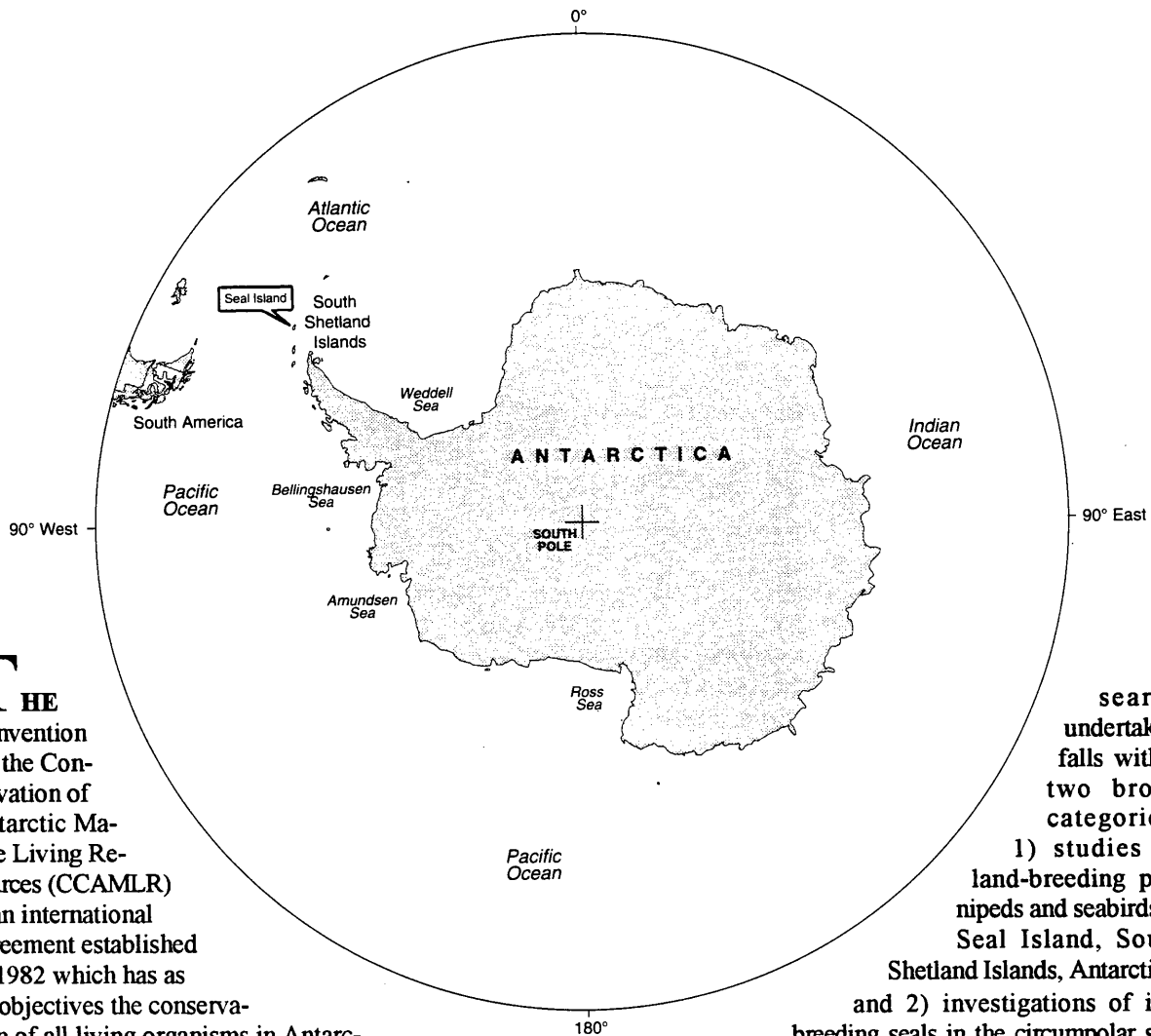


# INVESTIGATIONS OF ANTARCTIC LIVING MARINE RESOURCES

By John Bengtson



**T**HE Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) is an international agreement established in 1982 which has as its objectives the conservation of all living organisms in Antarctic waters and the maintenance of their ecological relationships. The National Marine Mammal Laboratory's (NMML) Antarctic Ecosystems Program has conducted pinniped and seabird research over the past 9 years as part of the CCAMLR Ecosystem Monitoring Program (CEMP). The underlying objectives of NMML's research have been to determine what factors are primarily responsible for influencing the population dynamics of Antarctic pinnipeds and seabirds, to detect significant changes in key components of the Southern Ocean ecosystem, and to distinguish between changes due to commercial fisheries and those due to natural causes. An important aspect of this work has focused on understanding the relationships among upper trophic level predators such as pinnipeds and seabirds, their prey, and environmental conditions. Re-

search undertaken falls within two broad categories: 1) studies of land-breeding pinnipeds and seabirds at Seal Island, South Shetland Islands, Antarctica; and 2) investigations of ice-breeding seals in the circumpolar sea-ice zone.

## Seal Island Research

To date, nine field seasons have been completed at the National Oceanic and Atmospheric Administration's (NOAA) research site at Seal Island (lat. 60°59'14"S, long. 55°23'04"W) since the 1986-87 austral summer. Major objectives of Seal Island research activities, conducted annually from early December to mid-March, have been

1. To assess long-term trends in pup growth rates and attendance patterns ashore of adult female Antarctic

fur seals (*Arctocephalus gazella*) according to CEMP protocols;

2. To conduct directed research on fur seal pup production, foraging behavior, diet, abundance, survival, and recruitment;

3. To evaluate long-term patterns in the breeding success, reproductive chronology, foraging behavior, chick diet, abundance, survival, recruitment, and fledging size of chinstrap penguins (*Pygoscelis antarctica*) and macaroni penguins (*Eudyptes chrysolophus*) according to CEMP protocols;

4. To conduct directed research on penguin chick growth and condition, seasonal patterns in diving behavior, and changes in foraging patterns throughout the breeding season; and

5. To investigate the relationships among seabirds' and pinnipeds' performance (behavior and vital rates), prey availability, and environmental features.

## Antarctic Fur Seals

Daily censuses are made of tagged juvenile and adult seals and of pups of the year. These counts provide a record of the reproductive history of adult females, pup production, and age-specific survival rates in each field season. Approximately 299 Antarctic fur seal pups were born on Seal Island during the 1993-94 season, an increase of 20% since observations began in 1986-87. The pup counts also provide insight into preweaning mortality rates. Predation of fur seal pups by leopard seals (*Hydrurga leptonyx*) is a major source of pup mortality at Seal Island, with as many as 50% of pups killed prior to weaning. During each sampling period, an attempt is made to weigh at least 100 fur seal pups. Pups are weighed at approximately 14-day intervals from late December to late February. The sex of weighed pups is recorded as part of a study evaluating the differential growth rates of male and female pups, which vary from year to year.

During their 4-month lactation period, female Antarctic fur seals make a series of feeding trips to sea, returning to shore between each trip to suckle their pups for 1-2 days. The attendance of 40 lactating fur seals on the rookery beach is monitored continuously during this time via radio transmitters attached to the seals and an automated radio reception/data-logging system. An attempt is made to monitor instrumented female fur seals for at least their first six feeding trips to sea. The radio

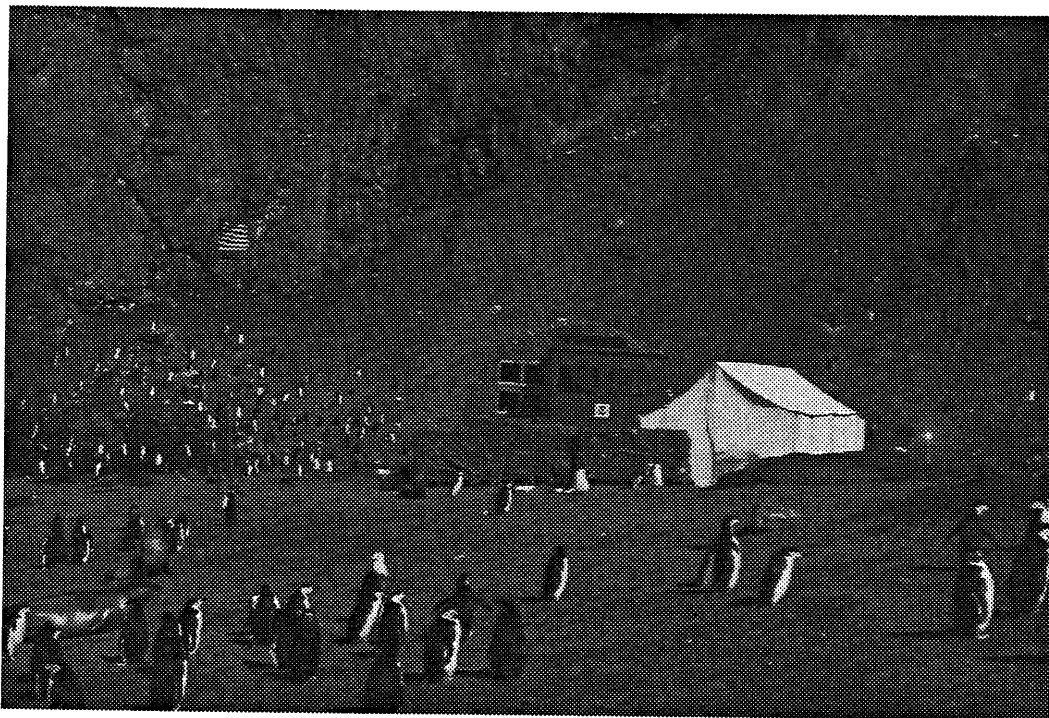
transmitters also enable determining the locations of fur seals' offshore foraging areas. Research vessels equipped with directional radio antennae are used to follow the seals when they go to sea to forage. Satellite-linked transmitters were deployed in the 1994-95 season in cooperation with Japanese scientists. Such studies have been successful in evaluating the interannual variability of fur seal foraging areas in relation to changing prey distribution and environmental features.

About 15 female fur seals in the foraging trip/attendance studies are also instrumented annually with time-depth recorders (TDRs) to document diving behavior as a measure of foraging effort expended at sea. Details of seals' diving behavior (e.g., dive depth and diel foraging pattern) are collected in conjunction with fine-scale hydro-acoustic surveys that are conducted offshore Seal Island by the NOAA research ship *Surveyor*, which allows subsequent comparisons of fur seal dive profiles and the horizontal and vertical distribution of Antarctic krill (*Euphausia superba*).

## Seabirds

Several census protocols have been established at Seal Island to monitor the intra- and interannual trends in the penguin nesting population, egg and chick production, and survival of offspring. More than 20,000 chinstrap penguins nest at Seal Island in most years. The island's breeding colonies of macaroni penguins (299 nests in 1993-94) reflect a small population near the southern extent of the species range. Following the Standard Methods established by CEMP, selected study colonies of both species are routinely observed to provide various measures of reproductive effort and success (e.g., daily checks of marked nests to assess the survival of eggs and chicks throughout the nesting season). The chronology of reproductive events is also monitored so that annual indices of reproduction and foraging can be standardized by time in the breeding season.

Samples of chinstrap chicks are weighed weekly to provide an index of growth rates from hatching through fledging, at which time daily samples of fledged chicks are weighed as they loiter on the beaches prior to their departure to sea. Comparison of weights among years gives an indication of the condition of chicks in relation to the relative abundance of prey in offshore foraging areas. Chick diet samples are obtained every 5 days by capturing and lavaging adults returning to the colony to feed their chicks. The food items regurgitated by the adults are preserved for detailed analyses of characteristics of prey fed to chicks. Krill is the major prey



The main camp at NOAA's research site at Seal Island, Antarctica, with chinstrap penguins and a Weddell seal and an Antarctic fur seal (on the left).

species evident from stomach lavaging at Seal Island. However, evidence of fish prey is often present in diet samples taken from birds returning from nocturnal feeding trips. For example, in 1992-93, 60% of the samples taken from nocturnal/early morning foragers ( $n = 15$ ) contained fish in addition to krill. In contrast, only 10% of the lavage samples taken from diurnal foragers ( $n = 20$ ) had evidence of fish.

Researchers monitor the duration of foraging trips of 40 chinstrap penguin adults fitted with radio transmitters to determine the amount of time at sea required by breeding adults to meet the energetic needs for themselves and for their chicks. This research provides information on trends in trip duration both within and between various seasons. In addition, TDRs are deployed on 40-50 chinstrap penguins to obtain detailed information on their diving behavior and foraging effort at sea.

### Pack-Ice Seal Research

Research in the sea-ice zone is conducted to complement land-based studies at Seal Island. The principal focus for these investigations is crabeater seals (*Lobodon carcinophagus*) and leopard seals, but complementary studies on Weddell seals (*Leptonychotes weddelli*) and Ross seals (*Ommatophoca rossii*) are conducted when

possible. The main objectives of pack-ice seal research are

1. To survey pack-ice seal abundance and distribution,
2. To monitor crabeater seal habitat use and seasonal movements,
3. To investigate seasonal changes in crabeater seal diving and feeding behavior,
4. To assess crabeater seal haulout patterns,
5. To evaluate the genetic discreteness of pack-ice seal populations,
6. To compare evidence of the presence of various diseases in ice seals from different areas, and
7. To determine long-term reproductive and demographic patterns.

Satellite telemetry is successfully utilized to assess the seasonal movements, habitat use, foraging behavior, and activity patterns of crabeater seals in the Weddell Sea and along the Antarctic Peninsula. Data on the seals' activity patterns, dive characteristics, and geo-



A colony of macaroni penguins at the North Cove study area.

graphic location are relayed via the ARGOS system aboard NOAA's polar-orbiting satellites for up to 10 months to provide data on seasonal changes in seal behavior and distribution.

Aerial surveys for pack-ice seal abundance and distribution will be conducted in February and March 1995 as line transect surveys flown from helicopters operating from a U. S. Coast Guard ice-breaker. Census observations also will be made from the ship when aerial surveys are not possible. Such surveys will be used to evaluate the extent to which ice type, proximity to the marginal sea-ice zone, and bathymetric features affect pack-ice seal distribution. Data on seal haulout patterns made possible by satellite telemetry will allow correcting estimates of seal abundance derived from aerial counts; haulout data allow estimating the proportion of seals that were not seen because they were not hauled out on sea ice during the surveys.

Specimen material from scientific and commercial collections of crabeater seals provides an excellent source of data on reproductive and demographic patterns. Data and specimens from a variety of sources (the United States, the United Kingdom, Russia, Nor-

way, and Sweden) have been compiled over the past 25 years into an integrated database at the NMML. Information on seals' reproductive status (reproductive tracts) and age structure (teeth) has revealed inter-decadal changes in the status of crabeater seal populations; analyses of this important database is continuing.

### Program Support

Research conducted through NMML's Antarctic Ecosystems Program has been supported by NOAA's National Marine Fisheries Service as part of its Antarctic Marine Living Resources (AMLR) Program, which is administered by the Southwest Fisheries Science Center. Following the conclusion of the 1994-95 field season, responsibility for the research on land-breeding pinnipeds and seabirds will be transferred to the Southwest Fisheries Science Center. The National Science Foundation's Office of Polar Programs has also provided support, particularly for pack-ice seal research. Early-season transportation of the Seal Island field team to its research site has been provided by the Antarctic tour operators Society Expeditions and Abercrombie and Kent.