Temporal variation in leopard seal presence and predation near an Antarctic penguin rookery
by Tracey Rae Mader

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science In Biological Sciences
Montana State University

Abstract:
Temporal and spatial variability in sea ice are hypothesized to impact all trophic levels of the Antarctic marine food web. The leopard seal, Hydrurga leptonyx, is a pack ice obligate and a generalist feeder. Information on the life history attributes of leopard seals has generally been limited to population censuses, diet studies of harvested animals, and observations of activity near penguin rookeries. Knowledge of the physical and biological parameters that regulate leopard seal distribution in the Antarctic Peninsula and the extent of their association with penguin rookeries is uncertain. Between 1984/85 - 1996/97 leopard seal sightings near a penguin rookery were recorded at the Admiralty Bay field station, a long-term research site, on the southwestern shore of King George Island (KGI), South Shetland Islands. Records of weekly leopard seal censuses and opportunistic leopard seals sightings were investigated to determine annual presence and predation patterns. Leopard seals were most often sighted in October and declined in each subsequent month of the austral summer. Annually, leopard seal numbers at the penguin rookery were highest in years following moderate ice winters when the October pack ice edge was in the vicinity of KGI. When the position of the ice edge was distant from our site, in years of both high and low ice winters, the numbers of leopard seal sightings were low. In addition to the long-term studies, we initiated a systematic study of intrannual variation in leopard seal presence and behavior near the rookery during the austral summer of 1995/96. Observations of leopard seals and associated physical and biological factors were recorded in fixed 3-hour blocks between 8 October and 11 February. Local sea ice condition, time of day, day of year, and penguin activity to and from the rookery were investigated as correlates of intrannual leopard seal presence. A logistic regression model for the 1995/96 data determined that the independent variables, day of year and ice condition, explained 31% of the variation in leopard seal presence near the rookery. Leopard seals were more likely to be present early in the season than later and there was a positive correlation between increasing local ice cover and leopard seal presence. Analysis of leopard seal predation observations indicated both diel and seasonal trends in the 1995/96 study and the long-term monitoring records. In October and early November, leopard seal predation behavior and penguin activity occurred throughout the day. During this time, Adelie penguins arrived at the rookery with 1-2 kg body fat to sustain them over their prolonged courtship period. In December and January, leopard seal predation behavior was concentrated between 1500-2100 hr., as was the number of penguins arriving to the rookery. During this time adult breeding Adelie penguins made frequent trips to sea in order to feed their growing chicks and carried up to 600g of krill upon their return. These findings indicated that leopard seal predation behavior was correlated with penguin activity and that as leopard seals frequented the coast near the rookery they preyed on those penguins which best afforded a fat, energy rich source of food at various times of the year.

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APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date April 14, 1998

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ABSTRACT

Temporal and spatial variability in sea ice are hypothesized to impact all trophic levels of the Antarctic marine food web. The leopard seal, *Hydrurga leptonyx*, is a pack ice obligate and a generalist feeder. Information on the life history attributes of leopard seals has generally been limited to population censuses, diet studies of harvested animals, and observations of activity near penguin rookeries. Knowledge of the physical and biological parameters that regulate leopard seal distribution in the Antarctic Peninsula and the extent of their association with penguin rookeries is uncertain. Between 1984/85 - 1996/97 leopard seal sightings near a penguin rookery were recorded at the Admiralty Bay field station, a long-term research site, on the southwestern shore of King George Island (KGI), South Shetland Islands. Records of weekly leopard seal censuses and opportunistic leopard seals sightings were investigated to determine annual presence and predation patterns. Leopard seals were most often sighted in October and declined in each subsequent month of the austral summer. Annually, leopard seal numbers at the penguin rookery were highest in years following moderate ice winters when the October pack ice edge was in the vicinity of KGI. When the position of the ice edge was distant from our site, in years of both high and low ice winters, the numbers of leopard seal sightings were low. In addition to the long-term studies, we initiated a systematic study of intrannual variation in leopard seal presence and behavior near the rookery during the austral summer of 1995/96. Observations of leopard seals and associated physical and biological factors were recorded in fixed 3-hour blocks between 8 October and 11 February. Local sea ice condition, time of day, day of year, and penguin activity to and from the rookery were investigated as correlates of intrannual leopard seal presence. A logistic regression model for the 1995/96 data determined that the independent variables, day of year and ice condition, explained 31% of the variation in leopard seal presence near the rookery. Leopard seals were more likely to be present early in the season than later and there was a positive correlation between increasing local ice cover and leopard seal presence. Analysis of leopard seal predation observations indicated both diel and seasonal trends in the 1995/96 study and the long-term monitoring records. In October and early November, leopard seal predation behavior and penguin activity occurred throughout the day. During this time, Adélie penguins arrived at the rookery with 1-2 kg body fat to sustain them over their prolonged courtship period. In December and January, leopard seal predation behavior was concentrated between 1500-2100 hr., as was the number of penguins arriving to the rookery. During this time adult breeding Adélie penguins made frequent trips to sea in order to feed their growing chicks and carried up to 600g of krill upon their return. These findings indicated that leopard seal predation behavior was correlated with penguin activity and that as leopard seals frequented the coast near the rookery they preyed on those penguins which best afforded a fat, energy rich source of food at various times of the year.

INTRODUCTION

Studies of the Antarctic Peninsula marine ecosystem have recently focused on the variability of sea ice and its impact on predator and prey populations dynamics (Fraser et al. 1992; Siegel and Loeb 1995; Trathan et al. 1996; Trivelpiece and Fraser 1996; Loeb et al. 1997; Trivelpiece and Trivelpiece in press). Annual variation in sea ice extent in this region ranges from an average maximum coverage in September to an average minimum coverage in February (Stammerjohn 1993; Stammerjohn and Smith 1996). Recent declines in the extent of Antarctic Peninsula sea ice have been correlated with a 50-year warming trend in air temperatures (Fraser et al. 1992; King 1994; Stark 1994; Smith et al. 1996). Between the 1940s and 1960's, winter temperatures were sufficiently cold for sea ice to extend north of the South Shetland Islands an average of 4 out of 5 years (Fraser et al. 1992). However, an analysis of microwave satellite imagery since 1973, indicates that annual winter sea ice currently reaches this region of the Antarctic Peninsula only 1-2 years in each 5-7 year period (Stammerjohn 1993; Stammerjohn and Smith 1996; Hewitt 1997). These cycles in the temporal and spatial distribution of sea ice are hypothesized to affect all trophic levels of Southern Ocean community including krill populations (Siegel and Loeb 1995; Loeb et al. 1997) and krill dependent predators such seabirds and seals (Fraser et al. 1992; Trivelpiece and Trivelpiece in press). The leopard seal, *Hydrurga leptonyx*, is a top predator in the Antarctic marine ecosystem known to eat krill, penguins, and seals (Ørtisland 1977; Siniff et al. 1979; Kooyman 1981; Laws 1984; Siniff and Stone 1985). If temporal and spatial variability in sea ice impacts all levels of the Antarctic marine food web, an examination of leopard seal abundance and predatory

behavior might reveal correlations between environmental parameters and predator-prey interactions.

The leopard seal, a pack ice obligate of the Southern Ocean has been relatively unexploited and understudied by humans because of its solitary existence and inaccessibility. An estimated 220,000 - 400,000 leopard seals live in the Antarctic with a circumpolar distribution, concentrated between 50^0 S and 79^0 S (Laws 1984). Leopard seals range from the coasts of the Antarctic continent to the edge of the pack ice with seasonal migrations or dispersals to Antarctic and Subantarctic islands (Müller-Schwarze and Müller-Schwarze 1975; Rousevell and Eberhard 1980; King 1983; Borsa 1990). During the austral summer, most leopard seals are found in the outer 100 km of the northern edge of the Antarctic pack ice (Gilbert and Erickson 1977). The leopard seal is generally a solitary species (Erickson et al. 1971), with females giving birth to pups in the pack ice from November to December (Laws 1984). Reports by Testa et al. (1991) suggest that the annual north-south movement of leopard seals may be cyclic and correlated with oceanographic features that influence Antarctic pack ice.

Information on the life history attributes of leopard seals has generally been limited to population censuses of distribution and short-term harvest studies. Analyses of stomach contents in such studies have indicated that leopard seals take both vertebrate and invertebrate prey. The major invertebrate prey species include krill (*Euphausia spp.*) and cephalopods which make up approximately 50% and 6% of the diet, respectively. Vertebrates in the diet of the leopard seal include penguins (20%), seals (14%) and fishes (9%) (Ørtisland 1977; Kooyman 1981; Laws 1984). Siniff and Stone (1985) reported temporal variation in the prey species eaten by leopard seals in the Antarctic Peninsula

region. Krill were important in the diet late in September and again in March, and most likely remained essential throughout the winter. Cephalopods were taken throughout the year. November through February young crabeater seal pups, *Lobodon carcinophagus*, were consumed as available (Siniff et al. 1979) and penguins were important to the leopard seal diet in mid-February when fledglings entered the water (Siniff and Stone 1985).

Though seasonal prey preferences may depend on availability, leopard seal presence is associated with most rookeries where penguins congregate to breed in the austral summer (Penney and Lowry 1967; Müller-Schwarze 1971; Müller-Schwarze and Müller-Schwarze 1975; Hunt 1973). However, the extent to which leopard seals associate with specific sites and their distribution in the Antarctic Peninsula during the austral summer is uncertain. Previous studies have examined leopard seal hunting methods and rates of predation and suggested that leopard seal behavior was influenced by environmental variables such as seasonal-effects, time of day, sea ice conditions, tide, and surf (Penny and Lowry 1967; Müller-Schwarze 1971; Müller-Schwarze and Müller-Schwarze 1975; Siniff and Stone 1985). The objective of this study was to determine the extent to which temporal and spatial variability in environmental factors affected the presence and predatory behaviors of leopard seals. I described and quantified leopard seal behavior and environmental variables near an Antarctic penguin rookery in 1995/96 and summarized long-term abundance data collected at the site between 1984/85 and 1996/97. Specifically, I wanted to determine if leopard seal behavior varied daily, seasonally, or annually and what biological and/or physical factors influenced this variance. I hypothesized that daily and seasonal leopard seal presence and predation near

the Admiralty Bay rookery was correlated to penguin activity, sea ice conditions, time of day, and time of season. To investigate temporal variation over a larger scale, I sought to correlate annual leopard seal presence with long-term data records of penguin abundance and mortality, and the extent of regional sea ice.

METHODS

Study Area

King George Island (KGI) is the largest of the South Shetland Islands and lies approximately 100 km northwest of the Antarctic Peninsula at 62^0 10' S, 58^0 27' W (Figure 1). KGI is bordered by the Drake Passage to the northwest and Bransfield Strait to the southeast. Currents from both these waters move in a northeasterly direction along the shores of KGI. The prevailing winds in this region are westerly which causes pack ice to consolidate against the northwestern side of the island, leaving the shores of the southeastern side open (Trivelpiece et al. 1987; 1990; Trivelpiece and Fraser 1996). Admiralty Bay, on the southeast side of KGI, is 5 km wide at its mouth and opens up into the Bransfield Strait where wind and ocean currents sweep ice in and out of the bay. The penguin rookery is located along the western shore of Admiralty Bay (Figure 1) and is designated a Special Site of Scientific Interest (SSSI #8) by the Antarctic treaty which prohibits visitors without a permit. The rookery is largely composed of two species of penguins: 5000-10000 Adélie (*Pygoscelis adeliae*) and 1500-2500 gentoo (*P. papua*) penguin pairs. An additional 3000-4000 pairs of chinstrap penguins (*P. antarctica*) breed at three nearby rookery sites along the western shore of Admiralty Bay.

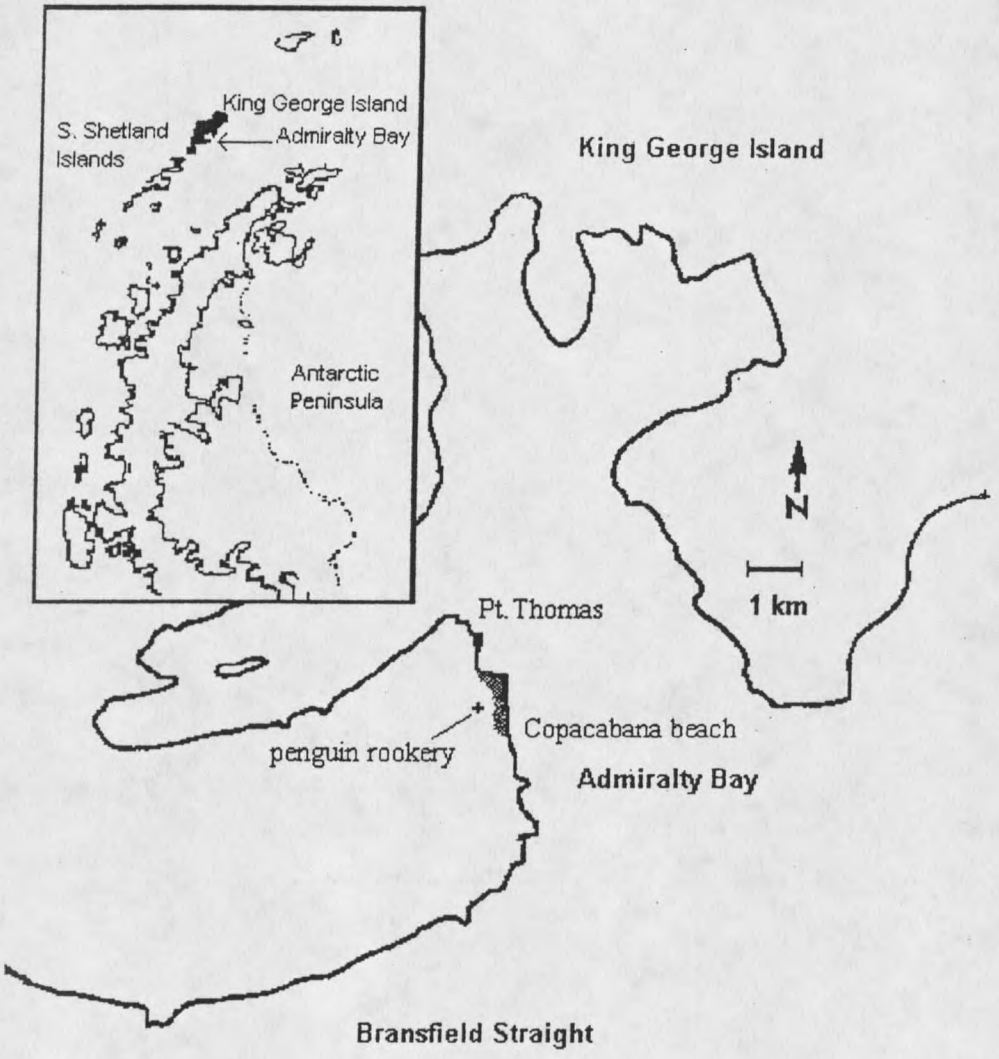

Figure 1. The location of Admiralty Bay on the southeastern shore of King George Island, South Shetland Islands, Antarctic Peninsula (adapted from Trivelpiece et al. 1990).

Data Collection

1995/96 Intrannual Leopard Seal Study

In the austral summer of 1995/96, a study of intrannual variation in leopard seal behavior was conducted at the Admiralty Bay field station. Observations of leopard seals were made between 8 October and 11 February from a blind overlooking the bay. The wooden blind was located on a hill approximately 30 m above the beach and 100 m from the tidal zone. The blind had windows on three sides which made it possible to observe the beach (200 x 1150 m) (Figure 1), as well as the surrounding ocean to approximately 1 km. Observations were made in fixed 3-hour blocks that were randomly scheduled starting at daylight and ending at dusk. Duration of daylight varied seasonally from 12 to 23 hours during the study. A total of 651 hours of observations were conducted (approximately 33 hours every week with a maximum of 9 hours recorded daily). Binoculars (10 X 40) and/or a spotting scope (45X) were used to locate leopard seals. At the beginning of each observational period, the following information was recorded: date, time of day, ice type (bergs or pack) and ice cover in bay and along shore (scale from 0 to 9 - no ice in bay to bay completely covered by ice). Leopard seal behavior, the number and species of penguins arriving and departing the rookery beach, and the occurrence and identity of flying bird species above or within the study area were recorded at intervals throughout the observations.

An attempt was made to document all occurrences of leopard seal behavior during each observation period. This method of sampling was possible because leopard seal behaviors above water were obvious enough to attract the attention of an observer, and behavioral events were not too frequent to record. The identification of individuals

during or between observation periods was not feasible; however, the probability of seeing any one seal at one time was random which provided a relatively unbiased sample of behaviors in the group as a whole. The following information was documented for each seal sighting: time, seal location (distance and direction from blind), size, sex, and behavior (four categories of leopard seal behavior included: haul out - resting on ice or land, patrol - swimming along beach, chase - chasing penguin, and kill - killing penguin. Predation events were timed in discreet phases: chase, kill (jerk-bite: throwing penguin back and forth with head and eating), or escape, recapture. Penguin species and age (adult or fledgling) were recorded for each predation event.

The number of penguins arriving and departing the rookery were censused every 30 minutes during the 3-hour observation period. A complete scan sample (Altmann 1974) took 60-120 seconds. To facilitate the census, the entire beach was divided into 50 m sections, marked by orange painted rocks that could be seen from the blind. Species and numbers of penguins entering or exiting the beach through each 50 m segment were recorded. Orientation of penguins towards the water as well as movement, behavior (i.e., shaking off water to dry feathers, preening), and the appearance of the underside flipper (penguins exiting the water display pink vascilated flippers to dissipate heat) were used to confirm whether birds were arriving or departing the rookery.

Birds flying above the study area were censused at these same 30 minute intervals (30 second scan sample). The abundance of each of the following species was noted: kelp gull *(Larus dominicanus)*, giant petrel (*Macronectes giganteus*), Wilson's storm petrel (*Oceanites oceanicus*), cape petrel (*Daption capense*), brown skua (*Catharacta lonnbergi*), south polar skua (*Catharacta màccormicki*), and snow petrel (*Pagodroma*

nivea). The presence of flying birds or feeding flocks on or above the water were particularly influential in locating leopard seal predation events. Birds circling and/or vocalizing over the kill drew the attention of the observer to the kill. The arrival sequence of flying bird species was of interest in determining which species were involved in locating prey and which species used other birds to locate this food source.

1984/85 – 1996/97 Annual Leopard Seal Study

During the austral summers of 1984/85 through 1996/97, surveys of leopard seal abundance were conducted in two ways: a weekly beach census and daily opportunistic sightings. Weekly beach censuses were made once each Sunday at mid-day from October through February. The censuses included leopard seals in the water, hauled out on the beach or on ice flows along a 2.5 km stretch from Pt. Thomas to Copacabana beach (Figure 1). In addition, daily opportunistic records were kept on leopard seal presence and predation behavior during consistent effort field studies at the Admiralty Bay field station. This documentation was considered opportunistic or *ad libitum* (Altmann 1974) in that no sampling regime was followed.

Census numbers from representative colonies of breeding penguins at the rookery provided annual estimates on the relative number of penguins breeding at the rookery between 1984/85 and 1996/97 (Trivelpiece et al. 1990). Records were also kept on 200 banded reproductive study birds each year. Nest sites of these breeding penguins were visited daily throughout each austral season and penguins that did not return to relieve their mates and/or feed their chicks were assumed to have been killed by leopard seals, as other known sources of adult mortality during the breeding season are limited. Banded

penguins that were considered lost to leopard seals in one season were never observed at the rookery in a subsequent year. A large percentage of these bands were recovered from carcasses of penguins that washed up on the beach each season, further supporting the assumption that penguin mortality was the result of leopard seal predation.

Long-term data concerning the extent of sea ice in the Antarctic Peninsula is based on summaries from Stammerjohn (1993), Stammerjohn and Smith (1996), and Hewitt (1997).

Data Analysis

The 1995/96 intrannual data of leopard seal presence and behavior and penguin activity to and from the rookery were summarized as frequencies and are presented as trends. Annual leopard seal presence and ice conditions at Admiralty Bay are presented as means ± one standard deviation. Logistic regression was used to determine the affect of 4 independent variables (date, time of day, ice condition, and penguin activity) on leopard seal presence/absence. To increase the independence of each sample, the analysis was based on 3-hour observation periods in which leopard seal presence were recorded as present (1) or absent (0). The regression model selection of subsets of independent variables and all their interactions were made using SAS proc logistic (SAS Institute 1988) and Wald chi-square values. Nonparametric two-way contingency table analyses (Fisher's exact test) were conducted to compare leopard seal presence in each month of the 1995/96 austral summer.

Multiple regression was used to analyze annual differences in leopard seal presence, penguin prey abundance, opportunistic leopard seal kill sightings, and penguin

mortality records between the years 1984/85 –1996/97. Non linear regression helped determine the relationship between the annual ice index and leopard seal presence. Nonparametric two-way contingency table analyses (Pearson's Chi square) were conducted to compare the frequencies of seal behaviors that were recorded by two different sampling schemes - systematic sampling during the 1995/96 field season and *ad libitum* sampling from 1984/85 –1996/97. STATISTICA (StatSoft 1994) was used for both parametric and non-parametric analyses. Parametric tests were applied if the residuals were normally distributed.

RESULTS

1995/96 Behavioral Observations

During the 1995/96 austral summer, 304 observations of leopard seals were recorded during 651 hours of observations. Haul out behavior accounted for 47% (n=142) of all leopard seal sightings. Thirty-six percent of the observations were patrols (n=110), 10% chases (n=31) and 7% kill (n=21). All leopard seal predation behaviors observed were timed, but only 2 of the 21 records captured the entire sequence of events from patrol to chase to kill. The times for these two records were 9.20 and 12.15 min. The mean time documented for all partial predation observations was 9.0 ± 11.0 minutes (chase: mean=1.7 ± 1.8 minutes; kill: mean= 6.0 ± 4.0 minutes). Leopard seals kill their prey by violently jerking the bird from side to side above the surface of the water. Mouthfuls of flesh are separated from the penguin carcus for the leopard seal to consume in "jerk-bites" (Müller-Schwarze and Müller-Schwarze 1975). After each jerk-bite, the leopard seal must retrieve the carcus to repeat the process. The mean number of leopard seal jerks-bites documented per kill was 24.0 ± 23.0. Of the penguin prey being chased and/or killed, 16 times the penguin was identified as an Adélie and once as a gentoo. Thirty-two observations were made of leopard seals waiting near ice bergs or pack ice for what appeared to be a surprise attack on incoming penguins. The seabird that most often congregated at kills was the kelp gull which arrived first 15 of the 21 times the event was recorded, followed by cape petrel (10 times), giant petrel (6 times), south polar skua (3 times), brown skua (2 times).

1995/96 Leopard Seal Presence and Correlated Variables

The results of a logistic regression using the dependent variable presence/absence (77 presences and 111 absences) and 4 independent variables (date, time of day, ice condition, and penguin activity) indicated that date (χ^2=9.1, p <0.01) and ice (χ^2=5.7, p=0.02) were the only two independent variables which added significantly to the model (penguin χ^2=0.09, p=0.77; time χ^2=1.08, p=0.29). Maximum likelihood estimation procedures (stepwise selection, forward selection, and backward elimination of best subsets in SAS) and Akaike Index Criteria (AIC) values were used to select the most parsimonious model for the data (Burnham and Anderson 1992). The model that included both date and ice accounted for 31% of the variance in leopard seal presence/absence and had the lowest AIC value (Table 1).

Once the Date + Ice model was chosen, a second best subsets procedure (SAS) was run to include potential interactions between the four independent variables. AIC values were used to rank the models in descending order of preference. The 2-3 variable models selected are presented in Table 2. Comparison of the Date + Ice model with the interaction models concluded that all models (Table 2) were within 2 AIC values of each other (i.e. a 90% confidence interval) and therefore comparable in parsimony and fit (Sakamoto et al. 1986). Correlation matrix graphs depicted the interactions between these variables and indicate that samples were well distributed across all dates and times, and that all types of ice conditions were represented (Appendix).

Table 1. Model selection of independent variables used in logistic regression to predict leopard seal presence in 1995/96. The variable date refers to the day of the austral summer. Ice represents ice coverage in the study area. Penguin refers to the number of penguins censused. Time represents the time of day.

Model	R-square	Variation %	AIC
Date	0.52	26.78	156.20
Ice	0.45	20.65	159.87
Penguin	0.26	6.76	170.46
Time	0.04	0.15	177.12
Date + Ice	0.56	31.14	150.24
Date + Ice + Penguin	0.56	31.32	150.98
Date + Ice + Penguin + Time	0.56	31.33	152.90

Table 2. Best subsets models of independent variables (date, ice, time, penguin) and their interactions obtained from SAS proc logistic for regression of 1995/96 leopard seal presence data.

Model	AIC
Date + Ice(Time)	148.65
Date + Date(Ice)(Time)	149.02
Date + Date(Penguin) + Date(Ice)(Time)	149.93
Date + Date(Ice)	149.98
Date + Ice	150.24
Date + Penguin + Date(Ice)(Time)	150.34
Date + Date(Ice) + Date(Penguin)	150.53

Date

Date explained 26.8% of the variation in the model used to predict leopard seal presence during the 1995/96 austral summer. There was a negative correlation between leopard seal presence and date (Julian calendar 1 =October 1) (Figure 2) indicating leopard seals were more likely to be present earlier in the season than later. Results of a Fisher's exact test indicated that the frequency of 3-hour observation periods in which a leopard seal was present was significantly higher in October (30 of 37 observations) than in any other month ($p<0.01$). Significantly more leopard seals were seen in November than in January or February ($p<0.01$). Leopard seal size also varied with date. In October and November, adult (>age 3) leopard seals (i.e. those with a length of >2.5 m (Laws 1958)) of both sexes were recorded. Smaller individuals were observed in December and January (five leopard seals < 2.5 m were hauled out on 1 December 1995). The sex of leopard seals observed in predation behavior was undetermined.

The number of leopard seal behaviors recorded per 3-hour period also declined from October through February (Table 3). Leopard seals were seen hauled out as well as patrolling and chasing in close proximity to one another during the month of October. On 13 October two leopard seals were observed patrolling side by side (within 3 m of one another) while a third seal was recorded chasing a penguin within 50 m. Twenty-eight adult leopard seals (both male and female) were observed hauled out on ice on 30 October.

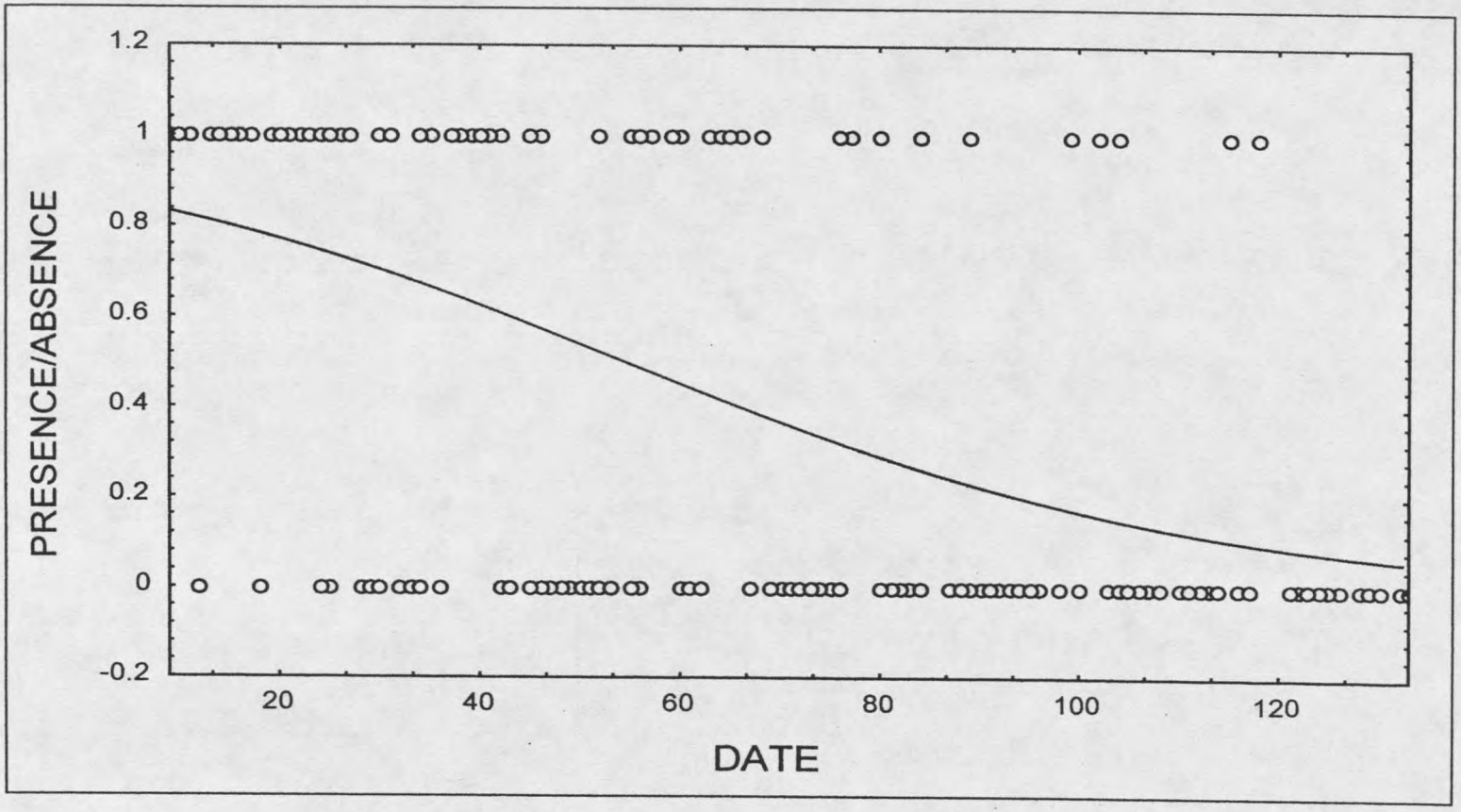

Figure 2. Non-linear estimate of 1995/96 leopard seal presence/absence (1/0) near the Admiralty Bay Rookery and date, or day of season (Julain date 20=October 20, 120=January 28).

Table 3. A summary of 651 hours of leopard seal behavioral observations including the number of observations of each behavior per month and the frequency of behaviors recorded in each 3-hour observation period for the 1995/96 austral summer.

	October		November		December		January		February	
Behavior	N	Freq.	N	Freq.	N	Freq.	N	Freq.	N	Freq.
Haul out	57	1.3	67	1.3	18	0.3	0	0.0	0	0.0
Patrol	71	1.7	10	0.2	17	0.3	11	0.2	1	0.1
Chase	20	0.5	7	0.1	4	0.1	0	0.0	0	0.0
Kill	13	0.3	3	0.1	4	0.1	1	0.0	0	0.0
Total obs.	161	3.8	87	1.7	43	0.8	12	0.2	1	0.1
No.3hr obs. per month	43		52		56		48		18	

Ice Conditions

There was a positive correlation between the extent of ice cover in Admiralty Bay at the time of each observation period and leopard seal presence (Figure 3). Ice condition explained 20.7% of the variation in the model used to predict leopard seal presence. As ice cover increased to fill half of the study area, the likelihood of seeing a leopard seal increased. The mean and range of ice conditions near the penguin rookery were larger in October (mean= 2.3 ± 2.4, range 0-9) and November (mean=2.3 ± 2.7 range 0-9) and then declined in December (mean=0.9 ± 1.4, range 0-5) and January (mean=0.1 ± 0.4, range 0-1), and increased slightly in February (mean= 0.5 ± 0.5, range 0-1).