Pinniped research at Cape Shirreff, Livingston Island, Antarctica, 2008/09

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Abstract Field biologists researched Antarctic fur seals, elephant seals and leopard seals at Cape Shirreff, Livingston Island between 24 October 2008 and 7 March 2009. The results of this field season include:

- The estimated number of total pups born (live plus cumulative dead) for the U.S. AMLR study site in 2008/09 was 1,569 (st. dev. = 4.6). Our count this year represents a 13.3% reduction in pup production over 2007/08.
- An estimated 46.2% of pups were lost to leopard seals by mid-February.
- Most scats, 94.0% (94/100) of those collected, contained krill. In addition, 1,851 otoliths were collected from 34.0% of the scat samples.
- The mean foraging trip duration for attending females' first six trips to sea was 2.70 days (±0,17).

Introduction

As upper trophic level predators, pinnipeds are a conspicuous component of the marine ecosystem around the South Shetland Islands. They respond to spatio-temporal changes in physical and biological oceanography and, in the case of Antarctic fur seals, are directly dependent upon availability of krill (*Euphausia superba*) for maintenance, growth, and reproduction during the austral summer. Because of their current numbers and their pre-exploitation biomass in the Antarctic Peninsula region and Scotia Sea, Antarctic fur seals are recognized to be an important "krill-dependent" upper trophic level predator. The general objectives for U.S. AMLR pinniped research at Cape Shirreff (62°28'S, 60°46'W) are to monitor population demography and trends, reproductive success, and status of pinnipeds throughout the summer months. The Antarctic fur seal, *Arctocephalus gazella*, is the most abundant pinniped at Cape Shirreff and our studies are focused to a large degree on the foraging ecology, diving, foraging range, energetics, diet, and reproductive success of this species.

The 2008/09 field season began with the arrival at Cape Shirreff of a five person field team via the R/V *Laurence M. Gould* on 24 October 2008. Research activities were initiated soon after and continued until closure of the camp on 7 March 2009. Our specific research objectives for the 2008/09 field season were to:

- Monitor Antarctic fur seal female attendance behavior (time at sea foraging and time ashore attending a pup);
- Monitor pup growth collecting mass measures for a random sample of 100 fur seal pups every two weeks throughout the research period, beginning 30 days after the median date of births;
- Document the phenology of fur seal pup production at designated rookeries and estimate total pup production on Cape Shirreff;
- Collect and analyze fur seal scat contents on a weekly basis to document trophic interactions and the timing and incidence of prey switching;
- Collect a milk sample at each adult female fur seal capture for fatty acid signature analysis as an independent non-biased measure of trophic interactions between fur seals and their prey;
- Deploy time-depth recorders on adult female fur seals for diving and at-sea foraging studies;
- Record at-sea foraging locations for adult female fur seals using GPS or ARGOS satellite-linked transmitters (most deployments coincidu with the U.S. AMLR Survey);
- Tag 500 fur seal pups for future demographic studies;
- Re-sight tagged known-aged animals for population demography studies;
- Monitor over-winter survival and natality of the tagged adult female population of fur seals;
- Extract a lower post-canine tooth from tagged adult female fur seals for aging studies;
- Deploy a weather station for continuous recording of wind speed, wind direction, ambient temperature, humidity and barometric pressure during the study period;
- Record any pinnipeds carrying marine debris (i.e., entanglement);
- Record any other tagged pinnipeds observed on the Cape;

- Capture, tag and instrument leopard seals for studies of top-down control of fur seal and penguin populations;
- Monitor pup production of southern elephant seals breeding at Cape Shirreff; and
- Deploy over-winter CTD-PTT instruments on 12 adult female southern elephant seals to monitor temperature and salinity profiles of the Southern Ocean along migration routes and in their foraging areas.

Methods

Female Fur Seal Attendance Behavior

Lactation in otariid females is characterized by a cyclical series of trips to sea and visits to shore to suckle their offspring. The sequential sea/shore cycles are commonly referred to as attendance behavior. Measuring changes in attendance behavior (especially the duration of trips to sea) is one of the standard indicators of a change in the foraging environment and availability of prey resources. Generally, the shorter the duration of trips to sea, the more resources a female can deliver to her pup during the period from birth to weaning.

We instrumented 30 lactating females from 4-13 December 2008. Twenty-nine of these were females with a single pup and one was a female suckling two pups (this female was excluded from estimates of trip duration). The study was conducted according to CCAMLR protocol (CCAMLR Standard Method C1.2 Procedure A) using VHF radio transmitters (Advanced Telemetry Systems, Inc., Model 7PN with a pulse rate of 40 ppm). Standard Method C1.2 calls for monitoring of trip durations for the first six trips to sea. All females were instrumented zero to two days post-partum (determined by the presence of a newborn with an umbilicus) and were left undisturbed for at least their first six trips to sea. Pups were captured at the same time as their mothers, and were weighed, measured, and marked with an identifying bleach mark. The general health and condition of the pups was monitored throughout the study by making daily visual observations. Presence or absence on shore was monitored for each female every 30 minutes for 30 seconds for the first six trips to sea using a remote VHF receiving station with an automated data collection and storage device. Data were downloaded weekly. Daily visual observations of instrumented females were conducted to validate automated data collection and to confirm proper functioning of the remote system.

Fur Seal Pup Growth

Measures of fur seal pup growth were collected every 15 days. At least 50 pups of each sex were weighed for each sample. The first sample of weights were initiated 30 days after the median date of pupping (4 Dec 2008) and the last sample was taken 18 February (four bi-weekly samples; collection dates: 3 Jan, 18 Jan, 2 Feb, and 18 Feb 2009).

Fur Seal Pup Production

Fur seal pups (live and dead) and females were counted by U.S. researchers at four main breeding beaches on the east side of the Cape, which comprise the U.S.-AMLR study site. Censuses for pups (live and dead) were conducted every other day from 2 November through 31 December. Only recently dead pups are counted at each census.

Neonate mortality is defined as pup mortality occurring from the start of the breeding season (~15 Nov) until up to one month after the median date of pupping (6 January). It occurs before the start of leopard seal predation (~early-January). It is measured by recording the number of new pup carcasses on our census beaches at each count and calculating a cumulative mortality every other day (i.e. at each census) from the start of births (this year 15 November) until the last of pupping (early January).

To estimate the extent of leopard seal predation on neonates we calculated the loss of pups from our tagged population of females. We assumed that once pups survived to one month of age, their disappearance was due to leopard seal predation. We included only females whose pup status could be confirmed, excluding female/pup pairs whose status was uncertain.

Diet Studies

Information on fur seal diet was collected using three different sampling methods: collection of scats, enemas, and fatty acid signature analysis of milk. In addition to scats and enemas, an occasional regurgitation is found in female suckling areas. Regurgitations often provide whole prey that is only minimally digested. Scats are collected from around suckling sites of females or from captured animals that defecate while captive. In addition to diet information from captive animals, ten scats were collected opportunistically from female suckling sites every week beginning 18 December. The weekly scat samples are collected by systematically walking transects of female suckling areas and collecting any fresh scats within a short range

of the observer. This method prevents any bias associated with the difference in visibility between krill laden scats, which are bright pink, and fish laden scats, which are gray to brown, and blend in with the substrate more easily.

In total, we collected and processed 100 scats from 18 December 2008 through 23 February 2009. Diet samples that could not be processed within 24 hours of collection were frozen. All samples were processed by 26 February. Up to 25 krill carapaces were measured from each sample that contained krill. A total of 2,267 krill carapaces were measured according to Goebel et al. 2007. Discriminant equations determined sex and age class, after which independent regression equations for juvenile, male and female lengths were applied. Otoliths were sorted, dried, and identified to species. Squid beaks were counted and preserved in 70% alcohol for later identification.

Fatty Acid Signature Analysis of Milk

In addition to scats, we collected 90 milk samples from 60 female fur seals. Each time a female was captured (either to instrument or to remove instruments), ≤30 mL of milk was collected by manual expression. Prior to collection of the milk sample, an intra-muscular injection of oxytocin (0.25 mL, 10 UI/mL) was administered. Milk was returned (within several hours) to the lab where two 0.25 mL aliquots were collected and each stored in a solvent-rinsed glass tube with 2 mL of chloroform with 0.01% butylated hydroxytoluene (BHT, an antioxidant). Samples were flushed with nitrogen, sealed, and stored frozen until later extraction of lipid and trans-esterification of fatty acids.

Diving Studies

Nine of 29 females outfitted with transmitters for attendance studies also received a time-depth recorder (TDR, Wildlife Computers Inc., Mark 9s, 66 x 18 x 18mm, 31g, N=7; Mk-10: N=2) on their first visit to shore. All females carried their TDRs for at least their first six trips to sea. In addition, three more females captured for studies of at-sea foraging locations in December brought the total number of females with GPS-TDRs or ARGOS PTTs to 11. A total of 20 dive records were collected from 18 females in 2008/09. No TDRs were lost this season.

Adult Female Foraging Locations

We instrumented 11 females with GPS (Global Positioning System) TDRs (Mk10-F; Wildlife Computers, Inc.) with fast-loc technology. Three females carried both an Mk10-F and an ARGOS satellite-linked transmitter (SPOT5; Wildlife Computers, Inc.). The first five of these deployments were from 18 December – 27 January.

Demography and Tagging

We tagged 500 fur seal pups (259 females, 239 males, two unknown) from 2 February to 1 March 2009. All tags used at Cape Shirreff were Dalton Jumbo Roto or Flexi tags with white tops and orange bottoms. Each pup was tagged on both fore-flippers with identical numbers. Series numbers for 2008/09 were 6001-6500 (the sex for tags 6140 and 6224 was recorded as uncertain).

In addition to the 500 pups tagged, we also added fourteen new tags to the adult female population (432-445).

Age Determination Studies

We began an effort of tooth extraction from adult female fur seals for age determination in 1999/00. Tooth extractions are made using gas anesthesia (isoflurane, 2.5-5.0%), oxygen (4-10 liters/min), and midazolam hydrochloride (1cc). A detailed description of the procedure was presented in the 1999/00 annual report. This year we took a single post-canine tooth from 16 adult females.

Weather at Cape Shirreff

A weather data recorder (Davis Weather Monitor II) was set up at the U.S.-AMLR field camp at Cape Shirreff from 26 October 2008 to 28 February 2009. The recorder archived wind speed and direction, barometric pressure, temperature, humidity, and rainfall at 15-minute intervals. The sampling rate for wind speed, temperature, and humidity was every eight seconds; the averaged value for each 15-minute interval was stored in memory. Barometric pressure was measured once at each 15-minute interval and stored. When wind speed was greater than 0, the wind direction for each 8-second interval was stored in one of 16 bins corresponding to the 16 compass points. At the end of the 15-minute archive interval, the most frequent wind direction was stored in memory.

Entangled pinnipeds

We recorded one adult male fur seal with marine debris around its neck. The debris was identified as plastic line. Attempts to remove the debris failed.

Other pinnipeds: leopard seals

To better understand the role of Leopard seals within the region and their influence on krill-dependent predators we began a study of foraging range and dispersal. In 2008/09, we captured and instrumented two Leopard seals with Mk9 time depth recorders (Wildlife Computers. One of the two was successfully retrieved without recapture and had recorded over a month of diving behavior. No leopard seals were instrumented with ARGOS PTTs (Platform Terminal Transmitter) in 2008/09.

Other pinnipeds: Southern elephant seals

U.S. AMLR, in collaboration with University of California researchers, instrumented 12 adult female elephant

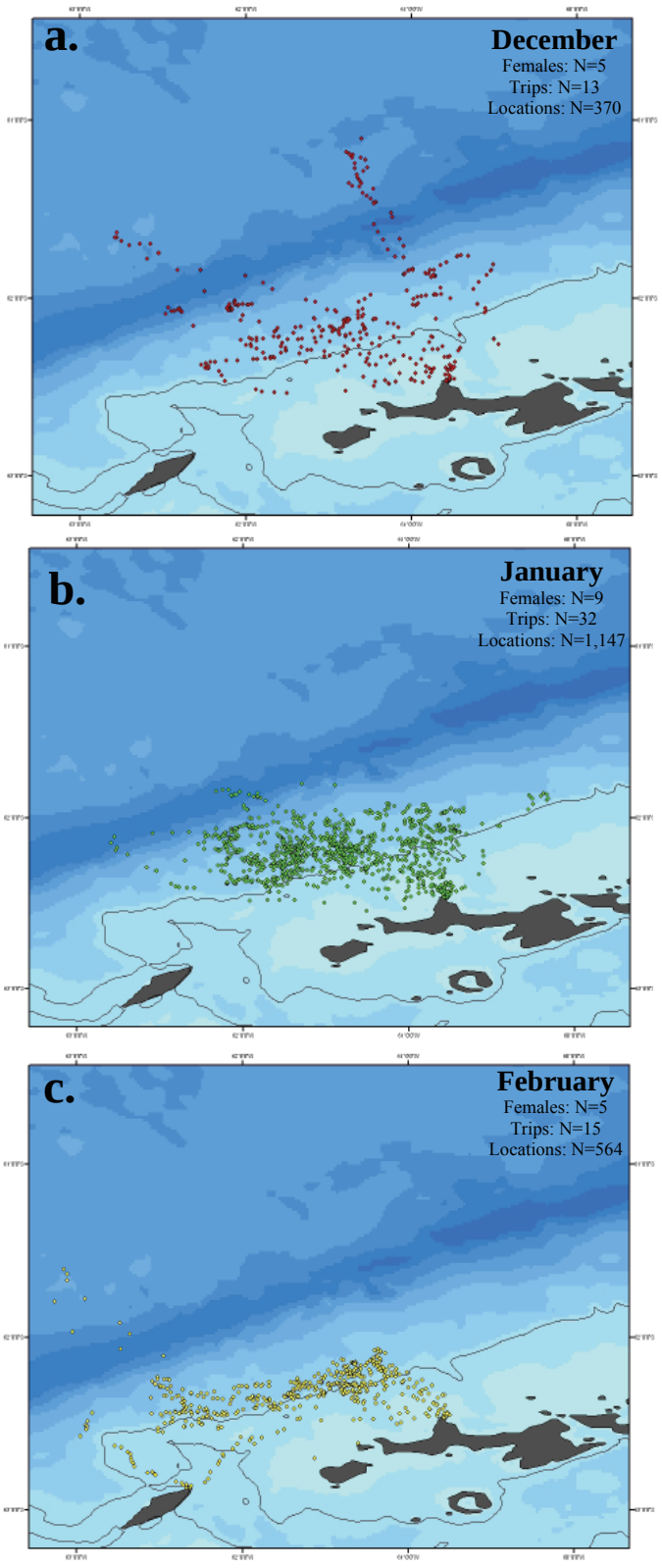

Figure. 7.1. At-sea locations of lactating Antarctic fur seals in a) December (red), b) January (green), and c) February (yellow) foraging from Cape Shirreff, Livingston Island, South Shetland Islands, 2008/09. The 500 m bathymetry is outlined to show the location of the continental shelf edge.

seals with ARGOS satellite-linked CTD-PTT transmitters for post-molt dispersal at sea. In addition, U.S. AMLR personnel captured and weighed 33 elephant seal pups within 48 hours of weaning. A total of 34 pups were born on Cape Shirreff (33 live, one dead) and an additional six were born on a small sandy point between Cape Shirreff and Punta Oeste. Thirty-one of the 39 pups sexed were male.

Results

A total of 53 trips to sea were recorded with GPS and ARGOS instruments for three sampling periods (December, January, February) in 2008/09. The tracklines of those trips are in the process of being analyzed, and can be seen in Figure 7.1.

The first female in our study to begin her foraging cycles did so on 10 December. All females had completed six trips to sea by 24 January. Four females lost their pups before completion of six trips to sea. The mean trip duration for the first six trips to sea was 2.70 days (±0.17, NFemales=29, NTrips=168, range: 0.33-5.35). There was no significant difference in duration for the first six trips (ANOVA: $F_{5,165}=0.32$, $P=0.899$; Figure 7.2). The mean duration for the first six non-perinatal visits was 1.70 days (±0.12, NFemales=29, NVisits=163, range: 0.35-4.08 days; Figure 7.1).

Ten of the 29 females in our sample size also carried time-depth recorders (Wildlife Computers, Redmond, WA; Mk9: N=8; Mk10: N=2). There was no significant difference in trip duration between females instrumented with only a VHF transmitter and those instrumented with a VHF-TDR pair of instruments (ANOVA: $F_{1,166}=0.13$, $P=0.72$).

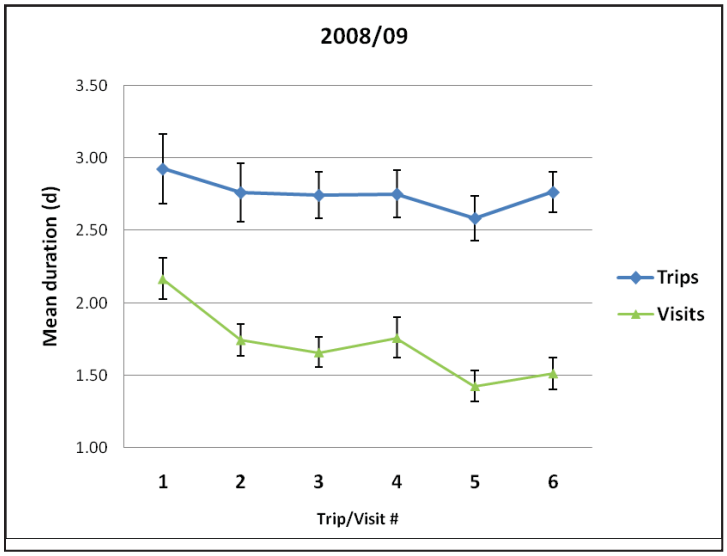

Figure 7.2. Antarctic fur seal mean trip and visit duration (with standard error) for females rearing pups at Cape Shirreff, Livingston Island. Data plotted are for the first six trips to sea and the first six non-perinatal visits following parturition.

The estimated number of total pups born (live plus cumulative dead) for the combined four beaches in 2008/09 was 1,569 (st.dev: 4.6; based on counts by three observers). Our count this year represents a 13.3% reduction in pup production over 2007/08. The median date of parturition was 4 December (two days earlier than last year). Throughout the season male fur seal pups grew, on average, 104.3g per day. Females grew 85.6g per day (Figure 7.3). Neonate mortality was 3.04%, a decrease over last year (4.2 %); The long-term average (based on ten years of data, 1998-2008), is 4.5% ±0.60.

Our estimate of pup mortality due to leopard seal predation, calculated 24 February, 82 days after the median date of pupping, was based on daily tag resights of adult females. By that date, 46.2% of pups were lost to leopard seals.

Our diet study this year showed that most scats, 94.0%

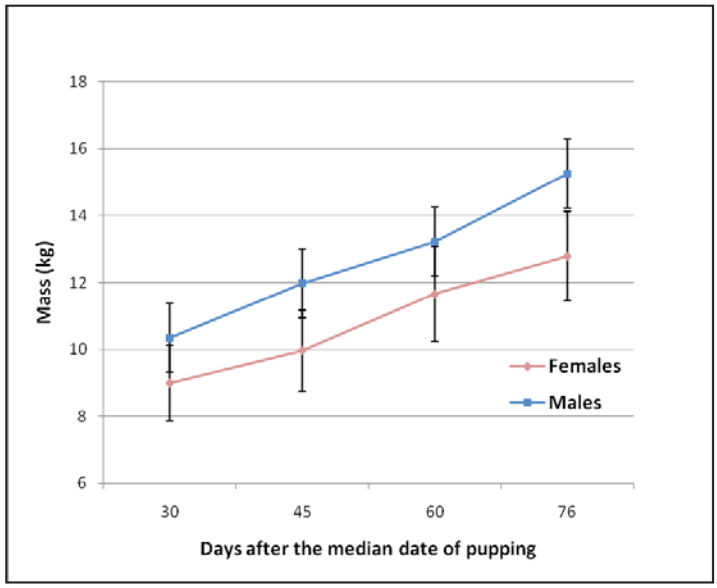

Figure 7.3. Antarctic fur seal pup growth. Four samples of pup weights were collected, every two weeks beginning 30 days after the median date of pupping (4 Dec 2008). Sample sizes were 64, 52, 53, and 49 for males and 48, 49, 47, and 51 for females.

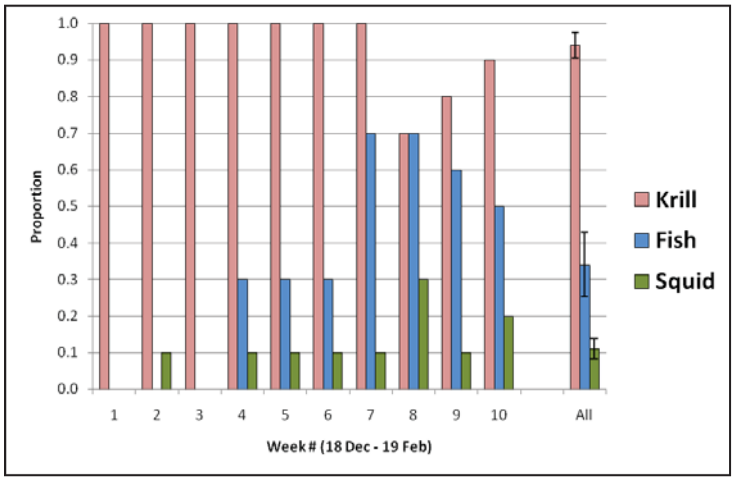

Figure 7.5. The weekly proportions of three types of prey in Antarctic fur seal diet 18 December – February 19 2009. The last series of histogram bars are the season average plotted with standard error. Most fish otoliths (87.2%; 1,614/1,851) recovered from fur seal scats in 2008/09 were from two species of myctophid fish (*Electrona antarctica*, N=201 and *Gymnoscopelus nicholsi*, N=1413). No *Electrona carlsbergi* otoliths were collected from any scats in 2008/09.

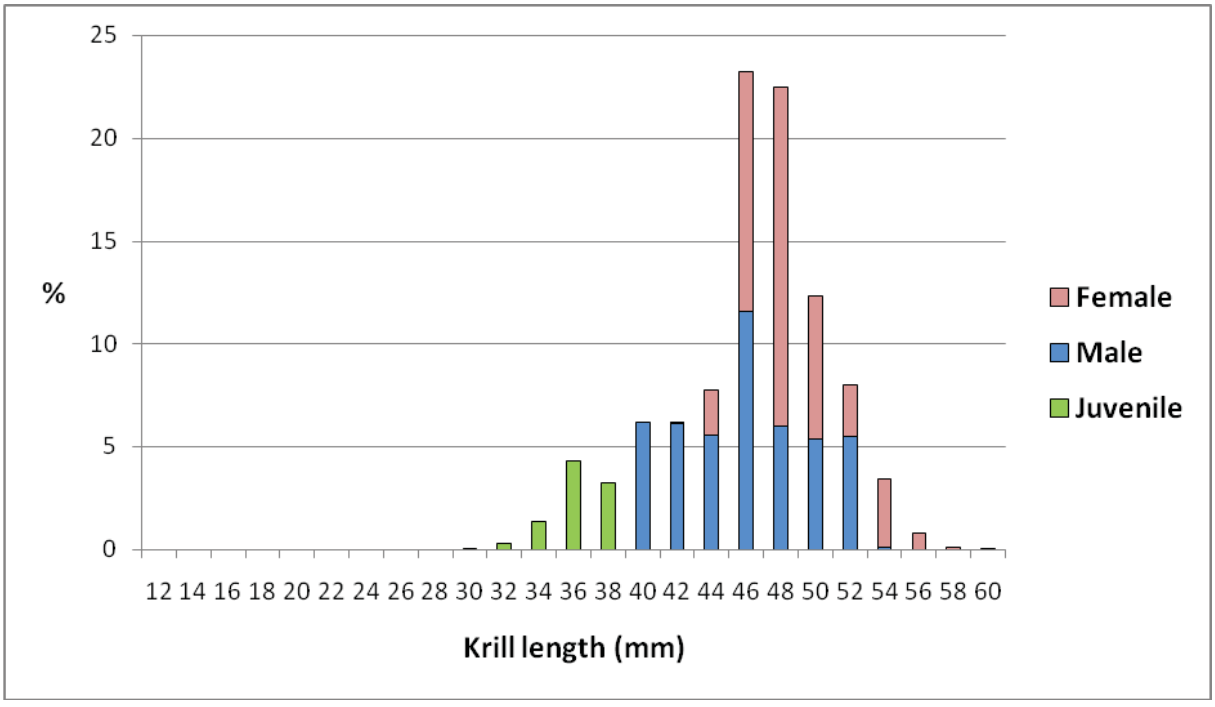

Figure 7.4. Krill length distribution in Antarctic fur seal diet from measures of 2,267 carapaces collected from fur seal scats. Data are derived by sampling 25 krill carapaces from each scat, measuring length and width, applying a discriminant function and independent regression equations for calculating total length of krill. A first order smoothing function is applied to two millimeter length bins.

(94/100) of those collected, contained krill. In addition, 1,851 otoliths were collected from 34.0% of the scats collected. As in previous years the incidence of fish in fur seal diet increased over the 10-week sampling period from 18 December to 19 February (Figure 7.5). Mean total length of krill in the fur seal diet was 46.5 mm (st.dev. ±4.45, N=2267). Juveniles comprised 8.6% of the sample (Figure 7.4) and the male:female sex ratio was 1.05. Most (87.2%, 1,614 otoliths) were from two species of myctophid fish (*Electrona antarctica*, n=201 and *Gymnoscopelus nicholsi*, n=1,413); an additional 3.7% (n=69) were eroded and unidentified otoliths. A total of 113 squid beaks (preliminary ID: *Brachioteuthis picta*) were collected from 11.0% of the scats.

Discussion

Fur seal pup production in 2008/09 at U.S. AMLR study beaches showed a decline (13%) over the previous year. This is the second year of double digit decline in pup production. The decline suggests poor environmental conditions overwinter or soon after weaning in 2008. However, the summer environment appeared to be one of the more favorable seasons for female foraging and reproductive success. Early season neonate mortality (3.0%) was lower than the long-term average of 4.5%. The median date of pupping, based on pup counts, was two days earlier than last year and the earliest on record. The mean foraging trip duration (2.7 days ±0.17) was one of the shortest mean trip durations on record and a day shorter than the long-term mean (3.8 days ±0.36; 1998-2008). Diet studies of fur seals indicated a high proportion of krill, especially in December and early January. The krill measured in fur seal diet indicated a bi-modal distribution with 8.6% juvenile krill and a second mode at 46 mm. No *Electrona carlsbergi* were recorded in fur seal diet this year. In general, winter conditions were less favorable compared to previous years but indices reflecting summer conditions were above average resulting in good predator performance.

During the summer months (Nov-Feb, the only months of human occupation of Cape Shirreff) leopard seals are frequently observed hauling out on beaches around Cape Shirreff and preying on fur seal pups and penguins. Our measures of fur seal neonate mortality extend only to the end of pupping (early January). In most years, neonate mortality experiences a peak during the perinatal period or soon after females begin their trips to sea. However, another peak in pup mortality occurs later, when young, inexperienced pups enter the water for the first time around one month of age and become vulnerable to leopard seal predation. Since remains are rare, evidence of this type of mortality is more difficult to quantify. However, we estimate that during January and February, leopard seals consume as much as half of all fur seal pups born on the Cape. Leopard seal predation is significant and may be an important top-down factor controlling recovery of fur seal populations (Boveng et al., 1998) as well as penguins populations, in the South Shetland Islands.

Protocol Deviations

Measures of fur seal pup growth were collected according to CCAMLR protocol (CEMP Standard Method C2.2 Procedure B) with the exception of weights being sampled every 15 days instead of every 30 days.

Disposition of Data

All raw and summarized data are available from Mike Goebbel at the Antarctic Ecosystem Research Division of the National Marine Fisheries Service, Southwest Fisheries Science Center, 3333 N. Torrey Pines Ct., La Jolla, CA 92037.

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UNITED STATES
AMLR ANTARCTIC MARINE LIVING RESOURCES PROGRAM

AMLR 2008/2009 FIELD SEASON REPORT

Objectives, Accomplishments and Tentative Conclusions

Edited by
Amy M. Van Cise

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