STUDIES OF THE EFFECTS OF NET FRAGMENT ENTANGLEMENT ON NORTHERN FUR SEALS PART 1: DAILY ACTIVITY PATTERNS OF ENTANGLED AND NONENTANGLED FUR SEALS

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ABSTRACT

Effects of net fragment entanglement on the behavior of fur seals were examined using radio telemetry. Radio transmitters were attached to three fur seals 5-8 years old kept in an aquarium. Two of the seals were entangled with 1- and 2-kg fishing net fragments, respectively, around their necks. Using radio telemetry, their activity patterns were recorded for 36 days, from 28 January to 4 March 1985. The seal entangled with the 2-kg net showed the shortest active time per day and the nonentangled seal showed the longest. Active time of the entangled individuals increased after removal of the nets. It becamed clear that the active time of fur seals was diminished by entanglement in net fragments.

INTRODUCTION

It has been reported that some northern fur seal, *Callorhinus ursinus*, returning to breeding islands were entangled in marine debris such as fishing net fragments and packing bands (Scordino 1985). The fur seal population of the Pribilof Islands declined to less than half of its 1940's peak, and mortality due to entanglement is suspected as a major cause of the population decline (Fowler 1982). In what period and at what rate do entangled fur seals die? This issue was examined through tag and resighting surveys of entangled fur seals on St. Paul Island (Bengtson et al. 1988; Scordino et al. 1988). The survival period of entangled animals is considered to vary according to the damage caused by entanglement. There have been only a few reports about the effects of net fragments on fur seals (Feldkamp et al. 1987). This study was intended to examine the effects of entanglement on activity patterns of fur seals using radio telemetry.

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MATERIALS AND METHODS

Experimental Fur Seals and Radio Equipment

The three female fur seals used in the experiment were captured off Joban coast, north Japan, between 4 and 9 March 1982, and had been kept in captivity for 3 years. The estimated ages of the animals were 5-8 years and body weights were 29.5-36.0 kg at the beginning of the experiment (Table 1). The experiment was conducted in an aquarium, Izu-Mito Sea Paradise, Numazu, central Japan, where the animals were kept.

A radio transmitter and trawl net fragments were attached to the seals on 28 January 1985. Of the three, one (referred to hereafter as N0) was loaded only with a transmitter. A transmitter and a 1-kg net fragment were attached to one of the remaining two (N1), and a transmitter and 2-kg net fragments to the other (N2). Trawl nets used in the experiments were those commonly used in commercial fishing; they were made of polyethylene with a twine size of 3.4 mm and a mesh size of 24 cm. The transmitter was cylindrical in shape, 35 mm in diameter, 155 mm long, and 200 g in atmospheric weight. It had a life of about 6 months (Fig. 1). Receivers and recorders were installed in an observation room near the experimental area (Fig. 2).

The transmitter was attached with a harness made of nylon webbing belts sewn together with colored tapes for individual recognition. Immediately after attachment of the transmitter and net fragments, the animals were released into the experimental area (Fig. 2). The experimental area, made by partitioning an inlet with nets, was about 1,400 m^2 and had a natural beach. The deepest part at high tide was about 7 m; there was a tidal range of about 1.5 m. The sea was calm throughout the year. In addition to the three experimental seals, 33 other fur seals were kept in captivity in this area. Activities of N0 were recorded continuously from 4 February to 4 March. Activities of N1 and N2, entangled in net fragments, were recorded from 28 January to 26 February. The nets were intentionally removed on 27 February and their activities without nets were recorded from 28 February to 4 March.

During the entire period, behavior and health of the experimental individuals were checked carefully at a regular time each day. Moreover, in order to compare actual movements with radio records, behavior of the three animals was observed visually several times a day for 4-5 h each time.

During the experiment, fur seals were fed with defrosted mackerel in the amount of 1-4 kg (an average of 2.44 kg) per day at 1000 and 1630 on the beach. At each feeding, food was provided first to each experimental individual, and later to the herd in general.

Weather observations were made around 1400 each day. The average air temperature during the experiment period was 10.2°C (ranging from 6.0° to 18.0°C), with average water temperature at 13.3°C (between 11.1° and 15.8°C) and average humidity at 63.1% (from 38 to 88%).

Table 1.--Information on the three fur seals used in the experiment.

Seal		Capture			Age and size at start of experiment		
			Location				
ID	Sex	Date 1982	Latitude	Longitude	Estimated age (year)	Body length (cm)	Body weight (kg)
N0	F	9 March	36°30'N	141°16'E	6	123	29.5
N1	F	4 March	36°42'N	141°15'E	8	123	36.0
N2	F	8 March	36°26'N	141°06'E	5	120	33.0

Analysis of Activity Records

Figure 3 shows an example of the activity records of a fur seal wearing a telemetry device. Records representing the activity of the animals are called "actograms." Waves in the figure indicate changes in intensity of electric signals due to movement of the animals. When an animal with a transmitter was on land, a continuous wave form was observed (Fig. 3A); movements of the animal on land could be recognized as fluctuations of wave form on the recording paper. The period in which the wave form was fluctuating was defined as active time on land. When the transmitter-loaded animal was in the water and dived, no signal could be received because electric waves are greatly attenuated in seawater. The recording pen then moved straight along the baseline. When the animal emerged, a sharply pointed line was recorded on the paper, corresponding to the abrupt rise of electric wave intensity. Thus, actograms for the animal moving at the sea surface showed a pectinate wave form (Fig. 3B). When the seal was resting at sea, either a flat line or a baseline could be recorded. The former means that the animal was resting with her back upward, and the latter, resting with her back under water. Therefore, the fluctuating wave form indicates activity ashore, and the pectinate wave form indicates activity at sea. We measured the length of such "active" periods in each actogram and calculated the active time and resting time in a day.

RESULTS

General Behavior

During the experiment period, other fur seals did not exhibit special behavior such as avoiding or threatening the transmitter-loaded animals or approaching them with curiosity. The fur seals with transmitters were always within the herd.

Differences in the general behavior of the three fur seals were recognized by visual observation. For several days after the experiment began, N1 and N2 tried to get rid of the attached net fragments by shaking their necks. Seal N2 moved slowly and chiefly engaged in slow swimming or

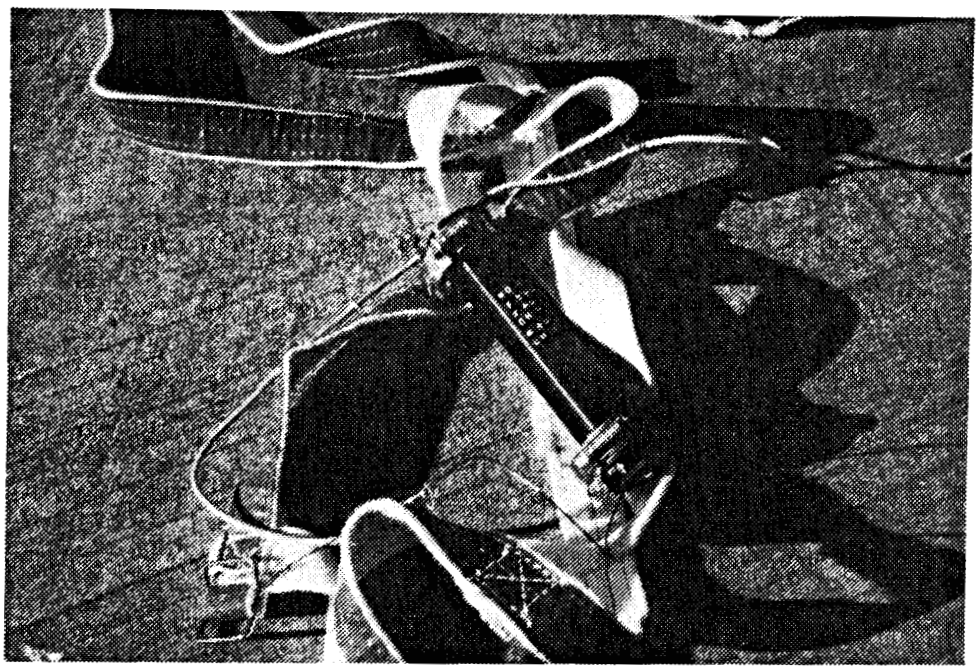


Figure 1.--A transmitter and harness.

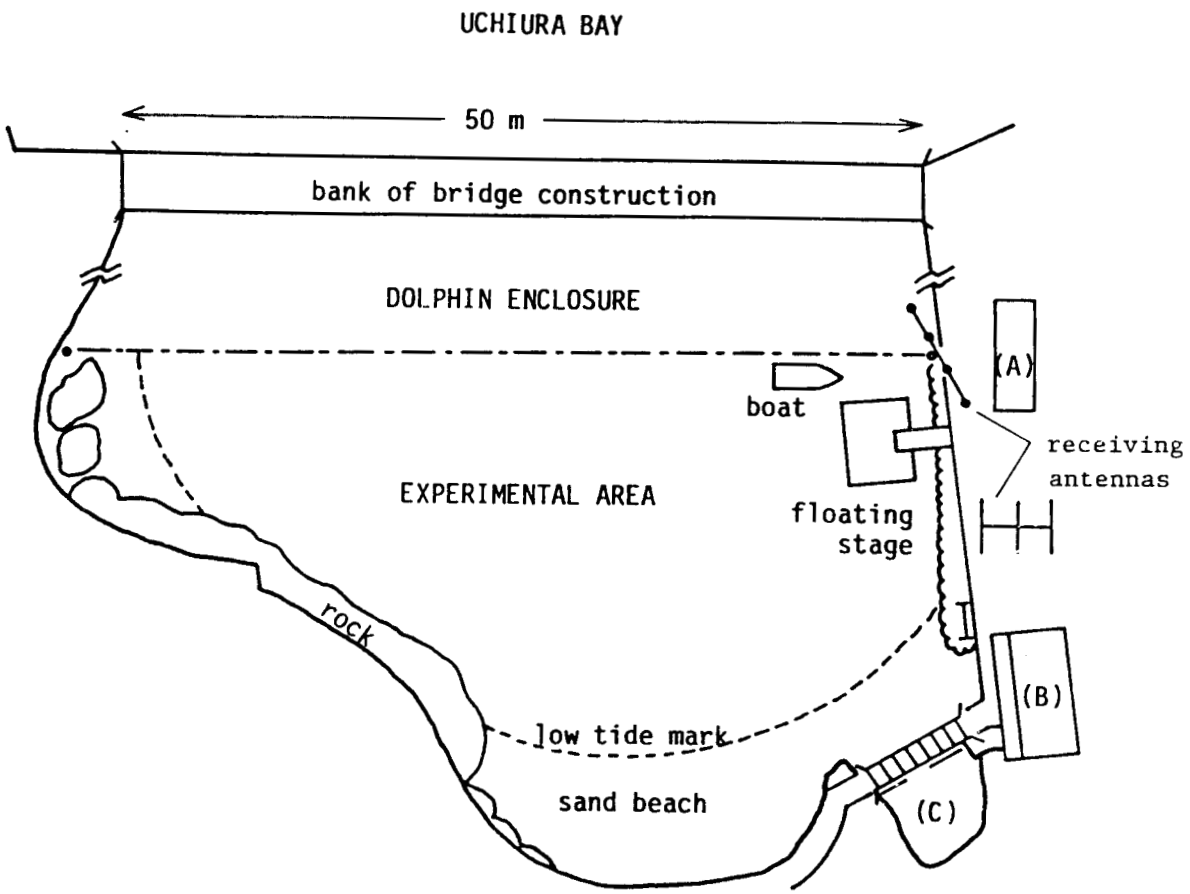


Figure 2.--Map showing the experimental area. A. Observatory where receiving instruments were settled. B. Indoor breeding facility. C. Partitioned section where transmitters were attached.

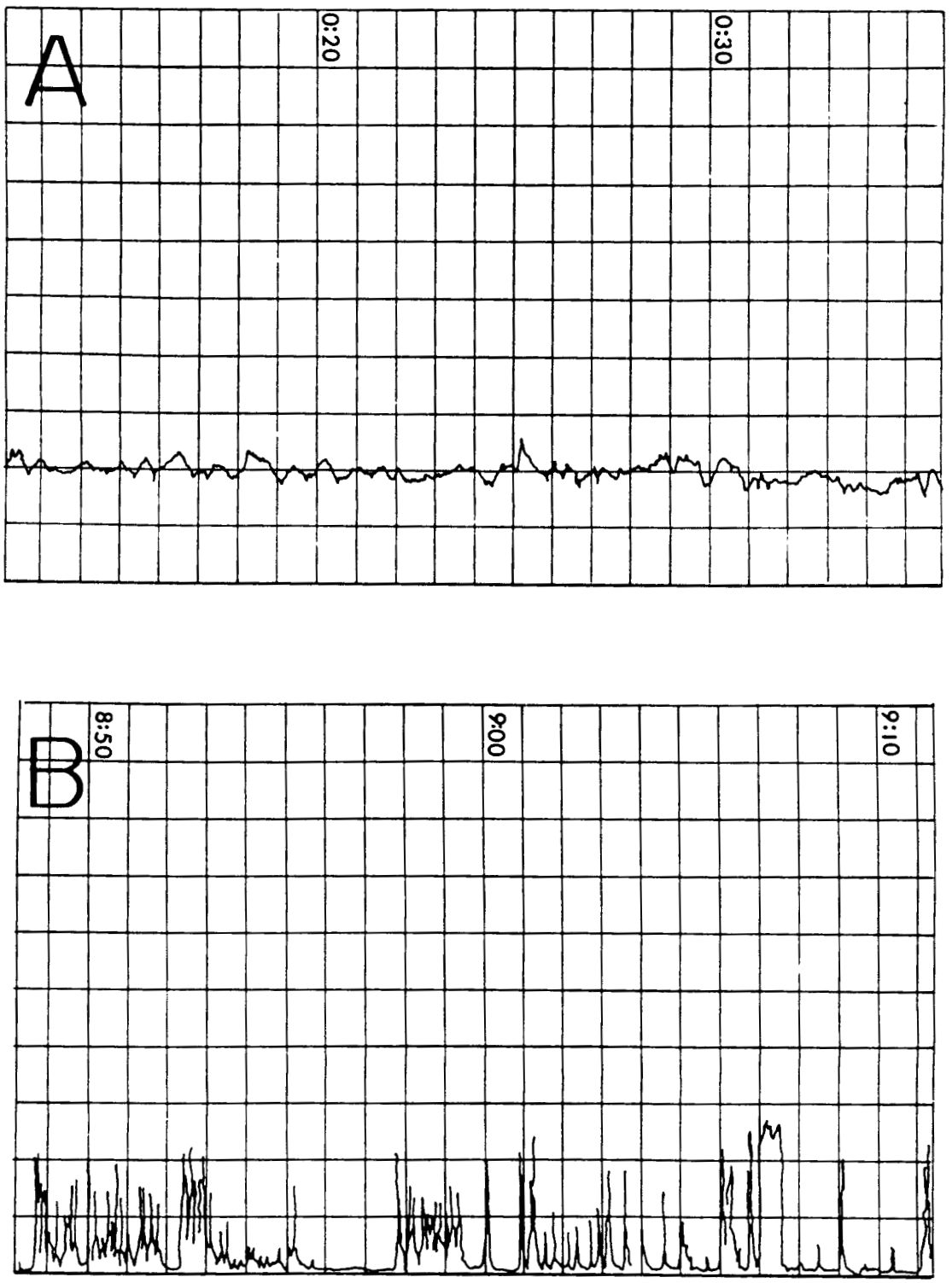


Figure 3.--Actograms, received electronic waves representing the activity of animals. A. Resting on land. B. Swimming at sea.

grooming. Dives and headstands in water, often seen in free-swimming seals, were not observed for N2. Seal N1 moved more smoothly than N2. Sometimes N2 made shallow dives or underwater headstands, but she made no extended deep dives. Seal N0's movements were very smooth and did not differ from those of individuals without transmitters.

For several days after the start of the experiment, N1 and N2 did not draw near to men even at feeding time. Later they approached the feeder as did the other seals. When food was thrown, the nonentangled individuals often caught it before the entangled ones. Seal N0's feeding activity was no different from that of nonloaded fur seals.

Activity Pattern

Active Time

Figure 4 shows variations in active time per day from 4 to 26 February. During this period, the amount of N0's active time fluctuated greatly, while fluctuations were small for N1 and N2. The average daily active time was longest for N0 (9.6 h/day), followed by N1 (4.1 h/day) and N2 (1.4 h/day), and any pair of them differed significantly (t-test, $P < 0.01$).

Table 2 shows the daily active times of N1 and N2 before and after the removal of net fragments. The average active time of N2 after net removal was 5.4 h/day, about four times longer than before net removal. The difference was statistically significant (t-test, $P < 0.01$). The average active time of N1 after net removal was 6.7 h/day, about double that of the period of net attachment, which also differed significantly (t-test, $P < 0.01$). The active time of N0 did not show a significant change between the two corresponding periods.

Daily Cycle of Activity

Figure 5 shows the average daily cycle of activity. The ratio of activity was calculated every 3 h (activity ratio) and averaged for the experiment period. For N1 and N2, the periods of entanglement and nonentanglement were treated separately. All three seals were very active in two time periods, 0900-1200 and 1500-1800, which corresponded to feeding times. Activity patterns of N1 and N2 did not change remarkably after removal of entangled nets, though the active time increased as mentioned above.

DISCUSSION

Baba and Yoshida (1988) conducted a field experiment in which they attached transmitters to two mature female fur seals, one of which was entangled in a 120-g net fragment, off St. Paul Island and compared their activities using radio telemetry. They reported that the frequency of dives longer than 1 min was less for the entangled animal. In our study, no extended dives were observed for animals loaded with nets of 1 and 2 kg. Although there were differences in research location and the amount of nets

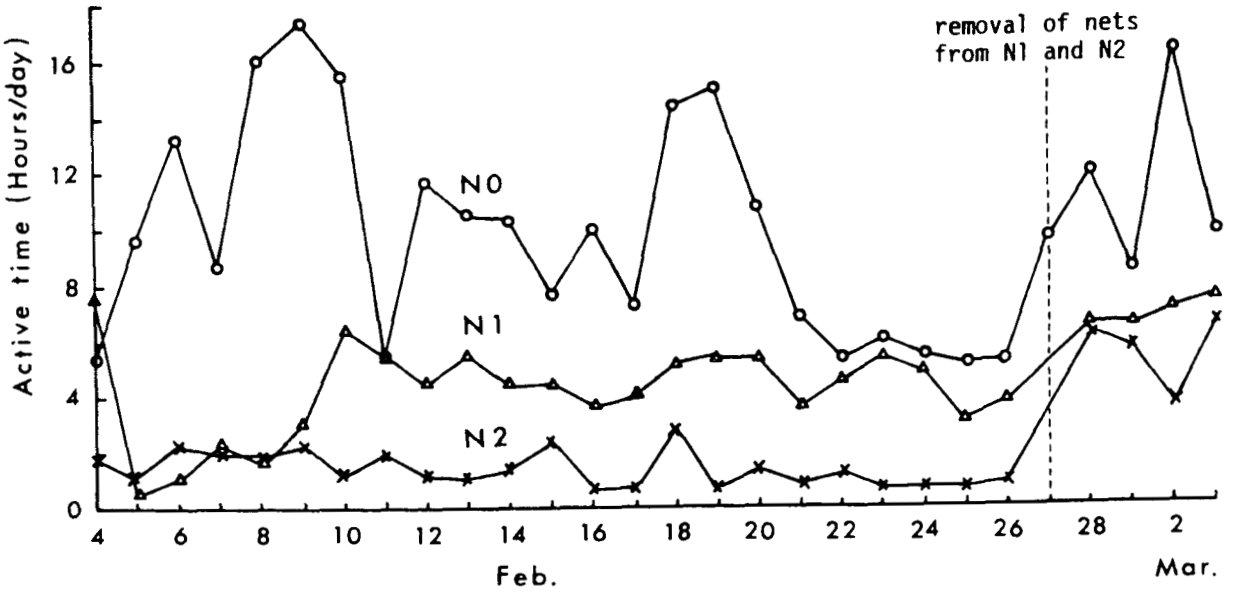


Figure 4.--Variations in daily activity of the three fur seals.

attached, their report is consistent with our study in that net entanglement hindered diving activities.

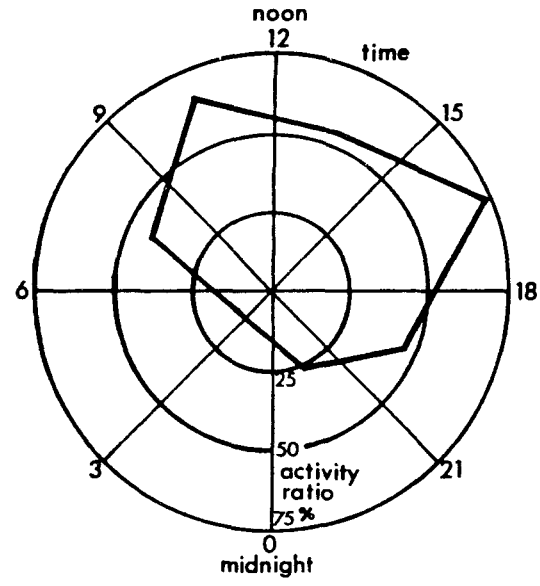
Daily activity cycles were the same for entangled and nonentangled animals. Baba and Yoshida (1988) also reported that no differences were observed in behavior patterns of entangled and nonentangled fur seals in the open sea. These results indicate that activity patterns of fur seals may not change even if they are entangled in net fragments.

Most of the trawl nets entangling the fur seals on St. Paul Island were <150 g in weight, although the biggest one weighed 6.75 kg (Scordino 1985). Therefore, it is also necessary to examine the effects of smaller net fragments on activity of fur seals.

It is clear that net entanglement suppressed the activity of animals because active time of the animals was short while entangled and increased

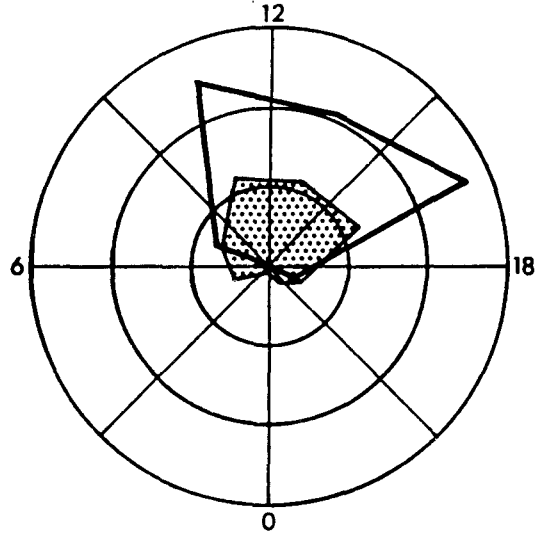
Table 2.--Daily active times of experimental seals with and without attached nets.

	4-26 February 1985			28 February-3 March 1985		
Seal ID	Net weight (kg)	Active time per day mean (min.-max.) (h/day)	S.D.	Net weight (kg)	Active time per day mean (min.-max.) (h/day)	S.D.
N0	0	9.6 (5.0-17.4)	4.0	0	11.4 (8.2-16.1)	3.4
N1	1.0	4.1 (0.4-7.5)	1.7	0	6.7 (6.3-7.3)	0.5
N2	2.0	1.4 (0.6-2.9)	0.7	0	5.4 (3.6-6.4)	1.3



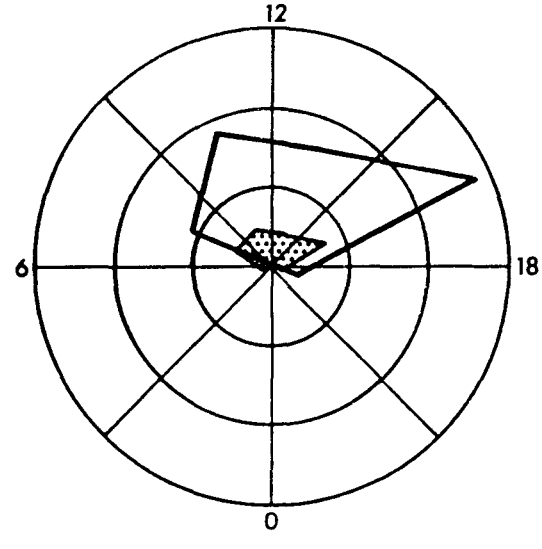
N0

4 Feb – 3 Mar ; nonentangled



N1

28 Jan – 26 Feb ; entangled
28 Feb – 3 Mar ; nonentangled



N2

28 Jan – 26 Feb ; entangled
28 Feb – 3 Mar ; nonentangled

Figure 5.--Daily activity cycles of three fur seals for entangled (dotted area) and nonentangled (solid line) periods. Activity ratio is defined as the percentage of active time in each 3-h period.

after net removal. The suppression of activity might be due to either the physical burden of nets or an adaptation of animals to conserve energy. A future task should be to study the physiological impact of entanglement and relate it to energy consumption and survival.

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