich, 1998; Wright, 1998; Hollingworth, 2001; Samuelson, 2001; Biegun, 2002; Brooking, 2002; Chandler, 2002; Pierce, 2003; Stella, 2003; Ball, 2004; Larimer, 2004; Ory, 2004; Zaino, 2004), though both Ball (2004) and Chandler (2002) found less than 20% of sea lions exhibited changes in behaviour in the presence of people. In general, closer approaches by people and larger groups were more likely to result in greater sea lion disturbance (Samuelson, 2001; Biegun, 2002; Brooking, 2002; Chandler, 2002; Stella, 2003). Longer encounters were more likely to be disturbing

but sea lions often returned to original behaviours (Chandler, 2002; Larimer, 2004; Zaino, 2004). Many researchers observed deliberate harassment of sea lions through shouting, clapping, stomping, throwing of sticks, and harassment with vehicles (Heinrich, 1998; Stella, 2003; Larimer, 2004; Zaino, 2004). Several sea lions have been deliberately killed in Otago in the last 15 years (Heinrich, 1998; Ludmerer, 2002; McConkey et al, 2002c). Sea lion reactions have ranged from no visible response to charging people and vehicles (Heinrich, 1995; Abrams, 1997; Heinrich, 1998; Hollingworth, 2001; Samuelson, 2001; Biegun, 2002; Brooking, 2002; Chandler, 2002; Pierce, 2003; Stella, 2003; Ball, 2004; Larimer, 2004; Zaino, 2004).

DIET

Sea lion diet has usually been investigated by studying the remains found in scat and regurgitations (Milne, 1996; Lalas, 1997; Bradshaw and Lalas, 1998; Ludmerer, 2002; McEwan, 2002). Differences in the prey items found in scat and regurgitations suggest that both need to be collected in order to get an accurate picture of diet (McEwan, 2002). Daily sampling was also found to be more accurate than intermittent sampling (McEwan, 2002). Sea lion diet changes seasonally from inshore in winter and spring to offshore in summer and autumn (Lalas, 1997). Prey species vary widely and include crustaceans, cephalopods, fish, birds and marine mammals (Milne, 1996; Lalas, 1997; Bradshaw and Lalas, 1998; Ludmerer, 2002; McEwan, 2002). There appears to be little overlap with commercial fisheries but prey species that may cause a public reaction include brown trout, salmon and Yellow-eyed Penguins (Ludmerer, 2002; McEwan, 2002; Lalas et al., 2007). Daily haul-out patterns suggest mainly nocturnal feeding (Beentjes, 1989a).

MOULT

Sea lions moult annually over a two month period between December and June (McConkey, 1997; McConkey et al., 2002a). Females and juveniles moult earlier than subadults and adults though 1-year old immigrant males appear to undergo only a partial moult (McConkey, 1997; McConkey et al., 2002a).

THERMOREGULATION

Behaviours associated with cooling (spreading flippers and sand-flipping) were seen more in warmer temperatures, lower wind speed and less cloud cover (Beentjes,

1989b; Nadler, 2003; Coria, 2004). Sea lions were also observed in the sand dunes, where wind speed was significantly reduced, more often in cooler weather (Nadler, 2003; Coria, 2004).

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3) RESEARCH ABSTRACTS AND SUMMARIES

PUBLICATIONS

BEENTJES MP, 1989. Haul-out patterns, site fidelity and activity budgets of male Hooker's sea lions (*Phocarctos hookeri*) on the New Zealand mainland. *Marine Mammal Science* **5**: 281-297.

Abstract: Diurnal and seasonal haul-out patterns, site fidelity and activity budgets of individually identified Hooker's sea lions were studied for two years at Papanui Beach, Otago Peninsula, New Zealand.

Fourteen male sea lions were identified. Lengths ranged from 1.65 m-2.28 m and estimated ages from 2-11 yr. The population consisted of four sexually and socially mature (potentially breeding), eight sexually mature but socially immature and two immature males. Most haul-outs (95.6%) were by nine identifiable individuals (*Residents*) returning on a regular basis, suggesting a high degree of site specificity. Emigration and recruitment were low in relation to the length of the study. Daily arrivals (mean = 0844 h, SD = 1.49) and departures (mean = 1802 h, SD = 1.18) indicate nocturnal feeding. During March 1986 sea lions spent 43.8% of each day ashore (= 78% of daylight hours). Numbers of sea lions hauled out declined in both breeding seasons; in 1986/87 this was due to a decrease in haul-out frequency of resident animals. All but one of these sea lions returned after the breeding season.

Sea lions preferentially selected the middle and the extreme ends of the beach as haul-out sites. During the winter use was made of the grass dunes as haul-out areas.

There were significant differences in the frequencies of behavioural activities between summer and winter; more time was allocated to resting in summer.

BRADSHAW CJ AND LALAS C, 1998. New Zealand sea lion predation on New Zealand fur seals. *New Zealand Journal of Marine and Freshwater Research* **32**: 101-104.

Abstract: Several sea lion species are known to occasionally hunt fur seals for food, but there have been few reports of New Zealand (Hooker's) sea lions (*Phocarctos hookeri*) hunting and eating New Zealand fur seals (*Arctocephalus forsteri*). We describe the first reported incidence of *P. hookeri* eating *A. forsteri* pups in mainland New Zealand, and present evidence suggesting that it was active predation rather than scavenging. In late April, early May, and early September 1997 we found three sea lion regurgitations containing the remains of fur seal pups on Otago Peninsula, New Zealand. One contained three plastic tags formerly placed on three different female fur seal pups from a nearby breeding colony. When ingested at least two of the three identifiable pups fell within the lower condition quartile calculated from pups at their natal colony. The incidence of such predation may increase with increasing densities of both fur seals and sea lions in Otago, but the impact on the trends in fur seal populations is, and should remain, low.

HAWKE DJ, 1986. Observations of Hooker's sea lion, *Phocarctos hookeri*, at a hauling ground on Otago Peninsula, New Zealand. *New Zealand Journal of Marine and Freshwater Research* **20**: 333-337.

Abstract: Observations made between January 1984 and December 1985 show that *Phocarctos hookeri* (Gray, 1844) has a fluctuating presence at Papanui Beach (45°52'S 170°44'E), Otago Peninsula, with low numbers (≤ 7 animals) all year. Most individuals are small (< 2.0 m nose to tail length), subadult males. No females were identified. The animals often form small groups, and are generally inactive.

HAWKE DJ, 1993. The presence of female Hooker's sea lions (*Phocarctos hookeri*) on the south-east coast of New Zealand. *New Zealand Natural Sciences* **20**: 75-77.

Summary: Eighty-eight surveys for sea lions at 21 localities from Katiki (45°24'S) to Wiapati (46°37'S) were carried out between 1984 and 1992. Four of the 28 animals seen were females, the first report post-sealing of females for mainland New Zealand. Observation of characteristic markings identified 2 different females. Most sightings were of juvenile males (18 of the 28 animals). Six animals were males with varying mane development but no socially mature males were found.

Overall sighting density was 0.34/km, compared with 8.6/km from literature results for Otago Peninsula's Papanui Beach.

LALAS C, 1997. Prey of Hooker's sea lions, *Phocarctos hookeri*, based at Otago Peninsula, New Zealand. Pp. 130-136 in *Marine mammal research in the southern hemisphere: status, ecology and medicine* ed by C Kemper and M Hindell. Beatty & Sons: Surrey.

Abstract: Species, numbers and sizes of individual prey were determined from diagnostic remains found in scats and regurgitates of Hooker's Sea Lions *Phocarctos hookeri* collected fortnightly from June 1991 to May 1992. Prey were diverse in taxa (crustaceans, cephalopods and fish) and habitats (benthic, demersal and pelagic). Foraging was apparently restricted to the continental shelf and changed seasonally, with inshore prey eaten more during winter and spring. Their disappearance from the diet indicated that sea lions foraged further from shore during summer and autumn. Only one species, Barracouta *Thyrsites atun* was eaten throughout the year.

LALAS C AND MCCONKEY S, 1994. A survey method for estimating the population size of Hooker's sea lions at Otago. *New Zealand Department of Conservation Miscellaneous Series No. 24*.

Summary: A small but increasing population of Hooker's sea lions (*Phocarctos hookeri*) at Otago marks the northern limit of a continuous of the species. Surveys in 1994 indicated that 40-50 males and a minimum of two females and one pup are resident, at least in the short term. Half are based at Otago Peninsula, mainly at Victory Beach and Papanui Beach, and half at The Catlins, mainly at Cannibal Bay and Surat Bay. Long-term monitoring restricted to counts of the numbers of animals ashore only indicates trends in population size. A more comprehensive survey method is presented to produce annual estimates of the total population size of male sea lions at Otago through application of the Peterson estimator. Data are recorded on standardised forms during an annual survey consisting of a series of replicate counts at key sites. The Peterson

estimator is a formula whose accuracy increases with the proportion of recognisable individuals in the population. This paper concentrates on methodology for the identification and documentation of features that assist in the recognition of individuals.

LALAS C AND BRADSHAW CJ, 2003. Expectations for population growth at new breeding locations for the vulnerable New Zealand sea lion (*Phocarctos hookeri*) using a simulation model. *Biological Conservation* **114**: 67-78.

Abstract: Management plans for threatened or recovering large vertebrate species that are increasing in population size and range focus on the establishment of viable populations within set temporal limits. New Zealand (Hookers) sea lions (*Phocarctos hookeri*) were declared a threatened species in 1997, and New Zealand legislation requires that threatened species of marine mammals must be managed to reduce human-induced mortality and achieve a non-threatened status within 20 years. The present breeding distribution of *P. hookeri* is highly localised, with over 95% of total annual pup production located at Auckland Islands and almost all of the remainder at Campbell Island. Breeding elsewhere has been ephemeral or restricted to <10 adult females. The only recorded sustainable breeding at a new location has been at Otago, South Island, New Zealand. This breeding population consisted of a total of four breeding females in 2002 and is derived from one immigrant female that gave birth to her first pup in the 1993/1994 breeding season. The New Zealand Department of Conservation management plan specifies that to achieve a non-threatened status *P. hookeri* (1) at Otago must increase in the number of breeding females to ≥ 10 , and (2) must establish ≥ 2 new breeding locations within the 20-year time frame, each with ≥ 10 breeding females. This study 1) projects the population growth trends at a new location (Otago) to see if it will achieve ≥ 10 breeding females within the legislated time frame, and (2) examines the likelihood that other breeding locations will establish elsewhere given the demographic information available for this species. We present 20 deterministic and three stochastic Leslie matrix model scenarios for female population growth for the initial years following the start of breeding at a new location. Our results indicate

that (1) a new breeding population derived from one immigrant female is unlikely to reach 10 breeding females in 20 years; this duration is more likely to be 23–41 years (deterministic models) or 23–26 years (stochastic model), (2) the likelihood of two new sites establishing within 20 years is unquantifiable, but the probability is low, and (3) if the legislated outcome and time limit are not revised in the population management plan, the feasibility and effectiveness of re-locating young females could be investigated.

LALAS C, RATZ H, MCEWAN K, AND MCCONKEY S, 2007. Predation by New Zealand sea lions (*Phocarctos hookeri*) as a threat to the viability of yellow-eyed penguins (*Megadyptes antipodes*) at Otago Peninsula, New Zealand. *Biological Conservation* **135**: 235-246.

Abstract: This study presented evidence that creates a quandary for conservation management: predation by one threatened species, New Zealand sea lion (*Phocarctos hookeri*), threatens the viability of another threatened species, yellow-eyed penguin (*Megadyptes antipodes*), at Otago Peninsula, South Island, New Zealand. Otago Peninsula holds the largest population of yellow-eyed penguins on South Island and the only breeding population of New Zealand sea lions on the New Zealand mainland. New Zealand sea lions here represent the vanguard of re-colonisation within their prehistoric range, with nine females and 50–70 males resident in 2005. The initial indication of a potential problem was an attack on a yellow-eyed penguin by a New Zealand sea lion witnessed in 1996. The majority of 20 records for attacks were at two neighbouring sites, where they coincided with decreases in penguin nest numbers and adult annual survival. In contrast, penguin nest numbers increased at a third site, the main base for male sea lions at Otago Peninsula. Evidence from prey remains indicated that male sea lions did not eat yellow-eyed penguins but that females ate 20–30 annually, with one individual possibly responsible for most kills. Modelling indicated that the penguin population at any one site could not remain viable if it was the sole source of penguins killed. The dilemma is either to do nothing, and risk collapse of the Otago Peninsula population of yellow-eyed penguins, or to take action against known culprits, and

risk failure in re-colonisation of the New Zealand mainland by New Zealand sea lions.

McCONKEY SD, 1999. Photographic identification of the New Zealand sea lion: a new technique. *New Zealand Journal of Marine and Freshwater Research* **33**: 63-66

Abstract: Photographic identification of individuals, a standard technique in the study of whales and dolphins, has seldom been attempted in pinniped studies. Photographs of damage and abnormalities in fore and hind flippers facilitated individual identification of almost 80% of individuals encountered during a 3-year study of New Zealand sea lions (*Phocarctos hookeri*) at the Otago Peninsula. Lower canine size and large body scars were also useful in identifying individuals. None of the features used to identify the 48 individuals in this study changed sufficiently to hinder positive identification. Especially in small populations, the method has several advantages over traditional tagging.

McCONKEY S, LALAS C AND DAWSON S, 2002a. Moulting and changes in body shape and pelage in known-age male New Zealand sea lions (*Phocarctos hookeri*). *New Zealand Journal of Zoology* **29**: 53-61.

Abstract: We observed a small population of male New Zealand sea lions (*Phocarctos hookeri*) in seven consecutive years at Otago, New Zealand, a region north of the main breeding population. Changes in pelage, body shape and body length, with growth of tagged, known-age males were used to define age class categories: "juvenile" (1-3 years), "subadult" (4-5 years) and "adult" (6 years and older). Accurate assessments of age are important to determine immigration rates of cohorts into a small population. We used photographic identification to recognise individuals so that the progression of moulting could be determined. Individuals 2+ years old underwent a complete annual moult over a period of c. 2 months between December and June. Juveniles moulted earlier than subadults and adults. However, 1-year-old males underwent only a partial annual moult. Knowledge of the timing of moult is important for the deployment of remote sensing devices glued to the pelage, because moult will result in the loss of attached equipment.

McCONKEY S, HEINRICH S, LALAS C, McCONNELL H, McNALLY N, 2002b. Pattern of immigration of New Zealand sea lions *Phocarctos hookeri* to Otago, New Zealand: Implications for management. *Australian Mammalogy* **24**: 107-116.

Abstract: The present management strategy for New Zealand sea lions *Phocarctos hookeri* assumes that kills in a squid trawl fishery around Auckland Islands, the species population base, have prevented an increase in abundance of sea lions. This strategy also assumes that emigration will be initiated as the population reaches carrying capacity, and that emigration rates will be density dependent. We used the combination of photographic identification of individuals and diagnostic features of age classes to estimate immigration rates of *P. hookeri* to Otago, South Island, New Zealand. Most immigrants were males ≤ 2 years old at arrival, and included animals tagged as pups at Auckland Islands. Estimates for total numbers of immigrants to Otago from four consecutive cohorts, 1991/92-1994/95, varied three-fold through a period of constant annual pup production at Auckland Islands. The greatest influx was from the 1993-94 cohort, a breeding season that predated the enforcement of early closures of the squid fishery. We suggest published records from the Auckland Islands indicate that this population is already at carrying capacity. If so, then factors other than, or in addition to, pup production and fishery mortality have an impact on emigration rates.

McCONKEY S, McCONNELL H, LALAS C, HEINRICH S, LUDMERER A, McNALLY N, PARKER E, BOROFKY C, SCHIMANSKI K, AND McINTOSH G, 2002c. A northward spread in the breeding distribution of the New Zealand sea lion *Phocarctos hookeri*. *Australian Mammalogy* **24**: 97-106.

Abstract: The primary objective of the population management plan for New Zealand sea lions, *Phocarctos hookeri*, is to move the species from its current conservation status of threatened to non-threatened. The mechanism by which this will occur is through the establishment of new breeding colonies away from the only existing colonies at Auckland Islands and Campbell Island. Otago, on the southeast coast of the South Island of New Zealand, is one of only three locations

where breeding has been recorded away from these islands in modern times. We found only one female at the initiation of our surveys here in 1991, an individual that had been tagged as a pup at Auckland Islands. This female has remained resident at Otago and is now breeding. Her first live birth, in the 1993-94 breeding season, represented the first record of a *P. hookeri* pup on the New Zealand mainland since the elimination of the species here by humans c. 150 years ago. Up to and including the 2000/01 breeding season she had produced six pups. Her surviving pups have remained at Otago and her eldest two daughters have started breeding, producing a further three pups. From this total of 9 live births, 2 pups have died. Although 6-8 other migrant females have been recorded, to our knowledge none have bred at Otago. We conclude that the initiation of breeding by *P. hookeri* at Otago has been a serendipitous event attributable to atypical behaviour by a single female.

McCONKEY S, 2004. Management of the New Zealand sea lion population at Otago.

Department of Conservation Report.

1. Executive Summary

1.1. The New Zealand sea lion population at Otago

- New Zealand sea lions returned to the Otago coastline approximately 20 years ago.
- Sea lions at Otago are concentrated in two areas, Otago Peninsula and The Catlins.
- The current population is similar to estimates for 1999 (108 males, 3 females).
- Almost all of these sea lions are immigrants from the subantarctic now resident at Otago.

1.2. Sea lion breeding at Otago

- The first birth of a live pup at Otago occurred in the 1993/94 breeding season.
- A total of 12 live births have been confirmed prior to the 2002/03 breeding season.
Two of these pups did not survive.
- All breeding is so far descended from one female.
- The first three pups born at Otago (all females) have started breeding.

- Two aborted foetuses have also been found.
- The breeding population at Otago is unlikely to reach the desired management goal of 10 breeding females in a twenty year time frame taken from the start of breeding.

1.3. Required management actions

- Greater emphasis needs to be given to monitoring the local population in order to better understand the population dynamics and factors involved in the establishment of a breeding colony.
- A higher priority needs to be assigned to:
 - 1) investigating reports of sea lions in new places, especially females and pups;
 - 2) investigating reports of conflict between people and sea lions, especially killing of sea lions;
 - 3) protecting females and pups, including relocation when necessary; and
 - 4) installation of interpretive signs at locations where sea lions are commonly found.
- Education of the public in areas where sea lions are found or may be found in the near future is likely to increase acceptance of sea lions and reduce the potential for conflict.

WILSON GJ, 1979. Hooker's sea lions in southern New Zealand. *New Zealand Journal of Marine and Freshwater Research* **13**: 373-375.

Abstract: The discovery at Stewart Island of a hauling-out ground regularly used by Hooker's sea lions (*Phocarctos hookeri*) is described and recent sightings of sea lions in southern New Zealand are reported. An attempted copulation between a male Hooker's sea lion and a dead female fur seal is also described.

WRIGHT M, 1998. Ecotourism on Otago Peninsula: Preliminary studies of yellow-eyed penguin (*Megadyptes antipodes*) and Hooker's sea lion (*Phocarctos hookeri*). *Science for Conservation* **68**. Department of Conservation.

Abstract: Ecotourism is the fastest growing sector of the tourism industry in New Zealand. It should be non-degrading and ecologically sustainable nature tourism; there should be no negative effects on the species targeted.

The majority of New Zealand's ecotourism activities are on Department of Conservation (DoC) administered land, or target marine birds or mammals that DoC is charged with protecting. Two ecotourism ventures on Otago peninsula were studied – one based on yellow-eyed penguins (*Megadyptes antipodes*) at Sandfly Bay and the other on Hooker's sea lion (*Phocarctos hookeri*) at Papanui Beach.

Sandfly Bay (45°54'S 170°39'E) on Otago Peninsula is a DoC Conservation Area with wildlife refuge status. The landing times of adult yellow-eyed penguins were recorded and compared with those of yellow-eyed penguins at Double Bay, an area closed to the public and less than 3 km from Sandfly Bay. This study concluded that there was no difference in landing times between the public and the non-public beach. On Sandfly Bay the numbers of humans visible on predetermined zones on the beach were also recorded and statistical tests compared the frequency of penguin landings with human presence on these different zones. It was found that the proportion of penguin landings was less while people were present in only one zone, - the eastern-most sector of the beach, nearest the penguin habitat and landing site. DoC's management strategy for Sandfly Bay consists of a viewing hide on the sandhills at the east end of the beach and signs encouraging people to use the hide and asking them not to go on to the area of the beach where this study found human presence equated with fewer penguin landings. This study concludes that if these guidelines are followed, the factor of human presence on the beach will have little short-term behavioural effect on yellow-eyed penguins.

The study of impacts on Hooker's sea lions was conducted at Papanui Beach (45°52'S 170°44'E). It involved two 'approachers' walking up to either a solitary sea lion or one which was a member of a group. Approaches were to 5 m, 10 m and 20 m of the sample animal. Behaviour was observed before, during and after the approach was made and the animal's behavioural state and the behavioural events it performed were recorded.

No significant difference in the proportion of time the sea lions spent in a specific behavioural state (lying versus sitting/moving) or in the number of times they performed a behavioural event was found with any of the six treatments (three approach distances with solitary or group animals). Positive correlations were found between thermoregulatory behaviours and both ambient temperature and black bulb temperature (an approximation of sea lion body temperature). The importance of these behaviours and possible outcomes of disturbance are discussed, as are population change implications. The extrinsic value of the approachers' group size in this and other studies is discussed. Other studies of Hooker's sea lion tolerance of humans at Papanui Beach suggest that habituation may have occurred at that beach.

UNIVERSITY OF OTAGO PHD AND MSc THESES

BEENTJES MP, 1989. Evolutionary ecology of the New Zealand fur seal (*Arctocephalus forsteri*) and Hooker's sea lion (*Phocarctos hookeri*). PhD thesis, University of Otago, Dunedin.

Abstract: Thermoregulatory behaviour, terrestrial locomotion and postcranial skeletal morphology of the New Zealand fur seal (*Arctocephalus forsteri*) and Hooker's sea lion (*Phocarctos hookeri*) are quantified and the results compared between the two species. Differences and/or similarities are discussed in terms of the evolutionary ecology of these two sympatric otariid species. Additionally, a single chapter, describes some aspects of the behavioural ecology of *P. hookeri*.

Quantitative and qualitative analysis of filming studies reveal that fundamental differences exist between the gaits of *Arctocephalus forsteri* and *Phocarctos hookeri*. Terrestrial locomotion of the latter species is similar to that of terrestrial vertebrates in which the limbs are moved in sequence, alternately and independently. In contrast, the gait of the New Zealand fur seal does not conform to this sequence, the hind limbs being moved in unison. The gaits of both species are defined and illustrated.

The gaits are here considered to be ecological specialisations which are adaptations to the mechanical problems imposed by different habitats. Gaits of

these species appear typical or representative of members of their inferred subfamilies (Arctocephalinae and Otariinae). The gaits of *A. forsteri* and *P. hookeri* are however paradoxical in light of their inferred evolutionary history since the gait of the Hooker's sea lion resembles more closely that of the putative ancestors of otariids (ursids = bears) than does the gait of the New Zealand fur seal; fur seals supposedly gave rise to the sea lions and are traditionally considered to possess retained primitive features.

There were minor (statistical) quantitative differences in some of the limb bone and vertebrae linear dimensions between *A. forsteri* and *P. hookeri* but these were differences in degree rather than kind. Analysis of gait and structure of *A. forsteri* and *P. hookeri* together with several specimens of the Australian otariids (*A. pusillus doriferus* and *Neophoca cinerea*) suggest that:

- a) There is no correlation between gait and postcranial morphology in these otariids.
- b) There do not appear to be any phylogenetic differences in the linear dimensions of postcranial morphology between fur seals (Arctocephalinae) and sea lions (Otariinae).

There was no statistical difference in the relative width of the humerus between *A. forsteri* and *P. hookeri*. This finding casts doubt on the utility of this character as a diagnostic indicator between fur seals (Arctocephalinae) and sea lions (Otariinae) as proposed by Repenning & Tedford (1977).

While the gaits of the New Zealand fur seal and Hooker's sea lion are profoundly different, no major concomitant structural differences between the species appear to exist. Selection for the behavioural control of the gait has apparently preceded concomitant structural modifications.

Thermoregulatory behaviour of the sympatric Hooker's sea lion and New Zealand fur seal in relation to air temperature and solar radiation were studied, quantified, and the results compared between the two species. Both species adjusted posture and flipper exposure so that surface area exposed to air increased as solar radiation intensified, providing quantifiable evidence that flippers are the major sites of heat exchange. The general pattern of thermoregulatory behaviour in these

species, while showing minor differences in the magnitude of postural and flipper adjustments to solar radiation, does not differ in the basic sequence or type of response. Non-postural thermoregulatory behaviour was shown to be influenced by the respective habitat substrates and topographies of the two species.

HEINRICH S, 1998. Population dynamics, haul-out behaviour and human impacts on New Zealand sea lions in the Catlins. M.Sc. thesis, University of Otago, Dunedin.

Abstract: The establishment of two local populations of New Zealand sea lions (*Phocarctos hookeri*) in Otago, South Island, New Zealand, represents a recolonisation of part of the prehuman distribution of this species. This study of the local population in the Catlins, South Otago, was conducted during a 15 month-period from December 1995 to February 1997 and focussed on population dynamics, haul-out behaviour and human impacts.

Identification from distinctive naturally-occurring features indicated that the Catlins local population totalled about three females and 59 males. The regular sighting of two females and 51 males throughout most of the year indicated that nearly all individuals were resident. At least 16 males and one female were recruited during the study period. Most new arrivals were juvenile males from a single cohort. A comparison between numbers of sea lions recruited annually into Otago and catch statistics of arrow squid (*Nototodarus sloanii*) indicated that juveniles arrived following consecutive years of high squid abundance during the nursing and weaning periods at the population stronghold at Auckland Islands.

Adult males were temporarily absent from the Catlins during summer and might have migrated to subantarctic rookeries to breed. Haul-out patterns of sea lions fluctuated diurnally and seasonally, and probably reflected seasonal changes in foraging behaviour. Individual haul-out durations and temporal changes in proportions of the population ashore must be taken into account when conducting population census work.

Spatial organisation of sea lions at the four main haul-outs reflected seasonal variations in habitat selection ashore and the influence of social stimuli. Sea lions favoured dunes only during winter, most likely for thermoregulatory reasons.

Associations between individuals were fluid, but compositions of groups showed age-specific companion associations probably caused by age-related dominance. Juvenile and subadult males were the most social age classes and they might have associated to practice motor and social skills for future breeding. In contrast, females, one-year old juvenile males and adult males were predominantly solitary. Thus, females and one-year old males might have actively avoided harassment by older males. Adult males could have avoided aggressive intraclass interactions.

Tests for the influence of temporal and meteorological factors showed that thermoregulatory constraints did not govern haul-out activity. Rather, diurnal and seasonal patterns in activity budgets might be attributed to social factors. Diurnal peaks in social interactions coincided with peaks in arrivals ashore and departures to sea.

Sea lions were subject to two potentially detrimental human impacts: viewing activities and deliberate harassment. Tests for the responses of sea lions to the approach of visitors showed that approaches closer than 15m caused behavioural changes. However, these responses might not constitute a detrimental impact. Further investigation is needed to target age-, sex- and site- specific reactions of sea lions to visitors. Deliberate harassment with motorcycles caused major disturbance. In addition, an average of about two sea lions annually are killed deliberately in Otago. More public education and effective enforcement of the current protective legislation are imperative in order to ensure continued successful recolonisation of the mainland by New Zealand sea lions.

LUDMERER AJ, 2002. New Zealand sea lions (*Phocarctos hookeri*): abundance estimates and habitat utilization on the Otago Peninsula with preliminary diet composition study at North Otago. M.Sc. thesis, University of Otago, Dunedin.

Abstract: New Zealand sea lions (*Phocarctos hookeri*) are a threatened species, endemic to the waters and coastline of the New Zealand region. A small satellite population is found on the Otago Peninsula, the current northern limit of the species distribution. Continued monitoring of this population has occurred continuously since 1991. This study is a continuation of eleven years of population analysis.

Quarterly abundance estimates from October 2000 – September 2001 show that numbers of sea lions on the Otago Peninsula remained constant for the duration of this study between 40 – 50 individuals (CI 95%: 41-74). The number of sea lions on the Otago Peninsula has increased from c. 34 individuals (3rd quarter 1999) to c. 47 individuals as of the 2nd quarter of 2001.

Utilizing digital photographic techniques minimized both processing time and overall cost of this study. The mark quality grading system designed for this study aided in deriving abundance estimates. Using the two most distinct mark quality grades (grade A and grade B) resulted in smaller confidence intervals than estimates derived from all mark quality grades (grade A, grade B, and grade C).

The number of females on the Otago Peninsula has increased from one in 1994, to seven as of February 2002. This study documents the birth of one female during the 2000/2001 breeding season and two females during the 2001/2002 breeding season.

New Zealand sea lions on the Otago Peninsula show preference for certain beaches. Numbers of encounters on each beach surveyed do not correspond to beach area, however, beach length was shown to account for 21% of the variation seen in the numbers of sea lions encountered. Increased numbers of New Zealand sea lions have been reported in locations north of the Otago Peninsula. A preliminary diet analysis of sea lions hauling out at Shag River mouth showed no substantial overlap with local commercial fishers, however, analysis did show the presence of brown trout (*Salmo trutta*), which is prized by recreational fishers along the Shag River and Kakanui River. Reports of deliberate killings of sea lions along the Kakanui River highlight the importance of an effective conservation strategy including a public awareness program.

McCONKEY SD, 1997. Individual identification, population dynamics and moult of the New Zealand sea lion at Otago. M.Sc. thesis, University of Otago, Dunedin.

Abstract: A photographic record was kept of all New Zealand sea lions seen at seven study sites in Otago, New Zealand, throughout 1995. Seventy-nine sea lions were individually identified using distinctive features on the flippers, face and body such

as rips, nicks and surface scars and estimates of age class. The most commonly used features were those found on the periphery of both the fore and hind flippers. Over 90% of individual sea lions seen were identifiable. The computer program written in this study to improve the speed and accuracy of identifying sea lions was found to vary in effectiveness depending on the experience of the researcher. Using the program experienced researchers correctly matched animals more rapidly and more frequently than inexperienced researchers. Approximately 75% of animals identified at Otago Peninsula were present for at least six months of 1995. All individuals identified in 1994 were also seen in 1995, indicating a majority of resident animals. Numbers of sea lions ashore reached a maximum during spring and autumn and a minimum during winter and summer. Low numbers during summer were related to an absence of older animals. Low numbers during winter appeared to be due to a change in haul-out behaviour. Diurnal activity was investigated via the presence and absence of one-year old male sea lions at Roaring Bay, South Otago. Arrivals and departures peaked at mid-morning and mid-afternoon, behavioural activity peaked at 1400h, and the animals showed virtually no nocturnal activity. Only three females were present at Otago Peninsula during the study period: a breeding female and her two offspring, the first pups to be born on the mainland of New Zealand in recorded history. The timing and pattern of moult was recorded for male sea lions. Younger males moulted first with two-year olds beginning in December - January. Generally moult occurred later for each successive age class. Animals older than four began moulting in March - April. The exception was the one-year old age class, which moulted at a similar time to animals five years and older, but only went through a partial moult.

McCONNELL H, 2001. New Zealand sea lions on the South Island and Stewart Island: abundance, recolonisation status, and management considerations. M.Sc. thesis, University of Otago, Dunedin.

Abstract: New Zealand sea lions are currently recolonising the New Zealand mainland following a period of historical exploitation. Sea lions are now present on the southeast coast of South Island and Stewart Island, where they were formerly

absent. The use of photo-identification, based on natural diagnostic features, facilitated population monitoring at Otago Peninsula, the Catlins, Waipapa Point and Small Crafty Retreat, Stewart Island between February 1999 and May 2000. Investigations into these peripheral populations enables insights into the recolonisation process that can not be gained from studies at the population base (the Auckland Islands). The current conservation strategy for this species is contingent on new breeding sites being established at locations outside this southern population base. Areas of the mainland are viewed as potential breeding sites.

Scarcity of females on the mainland was identified as the primary limiting factor to the short-term expansion of breeding range. Less than ten females were encountered at mainland locations throughout my study. Numbers of males were estimated seasonally via mark-recapture methods to be between 41 (Spring 1999, 95% log normal CI = 38 - 45), and 48 (Summer 1999/000, 95% log normal CI = 39 - 59) at Otago Peninsula, and between 69 (Autumn 1999, 95% log normal CI = 64 - 74), and 77 (Summer 1999/00, 95% log normal CI = 70 - 84) in the Catlins. A single estimate of 49 (95% profile likelihood CI = 34 - 93) was obtained for Small Craft Retreat. Numbers at Waipapa Point were comparably lower with an estimated eight individuals using this area. A summation of these estimates indicates approximately 170 individuals were present on the mainland during my study. Longterm temporal trends were only quantifiable for the Catlins, where the local population increased significantly from 1995 to 2000, with an average annual growth rate of 14%.

The northward expansion of this species into regions more densely populated by humans, means that the frequency of interactions between sea lions and people can be expected to increase. Diet of sea lions was analysed in a pilot study of scat analysis at Small Craft Retreat. This analysis identified an overlap in the target species of sea lions and those of local fisheries. Observations of females from my study were used to highlight additional sea lion-human interactions, which, if not addressed, could potentially pose a threat to the future breeding success on the mainland.

In light of my study, recommendations were made regarding management of sea lions on mainland New Zealand. These recommendations are based on the general philosophy that in addition to by-catch mitigation in southern waters (where New Zealand seal lions are subject to incidental mortality in a trawl fishery), sea lion management on the mainland needs to be re-addressed if recolonisation is to be enhanced through active protection and management.

McNALLY N, 2001. New Zealand sea lion abundance, demographics and movements in southern New Zealand. M.Sc. thesis, University of Otago, Dunedin.

Abstract: This study represents the first comprehensive survey of the New Zealand sea lion, *Phocartos hookeri* populations at Campbell Island, the first surveys in nearly 30 years at The Snares and the continuation of a monitoring program in the Catlins. The results from each of these study locations, increases the understanding of the population dynamics of the species. Photo-identification and mark recapture techniques were used to obtain a population estimate for male sea lions in the Catlins. There are approximately 63 males, and at least two females. Over the eighteen-month period of this study, July 1997 - January 1999, only five new identifications were made. The population in the Catlins continues to increase, but it appears it will remain a predominantly male non-breeding colony, in the short term at least. Photo-identification and mark recapture techniques were used to study the abundance and demography of sea lions at North East Island, The Snares during autumn 1997 and autumn 1998. In total 118 male sea lions were identified, with 63% of identifiable sea lions from 1997 being resighted in 1998. The population estimates for male sea lions were 234 (95% CI 187 to 293) males in 1997 and 255 (95% CI 187 to 348) males in 1998. The minimum estimate for females was 2 in 1997 and 7 in 1998. A single pup was recorded in 1997, but none in 1998. The Snares, despite records of occasional breeding spread over nearly 100 years, remains a non-breeding colony. Campbell Island is the only major breeding site for sea lions outside of the Auckland Islands. Minimum pup production was estimated at 78 for the 1997/98 breeding season, compared with the only previous estimate of 122 from 1991/92, and represents less than 5% of the total pup production for the

species. Sea lions at Campbell Island have a widespread distribution, clumped at the coast with low densities inland. Local concentrations of sea lions were seen at Davis Point, Sandy Bay and both Northeast and Southeast Harbours. Isolated individuals were found up to 1.5km inland and at altitudes >250 m. Breeding females at Campbell Island are generally solitary and give birth inland, in contrast to the highly gregarious colonial rookeries seen on the coasts of the Auckland Islands. This study also presents the confirmation of an annual return migration by adult male sea lions based in Otago to the breeding colonies at the Auckland Islands.

WILLIAMS S, 2007. Breeding migration between South Island and Auckland Islands, of adult male New Zealand sea lions resident at South Island, New Zealand. M.Sc. thesis, University of Otago, Dunedin.

Abstract: New Zealand sea lions (*Phocarctos hookeri*) are slowly recolonising their former range on the South Island of New Zealand following extirpation by human hunting. Practically all New Zealand sea lions inhabit subantarctic islands south of New Zealand and only a small proportion (1%) are resident at the South Island. The South Island population is predominately male (>90%), and most are immigrants that were born in the subantarctic islands. Due to highly localized breeding, centred at the Auckland Islands, the species is classified as Threatened. The department of Conservation population management plan aims to establish new breeding locations outside the subantarctic islands and thus improve their status. Kills in the southern squid fishery and disease are seen as the two main threats to the species. Outbreaks of previously unidentified diseases have occurred at subantarctic breeding colonies in recent years, resulting in mass mortality events. The sources of these diseases remain unconfirmed.

The movement of organisms from one location to another is integral to the study of population dynamics. Understanding the movements of individual New Zealand sea lions has implications for the reproductive contribution of South Island residents separated from the main subantarctic population. Adult male New Zealand sea lions resident on the South Island could gain access to mates by remaining at the South

Island, where there were five sexually mature females compared to around 54 adult males in 2003/04, or they could undergo an annual breeding migration to the subantarctic islands where the vast majority of females reside.

Alphanumeric codes bleached into the pelage of South Island adult male sea lions allowed recognition of these individuals during the 2003/04 breeding season. Twenty-one (62%) of the 34 bleach marked prior to the breeding season were recorded at Auckland Islands breeding colonies, including five in breeding harems of females. This indicated that these males gained access to receptive mates and thus genetic interchange occurred between South Island males and Auckland Islands females. Therefore, not only do the South Island residents form the vanguard for the northern spread of the species distribution by recolonising mainland New Zealand but also they remain genetically connected to the Auckland Islands population.

Not all South Island resident adult males disappeared from the South Island during the 2003/04 breeding season. A comparison of fighting injuries and body weight index between migratory adult males and those that did not migrate allowed a total migration rate of 84% to be estimated for all adult male sea lions resident at the South Island.

The greatest implication for conservation management from the findings of this study is that South Island males migrating south during the breeding season could be the vectors of diseases to the subantarctic colonies.

UNIVERSITY OF OTAGO POSTGRADUATE 480/490 PROJECTS

AUGE A, 2004. Attendance patterns of breeding females and habitat use of New Zealand sea lions, *Phocarctos hookeri*, at Victory Beach, Otago Peninsula, in winter. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: The New Zealand sea lion, *Phocarctos hookeri*, is listed as vulnerable by the IUCN, primarily due to its restricted breeding distribution area with almost all pups born in only four breeding colonies at the Auckland Islands. The recent

recolonisation of mainland New Zealand is the sign of a natural recovery by the species. Victory Beach, Otago Peninsula, South Island, is currently the only nursery site of New Zealand sea lions on the mainland with three pups raised during 2004. It is thus essential to monitor this new population. The first aim of this study was to investigate attendance patterns of the breeding females of this new population in winter and the second aim was to investigate habitat use.

Field work took place at Victory Beach through 14 consecutive days, 14-27 June 2004 with three 2 hours surveys per day. During each survey, sightings were recorded with a GPS position and individuals were identified. Behavioural observations were recorded incidentally. The attendance patterns were analysed to determine the duration of foraging cycles of breeding females and their degree of maternal attendance once ashore. The habitat use was analysed by calculating the presence and location of sea lions at Victory Beach, especially pups, and by using a Geographic Information System to display a visual result.

The results showed that foraging cycles at Victory Beach were shorter than at the Auckland Islands in winter indicating that the new population may have a better nutritional environment. The female and pup sea lions at Victory Beach mostly used pine, *Pinus radiata*, forest habitat once ashore. This means that the forest is an important habitat for the population. However, pups as well as juveniles and adults, also used the sandy foreshore, where human interactions are likely to occur. Human disturbance could be an obstacle to the health of this population and thus be a potential threat that should be investigated.

Victory Beach seems to be a good environment for New Zealand sea lions, both for habitats on land and for food resources at sea. The population at Victory Beach should be one of the priorities in term of conservation management of this species.

BROOKING K, 2002. Demography, daily movements and human impacts of the New Zealand sea lion *Phocarctos hookeri* at Surat Bay, The Catlins. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: The population distribution and age-class of *P. hookeri* ashore was documented during the non-breeding period, 2002. Behaviour of male sea lions was

recorded in the absence and presence of visitors. Beach surveys recorded the number of visitors (guided/unguided), minimum approach distance, number of sea lions approached and any changes in sea lion behaviour.

A total of 160 sightings were made over the 14-day sampling period, with an average of 11.4 sea lions sighted per day. Group composition was mostly made up of adults (48.8%), with a similar number of subadults (25.6%) and juveniles (25.6%).

A significant difference was found between the sea lion population distribution of 2002, with that of 1996. Sea lions preferred haul-out site had shifted from the eastern end of Surat Bay (1996) to the western end (2002). Distances between sea lion and visitor had a significant effect, with large guided groups initiating more active behaviour. Sea lions displayed a more active behaviour in the presence of visitors in comparison to the behaviour in the absence of visitors.

HEINRICH S, 1995. Behaviour observations of juvenile male New Zealand sea lions, *Phocarctos hookeri* (Gray, 1884), at a hauling ground in The Catlins. Unpublished 490 report, Department of Zoology, University of Otago, Dunedin.

Abstract: New Zealand sea lions (*Phocarctos hookeri*; Gray 1844) were studied for 16 consecutive days from 24 June to 9 July 1995 at Roaring Bay in The Catlins. A total of 17 animals were recorded: 15 juvenile males (ie. less than 5-years old), one subadult male and one female. No adult animals (ie. older than seven years) were observed. This showed a site segregation by age of males in The Catlins. Six of the ten recorded 2-year old males were regularly observed throughout the study. On average, sea lions remained ashore during 85% of the daylight-day and departed to sea at dawn or during the night. The dominant activity ashore was lying (86% of the haul-out duration). Active interaction was largely confined to midday (1200-1400 hours), coinciding with peak numbers ashore. Human presence initiated active group interaction and induced behavioural alterations. Reactions to public visitors and the researcher were similar. Individuals showed broad differences in behavioural responses. The minimum distance of 7m between people and sea lions, as recommended by the Department of Conservation, appears to be appropriate.

HOLLINGWORTH K, 2001. Demography, dispersion, and the effect of human disturbance of New Zealand sea lions (*Phocarctos hookeri*) at Surat Bay, South Otago, New Zealand. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: The distribution of New Zealand sea lions ashore at Surat Bay was documented during the non-breeding season winter, 2001. Beach surveys recorded the sex, age class, distance to closest sea lion, GPS position and habitat that the animal was in. A total of 203 sightings of animals were recorded with an average of 25.4 animals sighted per day. Comparison of mean number of sea lions sighted since 1996 revealed that the population has increased. The sampling population consisted entirely of males, as there were no sightings of females or pups at Surat Bay and was largely predominated by adults. The composition of groups consisted primarily of adults followed by juveniles and subadults. Solitary sea lions were the most frequently encountered group size followed by a group consisting of two individuals. As group size increased, the frequency of groups decreased. There was a significant difference in numbers per age class between grouped animals and solitary sea lions indicating a higher proportion of adults in solitary groups. Log likelihood ratio testing found that the preferred haul-out area had significantly changed ($p < 0.00$) and had shifted from the east end of Surat Bay in 1996 to the west end June 2001. There was a relatively equal ratio of sea lions found within the dunes and on the beach (105:98). Minimum distance between sea lion and visitor, and visitor group size did not have a significant effect on the response (interactive or non-interactive) of the sea lions. However sea lions responded to the majority (63%) human sea lions encounters ($n=8$).

HUNT A, 2002. Female attendance patterns and pup behaviour by New Zealand sea lions (*Phocarctos hookeri*) at Victory Beach, Otago Peninsula. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: The New Zealand sea lion, *Phocarctos hookeri*, is one of the rarest pinniped species. This study examined attendance of pups by mothers and pup

activity budgets at Victory Beach, Otago Peninsula in June 2002. Thirty-three beach surveys were conducted over a 13 day period. Locations of the four mothers, their pups, and any other sea lions present within the study were recorded. Pup behaviour was also recorded between surveys for one hour. A difference in attendance was found between Katya (62%), the mother of a yearling, and Mum, Leone, and Suzie (30%, 25% and 27% respectively), the mothers of pups. No significant difference was found in the duration of time a mother was ashore and the duration of time she was attending her pup. A difference in behaviour was found between the six month old pups and between the pups and the yearling for the lying behaviour and time spent in the water ($P=0.014$ and $P=0.009$ respectively). A daily average of 3.85 (sd 1.86) males were seen at Victory Beach over the study period. No significant trends in the number, age, or distribution of males were detected. Results suggest that attending offspring for two years maybe less stressful for the mother and possibly increases the chance of the offspring surviving weaning. The lower attendance of mothers with pups compared to previous years may be typical of years with less food available or may be an anomalous year. Due to the importance of the Otago Peninsula population continued comparisons are needed to confirm these results.

McCONKEY SD, 1994. Population estimates and behavioural observations of Hooker's sea lions at Otago. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: From 31 May to 9 July, 17 trips were made to Papanui Beach every 2-4 days to record the numbers of recognisable and unrecognisable Hooker's sea lions hauled-out. From 31 May to 3 October 28 trips were made to Victory Beach to study the behaviour of a mother/pup pair resident on the beach during this time. A mark-recapture technique and the Peterson estimator were used to calculate a population estimate of about 20 sea lions for the Otago Peninsula. Numbers of resident animals and maximum haul-out numbers indicate a doubling of the population size over the last 10 years. Estimates from a three-day trip to The Catlins indicate a similar population size to Otago Peninsula and therefore six killings in the last two years could threaten the viability of this population. The behaviour of

the mother and pup is comparable to behaviour observed at Enderby Island, especially dispersal from the beach of birth when the pup is about two months old, and the use of trees as a predominant haul-out site.

McCONNELL H, 1998. Interactive behaviour and group dynamics of male New Zealand sea lions (*Phocarcto hookeri*) in the Catlins. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: The behaviour of resident male New Zealand sea lions ashore at the Catlins was documented in winter 1998. Focal group sampling (Altmann, 1974) was used to assess interactive behaviour within groups of sea lions on the beach. Continuous sampling (Altmann, 1974) was also used throughout the sample period to collect data relating to arrival from sea and movements ashore. Three age-classes were examined; juveniles, subadults and adults. Analyses of variance revealed that juveniles spent a greater proportion of time interacting than subadults and adults, were involved in interactive bouts more frequently, and that their interactive bouts lasted for a longer time. The duration of interactive bouts were also long for adults, also lasted a long time, however adults were involved in interactive bouts less frequently than juveniles. Of all the age-classes subadults spent the least proportion of their time interacting.

Log likelihood ratio testing on the movement ashore data found that both subadults and adults were more likely to join a group than remain solitary on the beach. Further analyses of variance found that within groups, the frequency of interactive bouts decreased significantly once a group size of four was exceeded. Additionally, the duration of interactive bouts increased significantly once a group size of three was exceeded.

Group stability was analysed using the coefficient of variation associated with mean group size as a measure of stability. This analysis found that the coefficient of variation decreased according to a power function curve ($y=0.387x^{-0.607}$), hence, group stability increased with increasing group size.

McEWAN K, 2002. Assessment of the winter diet of New Zealand sea lions resident at Shag River mouth, Otago, New Zealand. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: This study was conducted to determine the winter diet for New Zealand sea lions *Phocarctos hookeri* residing at the Shag River mouth, Otago. Scats (n=72) and regurgitations (n=19) were collected between the 14-28 June, 2002 for analysis. Diagnostic remains derived from these samples were attributed to the highest taxa possible. Using regression equations, diet composition was assessed by mass. The two dominant species, comprising 2/3 of the total diet were greenbone (*Odax pullus*) and octopus (*Pinnoctopus cordiformis*). Supporting previous research, large differences were recorded between scat and regurgitation remains, with regurgitations containing more cephalopod remains, and scats containing higher percentages of teleost fish. Comparisons between intermittent and daily sample collections revealed a large amount of data may have been lost using the intermittent sampling method previously applied by researchers. Differences were evident between the diet of individual sea lions. Interaction with commercial and recreational fisheries was negligible.

McNALLY N, 1996. Abundance of New Zealand sea lions, *Phocarctos hookeri*, at the Catlins, South Otago, in winter 1996. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: Photo identification of individuals and mark recapture techniques were used to obtain a population estimate for New Zealand sea lions, *Phocarctos hookeri*, at the Catlins, South Otago, New Zealand, for winter 1996. From a total of 15 field days between the 24 June and 15 July, 40 individual sea lions were identified using natural features, 12 of which were previously tagged. Three-year old male sea lions formed the largest age class and accounted for 35% of the identified individuals. One female sea lion was seen. Four “closed” mark recapture models were used to gain an estimate of population size: Petersen’s estimator, Schumacher’s estimator, Chapman’s modification and Bailey’s modification. Two estimates were produced from each model: one used all identified individuals as

marked and the other used only previously tagged individuals as marked. The proportion of identifiable individuals averaged 88%, and tagged individuals averaged 28%, of sea lions seen on each field day. The data gave a population estimate of approximately 50 sea lions which is about double the estimated population in 1994. The main haul out beach at the Catlins for New Zealand sea lions during the study period was Surat Bay, preference for which may be linked to thermoregulatory behaviour and habitat selection.

MILNE A, 1996. The diet of male New Zealand sea lions (*Phocarctos hookeri*) in the Catlins, South Otago, winter 1996. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: The winter diet of male New Zealand sea lions in the Catlins consists of at least 14 different genera of fish, two genera of cephalopods and 3 genera of crustaceans.

Importance of prey in samples was measured in three ways: the percentage occurrence in a sample type, minimum number of prey items and proportion of reconstituted wet weight.

The importance of the top prey differed depending on the type of sample collected. Red Cod (*Pseudophycis bachus*) was the most important species in scats for percentage occurrence and reconstituted wet weight of prey items. Octopus (*Octopus maorum*) was the most important prey item in vomits when all 3 methods of ranking are used.

No spatial difference in diet was found to exist between the population at the Catlins and that at Papanui Beach, but a change in diet over time was found.

This study has shown the importance of regular sampling trips to avoid bias in the type of samples collected, as it is shown here that the collection of scats only under-represents the importance of cephalopods in the New Zealand sea lion diet. This results in an over-estimation of the importance of fish species.

RITCHIE T, 1996. Abundance of New Zealand sea lions at the Otago Peninsula during winter 1996. Unpublished 480 report, Department of Marine Science, University of

Otago, Dunedin.

Abstract: Following prehistoric elimination from the New Zealand mainland, the New Zealand sea lion has recently been recorded in low but increasing numbers at the Otago Peninsula. This study aimed to estimate the abundance of sea lions at the Otago Peninsula, assess methods previously used for this purpose and establish what research is further necessary to improve documentation of abundance. Using mark-recapture methods, this study estimated the number of male New Zealand sea lions at the Otago Peninsula to be 39 individuals (95% confidence interval 31 – 47). Using census methods this study counted three female sea lions. The number of sea lions recorded by this study is approximately twice that noted in 1994. Census methods, previously used to determine abundance of male sea lions at Otago Peninsula, will become increasingly inappropriate for this task if sea lion numbers continue to rise. A Department of Conservation (DOC) method, previously used for estimating the abundance of male sea lions at the Otago Peninsula, produces estimates of abundance with low levels of precision. This study recommends methods to DOC for more precisely documenting the abundance of male sea lions at the Otago Peninsula. This study suggests that further research focuses on population dynamics of the New Zealand sea lion.

SCHIMANSKI K, 2001. Female attendance of pups and site selection by male New Zealand sea lions, *Phocarctos hookeri*, at Sandfly Bay, Otago Peninsula. Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: The New Zealand sea lion, *Phocarctos hookeri*, is the rarest of all sea lion species. This study examined female attendance of two pups and male distribution at Sandfly Bay, Otago Peninsula in June 2001. Thirty-six beach surveys over a 14-day period were conducted. Locations of the two pups, their mothers and any other sea lions present on the beach were recorded with GPS. A difference was shown between the attendance of the two mothers (11 - 41%). One of these mothers spent significantly more time ashore (33%) than attending her pup (11%). Mothers were always reunited with their pups if a pup response call was made. A non-mother relative called and attended a pup. The number of males increased over the study

period ($r^2=0.558$). These males became progressively closer to the females and pups ($r^2=0.635$). Results suggested that conventional behavioural research methods do not provide an accurate measure of maternal attendance. The distribution of male sea lions was influenced by female and pup distribution. Pup survival may be influenced by the presence of non-mothers, male interactions, and pup response calls. Pup survival is higher in colonies, however it is not certain if these Otago females will stay and form a colony. Due to the small size of the Otago population future studies are needed to clarify these results.

SCHOOL FOR INTERNATIONAL TRAINING (SIT) PROJECTS

ABRAMS D, 1997. Departure and arrival of Yellow-eyed penguins (*Megadyptes antipodes*) and New Zealand sea lions (*Phocarctos hookeri*) on Papanui Beach, Otago Peninsula. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: David recorded Yellow-eyed penguin and New Zealand sea lion departure and arrival times at Papanui Beach, during November-December 1997. He also recorded interactions between sea lions, fur seals, humans, and yellow-eyed penguins. Sea lion daily arrivals (mean = 1032h, SD = 4.22) were later than those recorded by Beentjes in 1986/87 and departures (mean = 1552h, SD = 5.42) were earlier. Average peak haul-out numbers were 11-12 per day, greater than Beentjes average (2-4). Sea lions were observed chasing yellow-eyed penguins, fur seals and people.

BALL A, 2004. Effects of tourists on New Zealand sea lions *Phocarctos hookeri* at Papanui Beach, Otago Peninsula, South Island, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Alexa investigated the impact of small tourist groups on sea lions at Papanui Beach, November 2004. Sea lion location, and changes in sea lion behaviour and posture were recorded, as well as minimum approach distances for tourist groups. Most (77%) sea lions were located in areas visited by tourists. Most

(83%) sea lions remained lying throughout encounters. Average approach distances were greater for sea lions that sat up. No more sea lions left from the tourist area of the beach than the non-tourist area.

BIEGUN KE, 2002. Tourist interactions with and impacts on New Zealand sea lions (*Phocarctos hookeri*) at Surat Bay, the Catlins, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Kyla focused on tourist interactions with and impacts on New Zealand sea lions at Surat Bay, during November 2002. Sea lion behaviour was monitored in both the absence and presence of tourists. Tourist numbers reached their peak in the middle of the day and coincided with the period when the highest proportion of sea lions were resting. The presence of tourists resulted in a change to more active behaviours. Closer approaches were more likely to alter sea lion behaviour.

BOROFSKY C, 1997. Behavioural observations of a New Zealand sea lion mother and pup pair at Victory Beach, Otago Peninsula, New Zealand. Senior Thesis, University of Vermont, Burlington.

Summary: Chad conducted behavioural observations, recording activity budgets, haul out locations and suckling locations of a solitary mother and her four month pup during April 1996. The behaviour of any males present was also recorded. The mother spent 52% of the 127.5 hours of observation with her pup. The mother suckled her pup more in the absence of males (36%) than with males present (19%). The longest suckling bout observed was 64 minutes and the pup terminated 40% of suckling bouts. Four suckling bouts were interrupted by males which were then chased off by the mother with another 15 instances of mother aggression toward males.

CHANDLER A, 2002. Effects of tourism on the New Zealand sea lion (*Phocarctos hookeri*) at Surat Bay, the Catlins, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Abbie recorded sea lion behaviour both in the absence and presence of people, during April-May 2002. In the absence of people, sea lions were most active in mid-morning and late afternoon. Adult sea lions were least active and juveniles most active. Most tourists visited between 11am and 12 noon, and between 2pm and 3pm. Less than 20% of sea lions exhibited changes in behaviour in the presence of people. Most of these changes were to a more active state but the majority of sea lions returned to their original behaviour within 10 minutes. Larger group size and closer approaches both lead to increased disturbance.

COOK WJ, 2002. New Zealand sea lion dispersion and demographics at Surat Bay and Cannibal Bay, Catlins. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Will recorded sea lion distribution and demographics at Surat Bay and Cannibal Bay, during November 2002. He found between four and 19 sea lions each day (average = 10): 45% juveniles; 37% adults; 18% subadults. Juveniles were more frequently sighted at Cannibal Bay, subadults were more common at Surat Bay and adults were evenly distributed. Most sea lions were observed on the beach rather than in the sand dunes. Location preference was focussed at the western end of Surat Bay and the length of Cannibal Bay. No trend was determined for average distance to nearest neighbour. Mean numbers ashore showed a decrease when compared with November 1996 (33) and November 1999 (23).

CORIA A, 2004. Terrestrial winter-weather thermoregulation of New Zealand sea lions (*Phocarctos hookeri*) at Surat Bay and Cannibal Bay, Catlins, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Alex recorded the location and behaviour of sea lions in different weather conditions (air temperature, wind speed, rain and cloud cover) during April 2004. More sea lions were found in the sand dunes in colder weather and on cloudy days rather than on the beach. Relationships between location and other weather conditions were not definitive. Extending flippers and sand-flipping was seen more

often in sunshine and less often in rain. These behaviours were also seen more often in higher air temperatures but only in lower wind speeds suggesting wind speed and air temperature may confound one another. Sea lions were found in body contact more often in windy conditions and in cooler air temperatures.

EUSDEN T, 2004. Dispersion and Attendance of New Zealand sea lion (*Phocarctos hookeri*) mothers and pups of Victory Beach, Otago Peninsula, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Tyler observed the location, behaviour and arrival and departure times of three female sea lions and their pups at Victory Beach in April 2004. Two female foraging cycles were calculated (1.7 days each) shorter than those at the Auckland Islands. Observed female attendance patterns were 27% for all three mothers. One mother was recorded also suckling her yearling on six occasions.

KROHN K, 2003. Attendance patterns, social interactions, and dispersion of adult male New Zealand sea lions (*Phocarctos hookeri*) at Papanui Beach, Otago Peninsula. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Kelly observed arrival and departure times of male sea lions as well as behavioural patterns of identifiable adult males, during November 2003. An average of 14 sea lions were seen during daily observations (range 6-20) with an average arrival time of 1115h and an average departure time of 1840h. Average arrival and departure times are unlikely to be accurate due to a seven hour break in observation period from 1100h to 1800h. From 30 observation periods (morning and evening for 15 days), 15 adult male sea lions were identified and only three were seen more than 5 times. Some identified males appeared to have favoured areas where they were usually found (possible territories) and some identified males were more likely to be found with other sea lions (usually juveniles).

LACZ R, 2000. The photographic identification of New Zealand sea lions (*Phocarctos hookeri*) on Otago Peninsula, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Ryan conducted beach surveys at Papanui Beach and Sandfly Bay during November 2000, taking photographs of all sea lions sighted. Of the 47 sea lions photographed 83% of sightings were of 20 identified individuals. Most identifying features were found on the front and back flippers.

LARIMER M, 2004. Effect of Tourists on the behaviour of New Zealand sea lions (*Phocarctos hookeri*), South Otago, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Monica investigated the effect of tourists on sea lion behaviour at both Surat Bay and Cannibal Bay, during April 2004. All sea lions spent most (76%) of their time lying down. Juvenile males spent more time interacting than other age and sex classes. Sea lions tended to be least active in the afternoon observation period (1430-1700h) and during higher temperatures. By recording posture changes during encounters with people Monica determined juvenile males were most easily disturbed and females least. Sea lions were disturbed more often during the morning and evening, and at higher temperatures. Longer encounters were more disturbing, but other than encounters within one metre (100% disturbance) greater separation between tourists and sea lions appeared to cause greater disturbance. Single sea lions appeared more easily disturbed than groups. Monica also observed a sea lion charging a car while others ran away, a sea lion being poked with a stick, and clapping, yelling and throwing of sticks at another sea lion.

MERRIGAN M, 2002. Time allocation and behavioural trends in three New Zealand sea lion pups at Victory Beach, Otago Peninsula, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Maile observed the behaviour of three pups and their mothers at Victory Beach, April 2002. Maile's results are sparse and lacking data and are not really

quantifiable. Pups all spent more time lying than any other behaviour with the male pup spending more time in social interaction than either of the female pups. Male sea lions often interrupted suckling and separated mothers from pups. Some females were seen defending pups other than their own.

NADLER C, 2003. Influence of weather conditions on the thermoregulatory behaviour of New Zealand sea lions (*Phocarctos hookeri*) ashore at Surat Bay and Cannibal Bay, Catlins, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Cory was investigating the effects of weather (temperature, wind speed and cloud cover) on the thermoregulatory behaviour of sea lions during November, 2003. Sea lions seemed to prefer resting on the open beach rather than in the sand dunes or on the edge of the dunes. These locations had little effect on the temperature but the edge of the dunes was slightly less windy than the open beach and in the dunes was significantly less windy. Prone sea lions were recorded in one of three behavioural categories: flippers tucked under body; flippers spread; flipping sand over body. Juveniles were seen flipping sand the most while adults were seen with flippers tucked under the body the most. The average temperature was significantly higher, and wind speed and percent cloud cover significantly lower, for sea lions observed flipping sand than for those not flipping sand. There was little difference for the other behaviours.

OLESNYCKY A, 2003. Attendance Patterns and Grouping Behaviour of New Zealand Sea Lions (*Phocarctos hookeri*) at Surat and Cannibal Bays, South Otago, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Andrew investigated the territorial and social behaviour of marked adult male sea lions during November 2003. An average of 13-14 sea lions were seen during midday and evening surveys with significantly more sea lions at Cannibal Bay. Adult males were found to haul-out and remain in

significantly smaller areas than juvenile males suggesting territoriality. Adult sea lions were seldom within 10m of other adults. Some adults were more likely to be found with subadults and juveniles than others, sometimes driving off another adult after coming ashore, suggesting dominance behaviour even in the absence of females.

ORY J, 2004. Natural behaviour of New Zealand sea lions (*Phocarctos hookeri*) at Surat Bay, Catlins, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Joanna studied the natural behaviours of sea lions at Surat Bay, during November-December 2004. Sea lions spent most of their time (68%) lying. Time of day had little effect other than more time interacting during the evening (1600-2100h). Adult males were the least active with subadult males interacting more than other age classes. Sea lions in groups of three or more spent much less time lying and more time sitting and interacting. Sea lions were more active in warmer weather (18-21°C), greater cloud cover (75-100%), and lighter winds. More time was spent interacting in the presence of tourists.

PARKER E, 1998. Two female New Zealand sea lions and their pups on the mainland, Otago Peninsula. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Emily recorded the activity budgets and attendance patterns of two mother/pup pairs, during April-May 1998. The older mother, "Mum", was with her female pup 66% of the time that the pup was able to be located. Mum was absent from the beach only 6% of the time. The younger mother, "Katya", was with her male pup 24% of the time that the pup was able to be located and absent from the beach 44% of the time. This difference may be due to mother experience, hunting ability or feeding cycle as no nocturnal observations were conducted. The male pup spent a lot more time alone or with other sea lions than the female pup. The male pup was more active than the female pup regardless of whether other sea lions were

present. The female pup's time spent suckling was much reduced when other sea lions were present and she was much more active; the male pup's suckling time was similar with or without the presence of other sea lions. Both mothers were observed attempting to chase away male sea lions that were causing a disturbance, sometimes successfully, sometimes not. Male aggression towards pups interrupted suckling and sometimes separated pups from their mother but no physical harm was observed. The female pup was once observed suckling from Katya for a total of 19 minutes.

PIERCE M, 2003. Effects of ecotourism on the behavior of yellow-eyed penguins (*Megadyptes antipodes*) and New Zealand sea lion (*Phocarctos hookeri*) at Papanui Beach, Otago, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Melissa studied the effects of small tourist groups on the behaviour of sea lions at Papanui Beach during April 2003. She recorded approximately one third of all sea lions approached were disturbed including sea lions more than 80m away. Disturbance lasted on average 6.1 minutes. Melissa's definition of disturbance (a sequence of behaviours seen relating to tourist presence) is vague and subjective so any conclusions may be unreliable.

SAMUELSON T, 2001. The effects of human presence on the natural behaviour of Hooker Sea Lions. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Todd recorded sea lion behaviours in both the presence and absence of people, during November 2001. Sea lions in the absence of people were found to spend most of their time lying down with juveniles demonstrating more time in social interactions than adults and subadults. Sea lions of all age categories appeared to sit up more in the rain than in cloudy or sunny weather conditions. The presence of people also caused more active behaviours (such as sitting and social interaction) from the sea lions. Larger groups of sea lions usually exhibited more social interaction and larger groups of people caused more active behaviours than

smaller groups. All results should be viewed with caution as there are discrepancies in the data.

SEGARRA K, 2001. Individual identification and haul-out patterns of the New Zealand sea lion (*Phocarctos hookeri*) at Papanui Beach, Otago. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Kate studied the haul-out patterns of individual sea lions at Papanui Beach in April 2001. An average of 5.6 sea lions were sighted per count, with lowest counts being at dawn (4.9); midday and dusk being equal (6.1). Midday counts varied from 1-12 individuals with over 50% of individuals being adult males. The highest hourly count was at 1500h (from 5 days of hourly counts). Most (79%) of the sea lions sighted were identifiable and were seen between one and ten times. Comparisons with an earlier study conducted by Beentjes in 1986 showed a similar daily count but a change in age structure from subadults to adults.

STELLA A, 2003. The effects of tourists on the behaviour of New Zealand sea lions (*Phocarctos hookeri*) in the Catlins, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Abbey observed posture changes in sea lions during tourist encounters and related this to disturbance, during April 2003. She also recorded the amount of time it took for the sea lion to return to its original behaviour. Tourist group size appeared to have no effect on sea lion posture change but sea lions took longer to return to previous behaviours after visits by larger groups. Closer approaches were more likely to elicit a posture change and sea lions took longer to return to original behaviours. Most (93%) sea lion charges were in response to approaches closer than 10m. Deliberate harassment of sea lions was more likely to cause a change in posture as were interactions with horses and vehicles. Adult male sea lions took longer to return to original behaviours. This study should be viewed with caution as

posture changes may have been from more active postures to less active postures so it is difficult to know which posture changes can be regarded as disturbance.

THIBAUT A, 2003. Maternal behaviour of the New Zealand sea lion, *Phocarctos hookeri*, at Victory Beach on the Otago Peninsula, Dunedin, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Ayrin recorded the attendance patterns of two mother/pup pairs and two mother/yearling pairs at Victory Beach, during April 2003. On days where either the mother or the pup/yearling were found attendance rates were 19% and 55% for yearlings, and 28% and 55% for pups. The lowest attendance (19%) may have been affected by the birth of a new pup which did not survive so the mother went back to suckling her yearling. Both mothers with pups were aggressive towards males when the pups were harassed.

WHITE W, 2003. New Zealand sea lion demography and dispersion at Surat Bay and Cannibal Bay, South Otago, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Whitney recorded the age, sex and location of each sea lion as well as the proximity to other sea lions during April 2003 at Surat and Cannibal Bay. Daily sea lion counts averaged 26 sea lions with only five of 435 sightings being female. Most sea lions (65%) were at Surat Bay with juveniles most common (41%) and subadults least common (29%). Most sea lions (81%) were on the beach instead of in the dunes.

ZAINO J, 2004. The behavioural effects of tourists on New Zealand sea lions (*Phocarctos hookeri*) at Surat Bay, The Catlins, New Zealand. Independent Study Project, School for International Training, University of Waikato, Hamilton.

Summary: Jenna-Lyn investigated the effects of both the duration and proximity of tourist visits on sea lion behaviour, during November 2004. Results showed slightly more active interactions between sea lions when tourists were present but in both situations most of the time was spent lying down. Sea lion activity increased with the duration of tourist visit until 15 minutes and then decreased again. This suggests sea lions may have got used to visitor presence and resumed resting behaviours. Sea lion activity was also found to be higher when tourists were further away. This may indicate an initial disturbance when tourists are further away followed by a return to resting behaviour once tourists stop approaching. More extreme tourist activities such as shouting and stomping were observed having a greater level of disturbance.

OTHER RELATED THESES AND PROJECTS

DICKIE G, 1995. Population dynamics of the New Zealand sea lion (*Phocarctos hookeri*). Unpublished 480 report, Department of Marine Science, University of Otago, Dunedin.

Abstract: A substantial number of New Zealand sea lions are caught as bycatch in the southern squid trawl fishery, and the impact of the bycatch on the population is unknown. Population modelling is a useful tool for estimating the impacts of incidental catch, but requires information on life history parameters. The models generally consider only females and the information required includes age at first reproduction, maximum age, survival rates and pupping interval. Age at first reproduction and maximum age can be determined from carcass dissections, and survival rates and pupping intervals from field studies.

Methods have been investigated to estimate the age and reproductive status of New Zealand sea lions killed as bycatch in the southern squid trawl fishery. Age was estimated by counting the incremental growth layers in longitudinal tooth sections. Reproductive status was determined by histological examination of the ovaries and uterus from female New Zealand sea lions. Though an age at first reproduction of 4 years is given in the literature (Gales, 1995), the sample size from which that estimate was obtained is not given. Hence determining the reliability of this estimate is a priority.

In this project seven sea lions were dissected and aged. Etched teeth were read by two independent readers, whose estimates never differed by more than one year. Age estimates ranged from less than one year to 12 years. Four of the sea lions were females aged 3, 3, 5 and 12 years respectively. All except one 3 year old, whose ovarian status could not be determined, were mature. The uteri of the 5 and 12 year olds showed they had borne pups. These results confirm the utility of the techniques used. The limited data presented here support the contention that AFR is indeed 4 years, but many more dissections are needed to establish this estimate with statistically acceptable reliability.

Collection of data from carcass dissections and field studies is essential to determine the status of the New Zealand sea lion population and the impact that the

bycatch is having. The sea lion population is small, and its range limited. It is therefore important to quantify adverse human impacts to ensure protection of the species.

DICKIE G, 1999. Population dynamics of New Zealand fur seals (*Arctocephalus forsteri*) and New Zealand sea lions (*Phocarctos hookeri*). M.Sc. thesis, University of Otago, Dunedin.

Abstract: Bycatch of marine mammals occurs in fishing operations worldwide. Substantial numbers of New Zealand fur seals (*Arctocephalus forsteri*) and New Zealand sea lions (*Phocarctos hookeri*) are captured incidentally each year. Lack of information on population biology and population size over the duration of the major bycatch fisheries means that bycatch impacts cannot be estimated for either species. In an attempt to redress this, I studied the population biology and dynamics of New Zealand fur seals and New Zealand sea lions.

Growth and reproductive biology of both species were studied by examining animals killed incidentally in fishing gear in New Zealand waters in 1996. Tooth sections were used to age the animals, and male and female reproductive organs were examined macroscopically and histologically. One hundred and twenty seven New Zealand fur seals were examined. The maximum age observed in the sample was 22 years for females and 12 years for males. Males were significantly larger than females, but growth was similar up to five years. Males reached sexual maturity between five and nine years of age, whereas females did so between four and six years. The pregnancy rate in females was approximately 69%.

The first steps towards modelling population growth of New Zealand fur seals are taken in Chapter 3. These models use the biological data from fur seals but rely on data from other species where such data are not yet available. For this reason model results should be considered indicative rather than definitive. The models use a risk analysis program to incorporate uncertainty in the input, and provide a distribution of estimates of population growth rather than a single point estimate. They illustrate a productive approach and outline possible population trajectories.

They also indicate what data are most urgently needed to provide more realistic modelling.

Stomach and lower intestine contents were examined for 112 of the fur seals. Remains of 19 taxa were identified. Seals were targeting similar prey species to the fishery in which they were captured. However, it was clear that, at least in the west coast South Island fishery, seals took much smaller hoki than the fishery. A surprising result was that extremely small fish (< 12 cm) are taken directly, and in quantity, by seals. There has been doubt in previous studies as to whether these remains have occurred indirectly from the stomachs of other species eaten. Comparison of stomach versus colon contents showed differences in digestion of prey species and only smaller items appeared to pass through the colon. This suggests that larger indigestible items are regurgitated by the seals, resulting in misleading results from studies based on scats or regurgitates only. It is therefore advisable that studies using these types of remains are based on both scats and regurgitates.

The sample size available for New Zealand sea lions was much smaller than for fur seals, with only 30 sea lions dissected. The maximum age observed in the sample was 21 years for females and 12 years for males. As with other seal species, males reached larger sizes than females. Males appeared to reach sexual maturity between five and nine years of age, as is the case for New Zealand fur seals. Maturity in females seemed to occur between three and five years. Due to the season of capture it was not possible to establish pregnancy reliability. However, the data do suggest a delay in implantation of the embryo of at least three months. A larger sample size of New Zealand sea lions is necessary to further confirm these results.

GORMLEY A, 2000. Mark-recapture for estimating abundance in four marine mammal species. Unpublished 495 research proposal, Department of Marine Science, University of Otago, Dunedin.

Introduction: Good estimates of animal abundance are important for two reasons. Firstly, to understand the ecology of a particular species, we must have an idea of

its population size. "Population size is the fundamental descriptor of a population" (Hammond 1990, p135). Secondly, sound wildlife management decisions cannot be made without estimates of animal abundance. Abundance estimates allow us to assess human impacts such as bycatch in fishing or the effects of increasing tourism, such as whale watching. While "how many are there" is one of the most basic questions one can ask about a population, in practice it can be very difficult to answer satisfactorily. Good models must be robust under the failure of assumptions (Buckland 1982).

The aim of this research is to develop mark-recapture analyses for four species of marine mammal. It is likely that a separate model will be required for each species due to their different characteristics. The biases and assumptions of each model will be examined and presented in order to enable the practitioner to select the most suitable method. The sensitivity of parameters to sampling variability and violation of the assumptions will also be assessed. A decision-making framework will then be developed in order to choose the most suitable mark-recapture model for future studies of marine mammals using photo-identification.

GORMLEY A, 2002. Use of mark-Recapture for Estimating the Abundance of Four Marine Mammal Species in New Zealand. M.Sc. thesis, University of Otago, Dunedin.

Abstract: Mark-recapture methods require animals in a population to be individually identifiable. To achieve this, early application of mark-recapture methods used artificial marking methods that required affixing a plastic tag or similar. More recently, it has been recognised that many species possess natural markings that enable positive identification of individuals.

This study assessed the suitability of using mark-recapture methods in combination with photo-identification of natural markings, in order to estimate the abundance of marine mammal populations. Abundance estimates were derived for sperm whales at Kaikoura, bottlenose dolphins in Doubtful Sound, Hector's dolphins in Banks Peninsula and New Zealand sea lions on Otago Peninsula. The most recent estimates are as follows: 58 resident sperm whales at Kaikoura (cv=0.09), 49 adult bottlenose dolphins in Doubtful Sound (CV=0.02), 843 Hector's

dolphins around Banks Peninsula ($cv=0.17$), and 46 adult New Zealand sea lions on Otago Peninsula ($cv=0.09$). The low CV values are due to a number of factors such as high average capture probabilities (ranging from 0.33 for resident sperm whales to 0.98 for bottlenose dolphins) and long-term studies in every case (ranging from 9 sampling periods for New Zealand sea lions to 21 sampling periods for sperm whales). These factors ensure that a high proportion of individuals are captured a large number of times, resulting in better estimation of population size.

The four species studied here generally have a high proportion of individuals that are identifiable from permanent natural markings. Termed the mark-rate, this value ranged from 12.5% for Hector's dolphin up to 100% for sperm whales.

It is apparent from this study that there is not any one "best model" that is suitable for estimating the abundance of every population. Instead, the choice of an appropriate model depends very much on the situation of each population. Nevertheless, many studies follow a naive approach of using one of the more commonly used models, with little consideration as to its suitability. By comparing estimates from the most appropriate model to those from commonly used models, I have shown that such an approach is likely to result in estimates of abundance that are severely biased. As a result, it is recommended that a more informed choice of model be used for mark-recapture analyses. This may be achieved by using goodness-of-fit tests, and also by testing among potential models.

JACKSON J, 2003. Gregariousness in a nascent breeding population of New Zealand sea lions at Otago Peninsula. Unpublished 495 research proposal, Department of Marine Science, University of Otago, Dunedin.

Executive summary: The New Zealand sea lion, *Phocarctos hookeri*, was extirpated from the New Zealand mainland following colonisation by people and subsequent subsistence and commercial hunting. It is one of the least abundant pinniped species with a highly restricted breeding distribution around New Zealand's subantarctic islands. The development of a trawl fishery for arrow squid (*Nototodarus sloanii*) around the Auckland Islands has led to incidental fishing related mortalities and the philopatric nature of sea lions limits the capacity of this population to colonise new

areas. Late age to maturity and the relatively short lifespan of *P. hookeri* further compounds the problem of limited population expansion.

Emigration will be initiated as the population at the Auckland Islands reaches carrying capacity. Immigration of *P. hookeri* to Otago has been observed and breeding has been initiated in the last decade. The expansion of breeding grounds away from the main centre at the Auckland Islands is important for the growth of the *P. hookeri* population. The Otago Peninsula population is the only record for this species that begins at colonisation and presents a unique research opportunity. The motivation of this study is to document the early stages of recolonisation by determining the exact timing and locations of births in the 2003/04 breeding season at Otago. This study also provides the opportunity to evaluate attendance patterns of *P. hookeri* and to make comparisons with the Auckland Islands population as well as to observe interactions between females at Otago.

OSMAND J, 2005. Thermoregulatory behaviour of the New Zealand sea lion (*Phocarctos hookeri*) at Otago Peninsula. Unpublished 495 research proposal, Department of Marine Science, University of Otago, Dunedin.

Abstract: Pinnipeds are amphibious mammals that have adaptations that enable them to reduce heat loss in water. Water is a medium that conducts heat away from the body 25 times faster than that of air. They have thick blubber, thick pelage, counter-current exchange systems in their flippers, and smaller surface area to volume ratio than terrestrial mammals of similar mass. These mechanisms that enable them to reduce heat loss in water can cause heat stress on land. Pinnipeds have therefore developed a number of physiological and behavioural adaptations to reduce heat loading, including heat loss via conduction and convection through their flippers, thermal windows along their bodies to increase evaporation, body and flipper posture adjustments and movement towards the sea. This study will assess whether heat stress, caused by the warmer climate of the New Zealand mainland (with respect to the sub-antarctic islands), will be a limiting factor in the recolonisation of this species. Behavioural adaptations of the New Zealand sea lion, *Phocarctos hookeri* will be examined at two locations, Victory Beach and Papanui Beach, on

the Otago Peninsula from November 2005 to August 2006, over a range of weather conditions. Environmental variables such as air temperature, solar radiation, soil moisture and soil temperature, and wind velocity will be measured. These will be correlated with thermoregulatory behaviour including body and flipper postural adjustments, sand flipping behaviour, and orientation relative to wind velocity.

SAMARANAYAKA A, 2005. Environmental Stochasticity and Density Dependence in Animal Population Models. PhD Thesis, University of Otago, Dunedin.

Abstract: Biological management of populations plays an indispensable role in all areas of population biology. In deciding between possible management options, one of the most important pieces of information required by population managers is the likely population status under possible management actions. Population dynamic models are the basic tool used in deriving this information. These models elucidate the complex processes underlying the population dynamics, and address the possible consequences/merits of management actions. These models are needed to guide the population towards desired/chosen management goals, and therefore allow managers to make informed decisions between alternative management actions.

The reliability that can be placed on inferences drawn from a model about the fate of a population is undoubtedly dependent on how realistically the model represents the dynamic process of the population. The realistic representation of population characteristics in models has proved to be somewhat of a thorn in the side of population biologists. This thesis focuses in particular on ways to represent environmental stochasticity and density dependence in population models.

Various approaches that are used in building environmental stochasticity into population models are reviewed. The most common approach represents the environmental variation by changes to demographic parameters that are assumed to follow a simple statistical distribution. For this purpose, a distribution is often selected on the basis of expert opinion, previous practice, and convenience. This thesis assesses the effect of this subjective choice of distribution on the model predictions, and develops some objective criteria for that selection based on

ecological and statistical acceptability. The more commonly used distributions are compared as to their suitability, and some recommendations are made.

Density dependence is usually represented in population models by specifying one or more of the vital rates as a function of population density. For a number of reasons, a population-specific function cannot usually be selected based on data. The thesis develops some ecologically-motivated criteria for identifying possible function(s) that could be used for a given population by matching functional properties to population characteristics when they are known. It also identifies a series of properties that should be present in a general function which could be suitable for modelling a population when relevant population characteristics are unknown. The suitability of functions that are commonly chosen for such purposes is assessed on this basis.

I also evaluate the effect of the choice of a function on the resulting population trajectories. The case where the density dependence of one demographic rate is influenced by the density dependence of another is considered in some detail, as in some situations it can be modelled with little information in a relatively function-insensitive way.

The findings of this research will help in embedding characteristics of animal populations into population dynamics models more realistically. Even though the findings are presented in the context of slow-growing long-lived animal populations, they are more generally applicable in all areas of biological management.

WILLIAMS S, 2003. Breeding migration to Auckland Islands by male New Zealand sea lions (*Phocarctos hookeri*) resident at Otago. Unpublished 495 research proposal, Department of Marine Science, University of Otago, Dunedin.

Conclusions: The study will provide an accurate estimate for the population size of adult male New Zealand sea lion resident at Otago. It will also give an indication of the proportion that migrate to breeding colonies and the proportion that remain in the Otago region. Resident Otago males input into the breeding colonies in the

Auckland Islands is also will also be investigated and an attempt shall be made at comparing breeding success of these individuals to those from other locations. The study will also document return dates for migratory Otago males and produce photographic evidence of the change in condition and damage resulting from the breeding migration to the Auckland Islands.

This project will form an integral part of the long-term research, initiated in 1991, documenting the colonisation of the New Zealand mainland by *Phocarctos hookeri*, the New Zealand sea lion. Investigating the annual breeding migration and the reproductive success of Otago males that form the vanguard of expansion in distribution will assist with the conservation and management of the species at Otago. This will be achieved by providing quantitative data concerning migration to breeding colonies, which is severely lacking within the literature.