

# A Study of Behavior and Ecology of Female Fur Seals on a Breeding Island by Radio Wave Telemetry and Visual Observation

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## Abstract

A study of behavior and ecology of female fur seals during their breeding season was conducted by radio wave telemetry and visual observation from July 20 to August 24, 1980 at Robben Island, which is situated at the tip of the northern Shiretoko Peninsula, Sakhalin, U. S. S. R.

A transmitter for activity observation was tagged to six female seals respectively and a transmitter for situation observation to 20 female seals, and data were collected continuously while they were staying on the island. Visual observations of the seals were also periodically conducted four times a day as well as meteorological observations.

Some information was obtained from the analysis of these data concerning the feeding cycle of mother seals and non-mother seals, the amount of their activity, the cycle of the activity, and the ratio of the number of female seals staying on the island and in the sea, and correlation between the number of female seals staying on land and environmental factors.

## Introduction

To know a behavior and ecology of fur seals is important for estimation of the amount of the resources and resource management. For instance, if one tries to estimate the total number of female fur seals by a direct estimation method, it is impossible to do so unless he knows the ratio of those on land and in the sea, even if he uses the number of the female seals on land. Therefore, studies of behavior of fur seals have been carried out in the past aiming at collecting the characteristic value necessary for their resource management.

Several studies of behavior of fur seals of the Pribilof group have been done: By BARTHOLOMEW (1953, 1959), BARTHOLOMEW and HOEL (1953), BARTHOLOMEW and WILKE (1956), MCGILVER (1957), PETERSON (1965, 1968), GENTRY and JOHNSON (1975, 1976), FISCUS *et al.* (1975, 1976, 1977), GENTRY *et al.* (1977, 1978, 1980), GENTRY and HOLT (1978), GENTRY and FRANCIS (1981) and GENTRY and GOEBEL (1982). Concerning the Commander group, a survey was made in 1975 (All-Union Research Institute of Marine Fisheries and Oceanography, Pacific Research Institute of Fisheries and Oceanography 1976), but no has been presented. Concerning the Robben group, a study was done only by BYCHKOV (1964).

For observations of seals' behavior in these studies paint marks, plastic tags and metal

tags were mainly used which were attached to the seals, and the behavior of the marked seals were observed. Although there is an advantage in this method as the marks give little impact on the animals, they have also defects including that marks are hard to recognize and that observations cannot be done at night or foggy days or when a marked seal moves behind an obstacle. If an observer goes close enough to recognize the mark in an attempt to overcome these defects, it will disturb the animal and it is hard to investigate its normal behavior.

The authors decided to use a biotelemetry system for a study of fur seals' behavior. This method enables us to record normal activities of the animals continuously for long hours without exposing observers to the fur seals. Also it is possible to conduct quantitative measurement of the amount of their activities without putting any bias of the observers in the obtained data.

The investigations of behavior of fur seals using a radio wave telemetry were made in the United States in 1967 and 1968 (Marine Mammal Biological Laboratory 1969), then in 1973 by JOHNSON (1974), between 1974 and 1976 by GENTRY and JOHNSON (1976), and GENTRY *et al.* (1977), and in 1974, 1976 and 1978 by BABA *et al.* (1979).

In this study, a behavioral ecology of female seals of the Robben group was investigated from July 20 to August 24. The main purpose of the study was to elucidate the periodicity in feeding of female seals during a breeding season, the amount of activities and the cycle of activities, and the ratio of the number of female seals staying on land and in the sea. It was an attempt to find a clue for future elucidation of the ecosystem in the nature when data are more accumulated and a correlation between the amount of activities and the amount of energy consumption can be obtained.

Along with continuous observations with telemetry system, visual observations were periodically made four times a day (at 8:00, 12:00, 16:00 and 20:00). In addition, observations of environmental factors were made to find out the relation between seals' behavior and environmental factors. The following is a report of some biological findings concerning the female seals of the Robben group obtained through analysis of the above-mentioned data.

## I. Instruments Used for the Research

The radio wave telemetry system used for the research consists of a transmitter, an antenna, a receiver, a controller and a recording apparatus. The characteristics of these instruments are small in size, light in weight and operable for long hours with small batteries. The outline of each instrument is as described below. For the engineering details of these instruments, please refer to MAKITA *et al.* (1979).

### I-1 Transmitter

A total of 26 transmitters were used: 20 for position detecting and six for activity observation. In terms of frequency all the transmitters were of 53 MHz, and with the transmitting system of crystal controlled pulse modulation system. The position detective

transmitter can work as long as six months and one for activity observation for three months (normal use). The weight of the transmitter is 200 g for the position detective transmitter and 220 g for the activity observation transmitter, which can be used up to 30 kg/cm<sup>2</sup> of atmospheric pressure.

### **I-2 Antenna**

As for antennas, a 4 element short type antenna and a Yagi type 3 element full scale antenna were used. The former is the one for detecting position of the seals and the latter is to observe the activity. Both are made compact and light and fabricated for the use in the field.

### **I-3 Receiver**

Two receivers were used. Each one can receive up to 11 radio waves, and can be used for long hours with dry batteries (10 batteries of single III type). One is of a beat detective system and the other of double super heterodyne beat type. The weight of the receivers is 1.5 kg including the batteries.

### **I-4 Controller**

As for controllers two models were used: One is the telemeter controller and the other is the antenna controller. The former is for activity observation and the latter for position detection. A researcher can observe an animal at any time by handling a preset knob in the controller in advance and at the same time the data are automatically recorded.

### **I-5 Recorder**

The recorders used are the following two models: an EPR-200A type of Toa K.K. and a VP-6723A type of Matsushita Electric Co., LTD. These recorders were operated with car batteries.

## **II. Items and Methods of Investigation**

### **II-1 The place where the radio wave telemetry system was set and visual observation locations**

The location and a map of Robben Island are shown in Fig. 1. Robben Island is an island of a strip about 650 m long and about 50 m to 70 m wide. The coast is made of a flat sand beach, and a strip of a height in the center of the island consists of rocks. The harem ground is developed mainly in the whole eastern coast and a part of the height. Therefore, the performance of the radio wave telemetry system the authors took was enough to fully receive radio waves from the transmitters no matter where on the island the receiver was set.

Because of the above-mentioned topographical condition the receiver was installed in a room (Plate I-Fig. 1) of the research center (A in Fig. 1) located in the central part of the island in order to avoid any influence as much as possible which might be caused by observation activities. The periodical visual observation (four times a day) and observation of

environmental factors were conducted at the blinds located at four places on the island (D in Fig. 1).

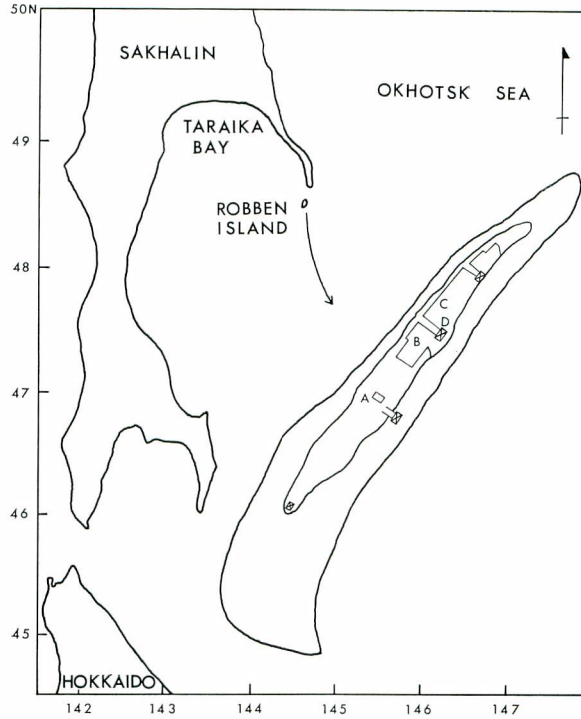


Fig. 1. Position of Robben Island and the map.

- A; Laboratory where receiving apparatus is installed.
- B, C; Harem ground
- D, ☒; Blind

## II-2 Method of setting transmitter

As a fur seal is susceptible to heat, the researchers conducted transmitter setting early in the morning at the harem ground (B in Fig. 1). The harem ground was partially surrounded with a wooden fence. First, several tens of female fur seals herding together inside the fence were gathered by the fence, and transmitters were set to the bodies of those which appeared to be adult female according to the color of their whiskers and the length of the body.

To fix a transmitter to a seal, a seal was first immobilized on a wooden fixture, and then a cloth belt with a transmitter (Harness) was harnessed on the seal. A colored tape was put on the harness to identify the seal with the aim of carrying on the research even if the transmitter goes wrong.

In this way the transmitter was set up to 14 seals on July 23 and 12 seals on July 24 making the total number of seals harnessed 26. The scene of harnessing a transmitter is shown on Plate I-Fig. 2.

### II-3 Investigation and its method for female seals' feeding cycle and the place of the stay

During the investigation period the telemetric observations were carried out four times a day at 8:00, 12:00, 16:00 and 20:00 to find out whether the radio-tagged seals were staying on land or not and the position of their stay. In due consideration of a trouble of the transmitter, visual observations always followed after the telemetric observation to check whether the radio-tagged seals were staying on land or not and their position was recorded on a map. These telemetric as well as visual observations were conducted not only periodically but sometimes when not scheduled in order to make the data more reliable.

### II-4 Investigation and its method for female seals' activity time in a day and their activity cycle

In order to investigate the female seals' activity time within a day on land and the periodicity of their activities the researchers attempted to collect data as much as possible through the telemetry system during the time when the radio-tagged seals were staying on land.

A part of the recorded data is shown in Fig. 2. The record on the left side of the figure shows the content of the activities and the one on the right shows the electric intensity of the received radio waves. The descriptive wordings in the center are the record of

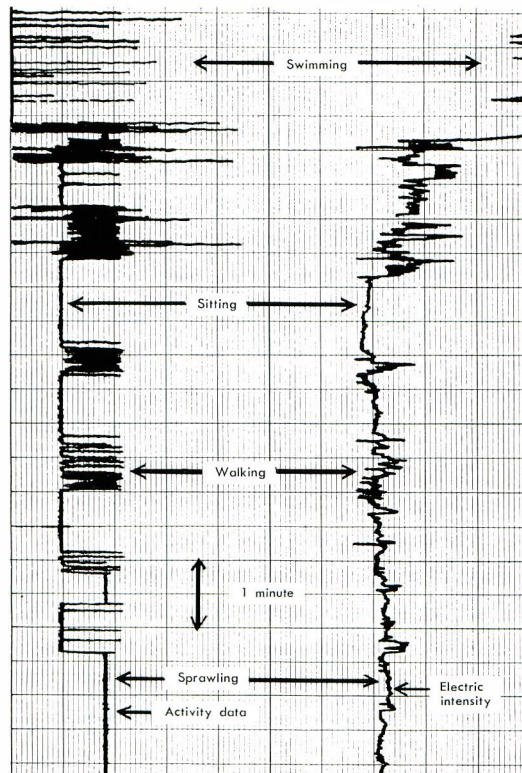


Fig. 2. Record of female seal's activity with a transmitter for activity observation.

activities of the radio-tagged seal obtained by visual observation which was conducted at the same time as telemetric observation.

As seen in the figure, when a radio-tagged seal moves, both the recorded line of activities and of electric intensity are disturbed. The more actively it moves, the more the lines are disturbed. Accordingly, the amount of activities was obtained by reading from the record their activity patterns such as walking and fighting and further reading the section corresponding to these patterns from the record, and adding up the time spent. A state of a female fur seal with a transmitter on a harem ground is shown on Plate I-Fig. 3.

#### **II-5 Investigation and its method for the change in the number of female seals staying on land within a day, the change according to the passage of days, and the relation between the number of female seals and meteorological factors**

During the period of investigation the number of the female seals staying at the harem grounds (B and C in Fig. 1) was counted, and the weather and temperature were observed four times a day periodically from Blind stations as shown D in Fig. 1. Sometimes according to a situation these observations were conducted at unscheduled times to collect information.

### **III. Result of the Investigation and Some Considerations**

#### **III-1 Feeding cycle of female seals**

Out of the 26 seals harnessed with a transmitter 18 seals (69 per cent of the total seals tagged with a transmitter) were confirmed to have returned to the island. Figs. 3 and 4 show the frequency of these 18 radio-tagged seals' stay on land and in the sea. For analysis the data were used which had obtained after more than a half day since the transmitters were set up, in consideration of the affect of their behavior due to the harnessing of the transmitters. Regardless of the length of the stay on land, if a seal was confirmed to be on land even once in a day, the day was counted as one that the seal stayed on land. However, the case that a seal was staying on land on the day when the transmitter was set and the one when the study was ended was excluded from the data. The similar method was applied for counting the number of days when the seal was staying in the sea.

As seen from Figs. 3 and 4 the period of 18 radio-tagged seals' stay on land ranged from one day to nine days with an average of 2.7 days. The period of their stay at sea ranged from one day to 22 days with an average of 6.4 days.

The short period of stay at sea for one to two days can be considered for the purposes other than seeking food as stated by BABA *et al.* (1979). GENTRY and JOHNSON (1975) investigated the feeding cycle of 11 female seals at East Reef Rookery of St. George Island in 1974 and reported that the average period of their stay on land was 2.1 days and that of their stay at sea was 5.7 days. These figures are almost corresponding to the result of the investigation by the authors.

Then, the researchers looked into the feeding cycle of an individual radio-tagged seal.

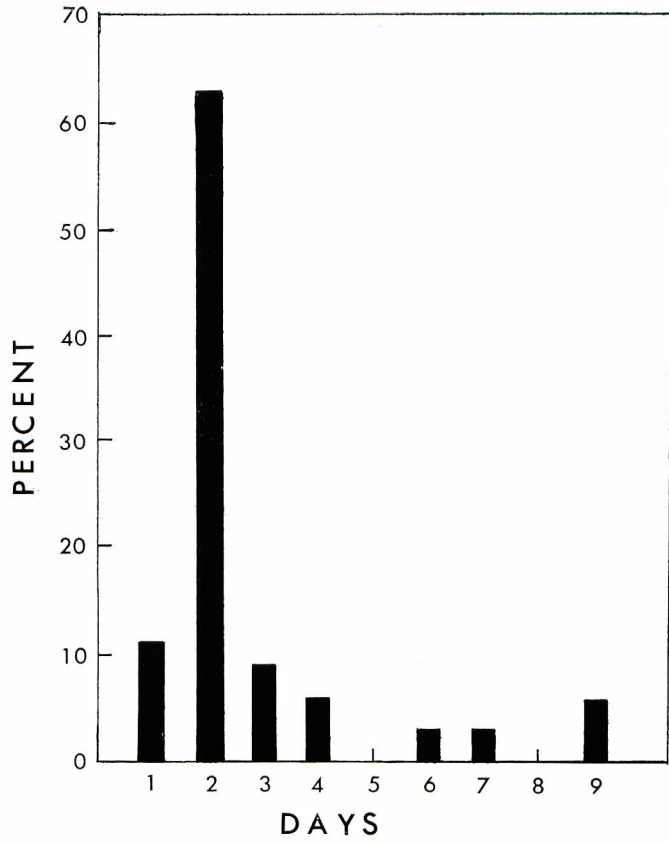


Fig. 3. Percentage of the period of radio-tagged female seal's stay on land.

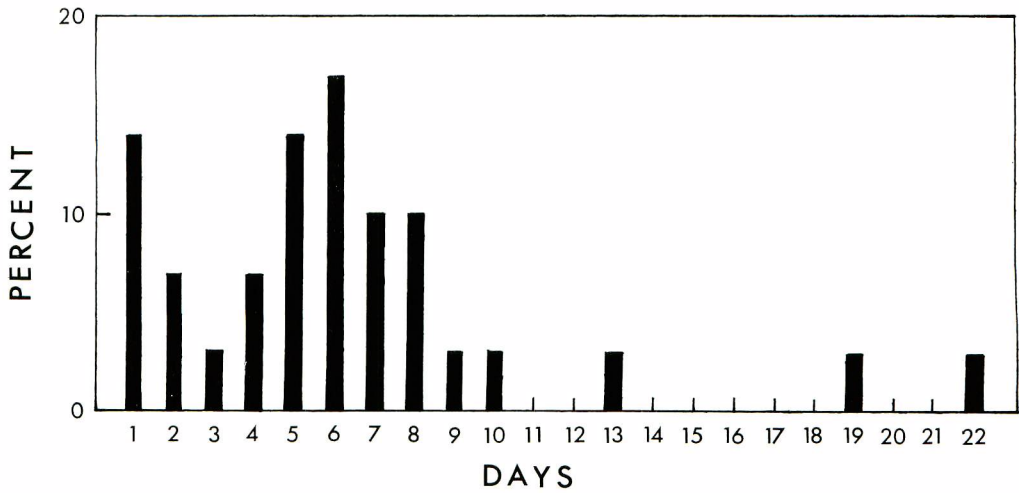


Fig. 4. Percentage of the period of radio-tagged female seal's stay in the sea.

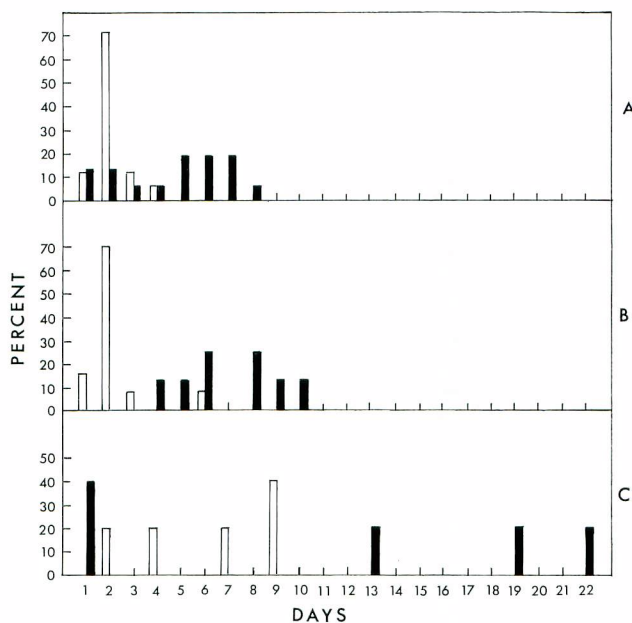


Fig. 5. Percentage of the period of stay on land and in the sea of radio-tagged nursing mother seals, non-nursing mother seals and female seals which did not delivery.

A; Pattern 1 (Nursing mother seal. Nos. of tagged transmitters, 7, 10, 17, 20 & 23)

B; Pattern 2 (Non-nursing mother seal. Nos. of tagged transmitters, 1, 2, 8, 13, 15, 18, 21 & 22)

C; Pattern 3 (Seal which did not delivery. Nos. of tagged transmitters, 3, 4, 5, 6 & 19)

■; Period of staying in the sea

□; Period of staying on land

As a result, it was found out that the period of stay on land and at sea of individual radio-tagged seals can be classified into three major patterns. The three patterns are shown in Fig. 5. The first pattern is that a seal repeats a short stay on land and at sea. The second pattern is that a seal repeats a short stay of land and a relatively long term stay at sea. The third pattern is a repetition of long stay on land and at sea.

The period of stay on land of those radio-tagged showing the first pattern ranges from one to four days with an average of 2.1 days. The period of their stay at sea ranged from one to eight days with an average of 4.7 days. The period of stay on land of those radio-tagged seals showing the second pattern ranged from one to six days with an average of 2.2 days. The period of thier stay at sea ranged from four to ten days with an average of seven days. The range of the period of stay on land of those radio-tagged seals showing the third pattern was from two to nine days with an average of 6.2 days. Their stay at sea



ranged from one to 22 days with an average of 11.2 days.

According to visual observations of individual seals with a transmitter conducted during the investigation period it was confirmed that all the individual seals which showed the first pattern had pups and were nursing them. Those showing the second pattern were often staying near the pups but it was not confirmed that they were nursing the pups. It can be assumed that these individual seals are mother seals for which nursing has become unnecessary for some reason. The seals which showed the third pattern did not stay near pups but were changing their place of stay one after another during the investigation. Based on this fact, it is assumed that they were female seals which had not delivered pups.

According to the above-mentioned telemetric and visual observations, it was found out that the feeding cycle of nursing female seals is shorter than that of female seals which do not nurse pups. It was presumed that the feeding cycle of female seals differs according to whether it is a nursing mother seal, a non-nursing mother seal or a female seal without having delivered a pup. Based on this, one can say that the nursing of a pup is a big factor influencing a feeding cycle.

PETERSON (1965) carried out a study of behavior of fur seals at Kitovi Rookery of St. Paul Island, and reported that an average period of stay on land of lactating female seals is 2.0 days that an average period of stay at sea is 9.4 days. The result of the mother seals' behavior that the authors obtained corresponds to that of PETERSON concerning the period of stay on land, but as far as the period of stay at sea is concerned, ours is considerably shorter than PETERSON'S.

GENTRY and JOHNSON (1976) classified the female seals' state of reproduction into four categories and investigated the feeding cycle of each category. As a result, the feeding cycle changes greatly according to the condition of whether they are nursing or not were reported (N. P. F. S. C. 1980). As in the authors' investigation the result shows that nursing influences feeding cycle of female seals, which corresponds to the above mentioned report.

### **III-2 Ratio of the number of female seal staying on land and at sea**

The change in the number of radio-tagged seals staying on land during the investigation is shown in Fig. 6. The seal which was the latest in returning the island after it was harnessed with a transmitter returned on August 17 for the first time. Accordingly, assuming that 18 radio-tagged seals were staying on land everyday during the period between August 17 and August 23, the end of the study, the authors decided to obtain the ratio of the number of seals between those staying on land and in the sea. However, as seen the black place in Fig. 6, actually only 25 seals were staying on land during the period between August 17 and 23. The ratio is as follows:

$$\frac{25(\text{seals})}{18(\text{seals}) \times 7(\text{days})} \times 100 \doteq 20\%$$

Therefore, the remaining 80% are supposed to be staying in the sea. Based on this, it was found out that about 20 per cent of female seals of Robben Island were staying on land and about 80 per cent in the sea at the end of August.

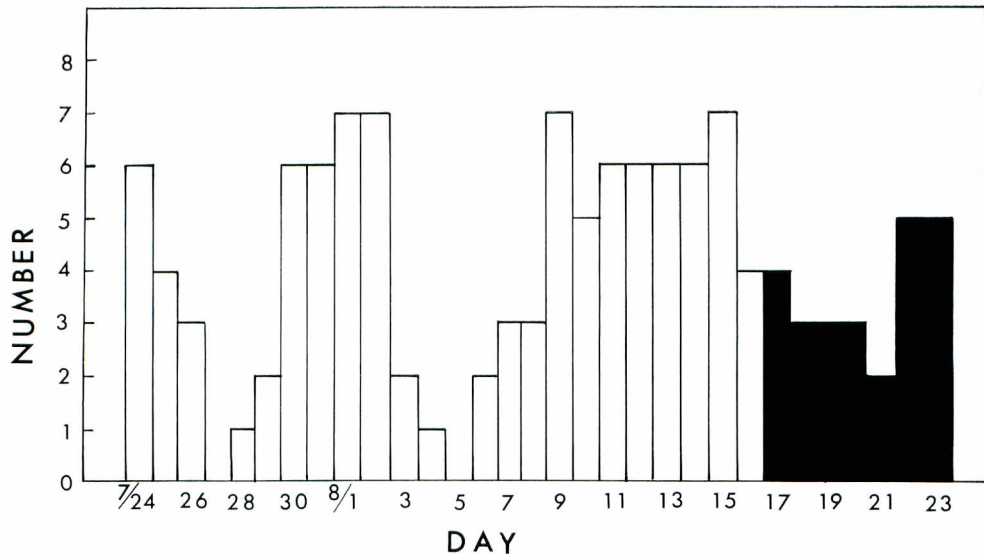


Fig. 6. Change in the number of radio-tagged female seals staying on land.

In the report of the study conducted on Pribilof Islands about 21 per cent of the female seals were staying on land and 79 per cent in the sea throughout a breeding season (N.P. F.S.C. 1980). The report corresponds to the result obtained by the authors.

### III-3 Place of stay of female seals

Fig. 7-(A), (B), and (C) show the analysis of the place of stay of seals with a transmitter. Out of 18 seals which returned to the island, 13 were staying during the investigation at the place where transmitters were set (B in Fig. 1 and (A) in Fig. 7). Four of them were nursing the pups. During the investigation the place of the stay of four pups did not change.

The place of the stay of three seals out of the remaining five seals with a transmitter moved from the place of harnessing transmitters to other places and returned to the original place again. Fig. 7-(B) shows one of the examples. The range of the move is small and they were often staying near the pups, but it was characteristic that their nursing to the pups was not confirmed.

The place of the stay of the remaining two seals was completely shifted from the place of harnessing transmitters to other places (Fig. 7-(C)). One of them changed its place of stay one after another in a wide range as shown with black circles in the figure. It never approached close to a pup. On the other hand, the place of stay of the other one shifted in a smaller range as shown with white circles in the figure. This female seals changed the place of stay whenever it returned to the island from a long-term stay in the sea. But at every place it settled upon return to the island, it was observed to be nursing the pup.

Based on the above-mentioned facts, since both female seals with pups and those which

appeared not to have a pup changed the place of stay, the selection of the female seals' place of stay can be assumed not so much due to their attachment to topography. Also, since mother seals changed the place of stay everytime they returned to the island and they nursed the pups at each place, the presence of pups can be pointed out as one of the factors which have them changed their place of stay.

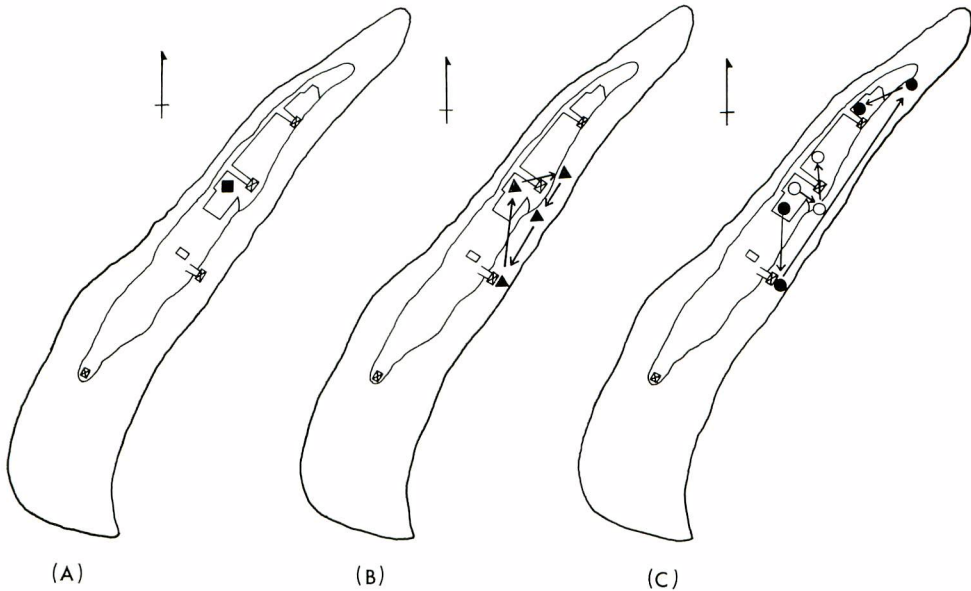


Fig. 7. Change in the place of stay of radio-tagged female seals.

- A ■; Seal with transmitter No. 1
- B ▲; Seal with transmitter No. 5
- C ●; Seal with transmitter No. 4
- ; Seal with transmitter No. 23

BARTHOLOMEW (1959) stated that mother seals generally have a strong attachment to topography and always stay at the place. He also stated, concerning the process of the reunion that a mother seal makes a call after settling at the place of delivery upon return, and that the pup comes close to the mother seal according to the call and that they confirm each other by sniffing each other's noses. Meanwhile, GENTRY and HOLT (1978) stated that female seals are influenced more strongly to the location of the pup rather than its favorite place where it landed. Since the number of cases is small the authors cannot make a conclusion but the result they obtained corresponds to that of GENTRY and HOLT.

#### III-4 Bathing time of female seals

The female seals after returning to the island from a long term stay in the sea are constantly staying on land but sometimes go out to the sea. Since it was confirmed through visual and telemetric observations that they stayed in the sea for a short time and were swimming near the coast line, it is considered to be not for seeking food but for a sort of escaping.

As a result of analysis of the observation record of the five radio-tagged seals, the bathing period was about 33 hours at maximum and 6 minutes at minimum with an average of about 3 hours, and the number of bathing per day was 5 at maximum and an average was 2.1 times. The bathing period varies greatly according to individual and even the same individual changes its bathing period according to time. Thus there is no regularity in terms of the bathing period.

In order to investigate the bathing time, the ratio between leaving and returning the island of the five radio-tagged seals by hours is shown in Fig. 8. The data in which a seal did not returned to the island for a long time after going out for bathing was excluded.

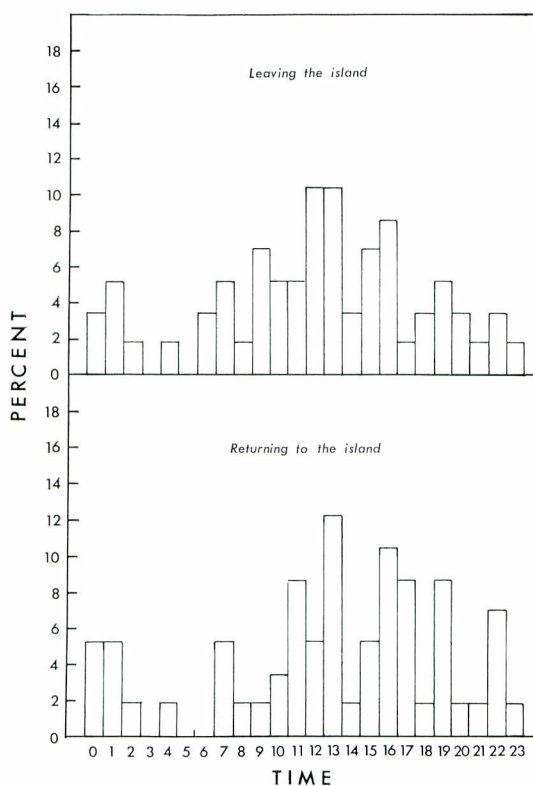


Fig. 8. Percentage of radio-tagged female seals' leaving and returning to the island for bathing by hour.

The percentage of leaving the island gradually decreases from 00:00 and begins to slowly increase from around 06:00, reaching the peak from 12:00 to 14:00 and gradually decreases since then until 24:00. The percentage of returning the island shows the similar trend to the change of the percentage of leaving the island.

From these outcomes, it is clear that although female seals go out to bathing any time of a day but most often during the period between 12:00 and 14:00, and that since their leaving and returning to the island is observed between around 21:00 and 06:00, whose percentage is relatively high between 00:00 and 02:00, they go out to bathing even at midnight.

### III-5 Daily activity and the cycle of the activities of female seals

The amount of activity in a day and the cycle of activities of the female seals with a transmitter (Transmitters Nos. 1, 2, 5 & 6) for activity observation were examined by analyzing the observation data. The data of seal tagged with No.2 transmitter were used only for reference since its period of stay on land was short.

The activity referred here means those active movements such as walking and fighting. The movements such as moving its head up and down were not treated as an activity. The activity at sea were not observed. The data collected on the days when there were some human disturbances such as the day when marks were attached on pups, the day when the number of dead pups was counted or the day when aerial photos were taken were not used. Table 1 shows the activity time of female fur seals attached activity transmitter (Transmitters Nos. 1, 5 & 6).

The fur seal attached transmitter No. 1 stayed 40 hrs. 39 min. on land and 46 hrs. 39 min. in the sea out of the total observing time of 87 hrs. 18 min. The activity time of 476.5 minutes was observed during the period of its staying on land. This makes the activity time of 280.8 minutes per day.

The fur seal with transmitter No. 5 stayed for 95 hrs. 12 min. on land and 34 hrs. 03 min. in the sea out of the total observing time of 129 hrs. 15 min. The activity time of 1329.0 minutes was observed during the period of its staying on land. This makes the activity time of 336.0 minutes per day.

The fur seal with transmitter No. 6 stayed for 91 hrs. 06 min. on land and 112 hrs. 52 min. in the sea out of the total observing time of 203 hrs. 57 min. The activity time of 1270.0 minutes was observed during the period of its staying on land. This makes the activity time of 333.6 minutes per day.

It was found out that these three fur seals made active movements for 281 to 336 minutes per day. However, the activity time per day is the average activity time in the total observing time and is the figure only with an assumption that female seals with transmitters were staying on land whole day. But actually since they often go out to bathing in a day, there is a considerably variation in the activity time. Therefore, the researchers examined the activity time of a day of a single seal. As a result, the minimum activity time was 18.5 minutes and the maximum 368.5 minutes with the average of 192.0 minutes. The individual seal which showed the minimum activity time stayed most of the time in the sea, landed at about 23:00 and moved a little bit until 24:00. The seal which showed the maximum time went out to the sea during the period between 13:00 and 17:00 but stayed on land the rest of the time.

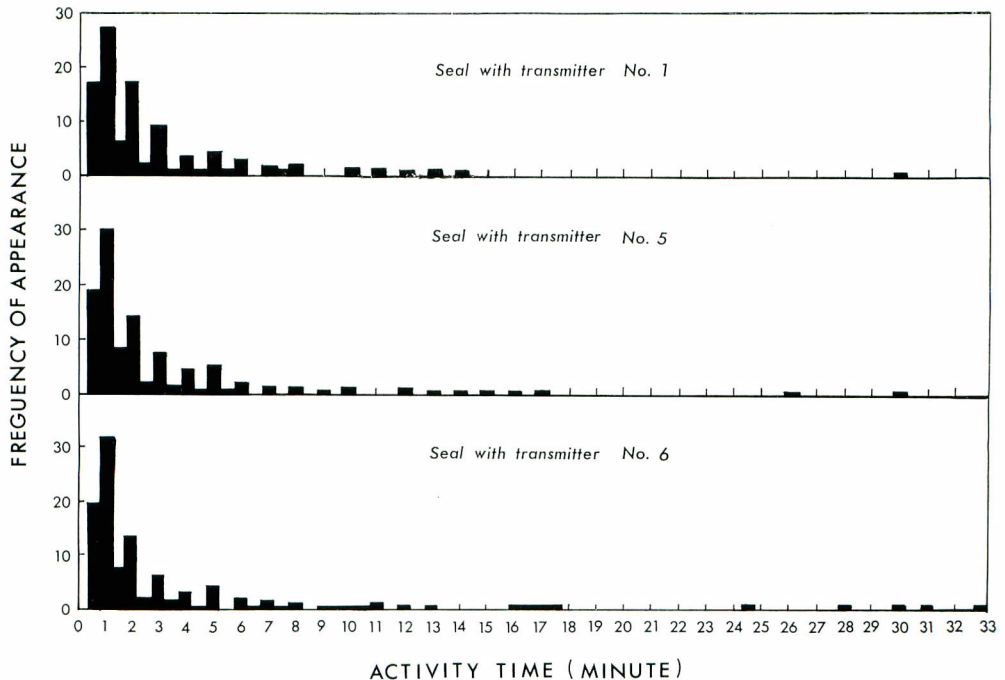
Thus, the activity time of female seals differs considerably since they go out for bathing, but one can assume that they generally make active movement for about 5 to 6 hours per day.

In Table 1 there was a difference seen in the activity time per day of these three individual seals. The researchers examined the difference by looking at the data by the state of reproduction. Through visual observation the fur seals with transmitter Nos. 5 & 6 are

**Table 1.** Activity time of female fur seals attached activity transmitter.

Tr. No. of seal	Observing times			Activity times			Activity time/Hour (2)/(1)=(3)	Activity time/Day (3)×24
	On land (1)	At sea	Total	Min.	Max.	Total (2)		
	h m	h m	h m	m	m	m	m	m
1	40 : 39	46 : 39	87 : 18	12.0	187.5	476.5	11.7	280.8
5	95 : 12	34 : 03	129 : 15	42.0	323.0	1329.0	14.0	336.0
6	91 : 05	112 : 52	203 : 57	18.5	368.5	1270.0	13.9	333.6

assumed to have no pups. It is not clear through the visual observation whether the seal with transmitter No. 1 has a pup or not. But assuming from the feeding cycle pattern shown in Fig. 5, it appears to be a female seal with a pup. Judging from this result, the difference seen in the activity time per day of the three seals shown in Table 1 can be assumed to be a difference between a mother seal and non-mother one. In other words, one can say that the activity time of a mother seal is slightly smaller than that of a non-mother seal. However, it cannot be determined due to a lack of the cases. The authors hope to make it clear by accumulating more data.

**Fig. 9.** Activity time of radio-tagged female seals per activity.

Then, the activity time per activity of these three individual seals was examined and the result is as shown in Fig. 9.

The time spent per activity of each seal is most often one to two minutes. From this fact one can see that the female seals' activity is a repetition of the pattern of moving a little and then taking rest. But sometimes these three seals move for a relatively long time, especially in the case of the seals with transmitter Nos. 5 & 6. The activity is assumed to be dallying with each other, but the authors hope to confirm it through visual and telemetry observations in future.

Next, the activity cycle of these three radio-tagged female seals per day was examined whose result is shown in Fig. 10. This figure shows the minimum, maximum and average values of the activity time at each hour.

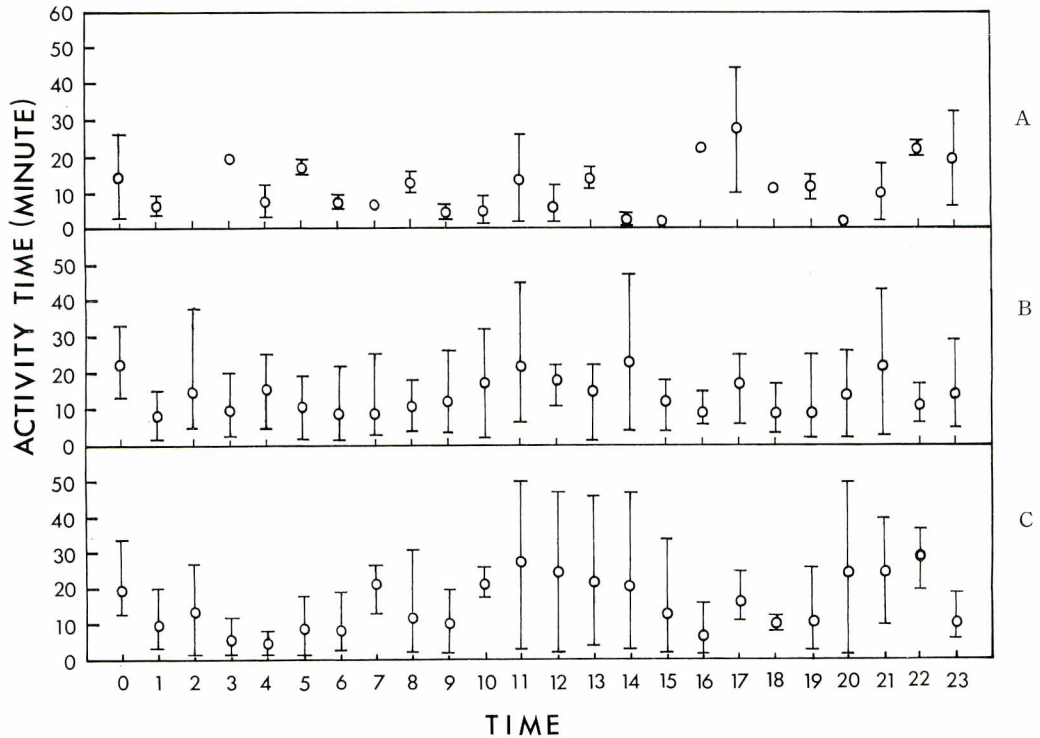


Fig. 10. Activity cycle of radio-tagged female seals in a day.

A; Seal with transmitter No. 1  
 B; Seal with transmitter No. 5  
 C; Seal with transmitter No. 6

Max. (vertical bar)  
 Mean (circle)  
 Min. (vertical bar)

The fur seal with transmitter No. 1 is making movement whole day long, but its activity time at each hour is less than 20 minutes, which is less than that of the other two seals. Looking at the activity time by each hour, it is small during the period between 00:00 and 15:00. It increases slightly from about 16:00 and becomes highest at 17:00. Then, it gradually decreases until 20:00 but increases again at about 21:00, showing a high value at 22:00,

and then gradually decreases.

The fur seal with transmitter No.5 is also making movement whole day like the one with transmitter No.1. However, its activity time at each hour is slightly more than that of the one with transmitter No.1. Looking at its activity time by each hour, it gradually decreases from 00:00 and begins increasing at about 07:00, reaching the peak between 11:00 and 14:00. Then it gradually decreases but shows a slightly high value at about 17:00. It decreases from 17:00 until 19:00, and it begins increasing again from about 19:00, reaching again its peak at about 21:00. Then it decreases.

The fur seal with transmitter No.6 shows a similar pattern to the one with transmitter No.5. However, the activity time at each hour shows a larger value than that of those with transmitter Nos.1 and 5. Its time zone of the activity has a similar trend to that of the one with transmitter No.5, but the activity time ranges a relatively long time with a high value.

From the above-mentioned facts, it was found out that female seals are moving or resting whole day long. It was also revealed that the peak of the activity is seen at about 00:00, during the period between 11:00 and 14:00, and at about 21:00. Although due to a great difference among the individual seals in terms of activity time and a lack of the cases, it is hard to determine, there seems to be a common pattern of activity cycle for female seals. It is necessary to accumulate more data to elucidate whether there is a difference in the pattern of the daily activity cycle among mother seals, non-mother seals and immature seals.

### III-6 Change in the number of female seals staying on land in a day

During the period of investigation the counting of the number of female seals staying at locations B and C shown in Fig. 1 was conducted through visual observation periodically four

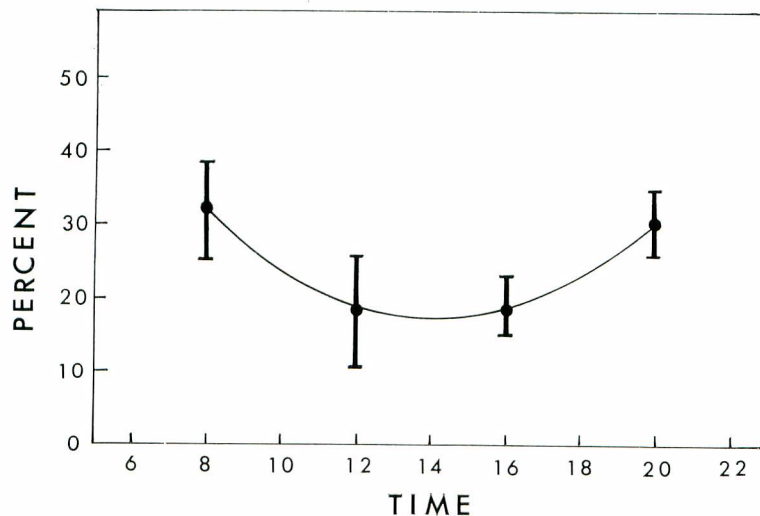


Fig. 11. Change in the ratio of the number of female seals at each observation time to the total number of female seals staying on land per day during the investigation period.



times a day, and investigated the change of the number of female seals according to the passage of days. The result is shown in Fig. 11. The figure shows the minimum, maximum and average values of the ratio of the number of female seals at each observation time to the total number of female seals staying on land per day during the investigation period.

It has been reported that fur seals go into sea when the weather is good and temperature is high (VNIRO/TINRO, 1966 and 1968; N. P. F. S. C. 1980). Also according to GENTRY and JOHNSON (1975) it is reported that fur seals go out to the sea without fail when there is human disturbance. Therefore, only the data of the observing days which meet the following conditions were used for analysis, excluding those of the days when there were some factors influencing the behavior of fur seals as mentioned above.

1. Data of the days when the weather did not change whole day.
2. Data of the days whose temperature was low and the gap in temperature between the observing times was less than 1°C.
3. Data of the days when there was no human disturbance.

As seen from Fig. 11, the number of female seals staying on land gradually decreases from 08:00 until 14:00, and gradually increases after 14:00 until 20:00. The number of the seals staying on land at 08:00 and 20:00 is almost the same. In other words, most of the female seals are gone into sea at about 14:00.

According to the ratio between leaving and returning the island of the radio-tagged seals for bathing as shown in Fig. 8, the peak of leaving the island was seen during the period between 13:00 and 14:00. Also, according to the daily activity cycle of radio-tagged seals shown in Fig. 10, the peak of the activity time was seen during the period between 11:00 and 14:00.

Based on the results shown in Fig. 8 and Fig. 10 and the changes in the number of female seals staying on land obtained through visual observation as shown in Fig. 11, one can say that female seals have a habit of going out for bathing at around noon.

### **III-7 Change in the number of female seals staying on land according the passage of days**

It became clear through the investigation of changes in the number of female seals staying on land in a day that the number of female seals staying on land changes according to hour. Also, the number of female seals staying on land at 08:00 and 20:00 was more than at other hours and the ratio between the two against the total daily number is almost the same. The authors tried, then, to examine which is the value less disturbed between those at 08:00 and 20:00.

First, the authors examined which hour was lower in temperature and small in the temperature change, since fur seals are susceptible to high temperature. As a result, it was found out that the hour 20:00 had more occasions whose temperature was lower than 14°C and with little change in temperature.

Then, the degree of change in the number of female seals staying on land during the period between 06:00 and 08:00 and 20:00 and 21:00 were examined.

As a result, it was found out that the number of female seals changed greatly during the period between 06:00 and 08:00, but that there was little difference in the change in the number of female seals during the period between 20:00 and 21:00. Based on the above-mentioned facts, the change of the number of female seals as the passage of days as shown on Fig. 12.

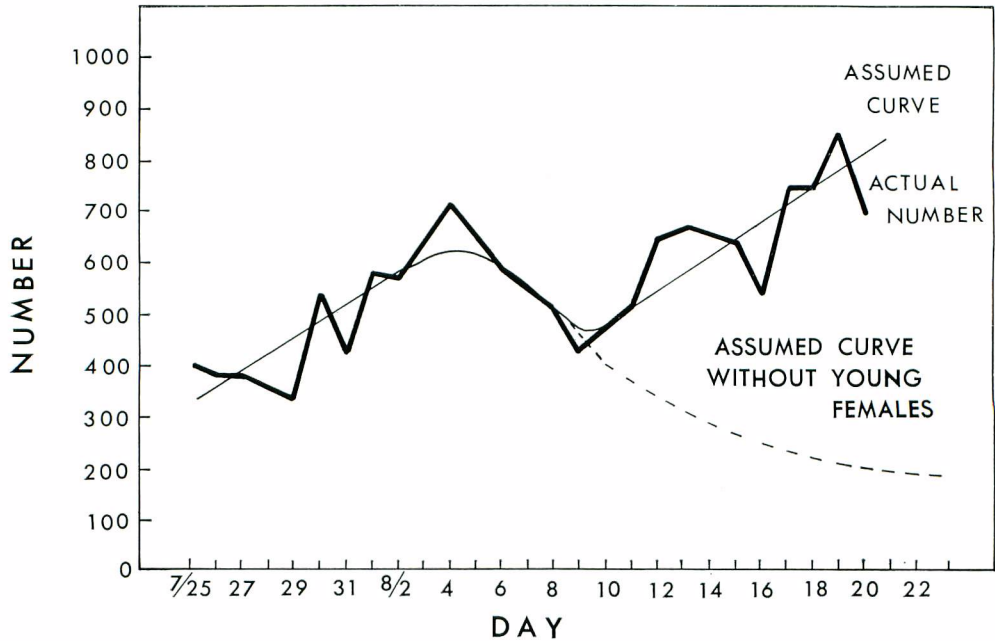


Fig. 12. Change in the number of female seals on land according to the passage of days.

As shown in Fig. 12, the number of female seals gradually increases during the period between July 25 and August 4 and with August 4 as a peak, it rapidly decreases until August 9. It increases again after August 9. Based on the visual observations on the color of whiskers and the physical features, the increase of the number of female seals after August 9 seems to be attributed by the addition of young female seals. Unless there was no addition of young female seals, the number of female seals must be gradually decreasing as the passage of days as shown with dotted lines in the figure.

BYCHKOV (1964) stated that female seals which had just had delivery were sporadically seen from the end of July to early August, and that it shows the final arrival of pregnant seals. He also stated that three-year old female seals (confirmed with marks) began appearing on Robben Island from the end of July, among which he could not recognize any in pregnancy or in nursing. This report means that the addition of immature female seals can be seen from the end of July, which corresponds to the finding of the authors. Furthermore, BYCHKOV stated that the breakdown of a harem begins from around the end of July and ends at early August. From this report, one can assume that the decrease of the number

of female seals staying on land during the period between August 4 and August 9 has something to do with the breakdown of the harem.

### III-8 Relation between the number of female seals staying on land and weather

The relation between the weather and the number of female fur seals that is total of the number of female seals counted at each observation time staying at locations B and C shown in Fig. 1 was shown in Fig. 13.

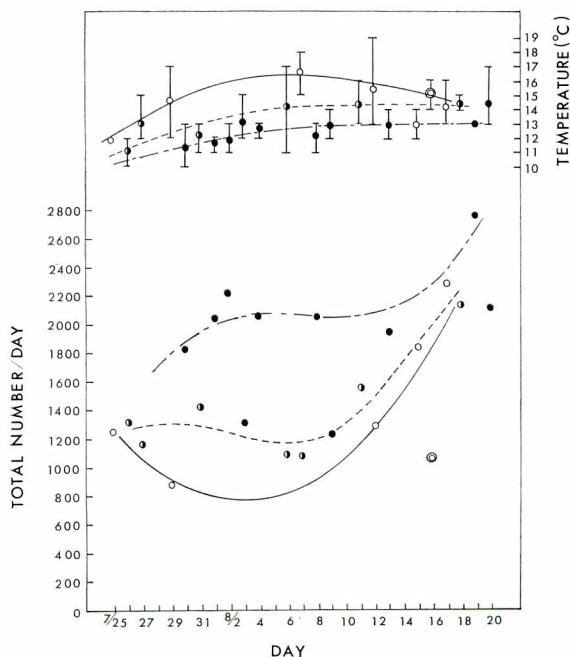


Fig. 13. Correlation between the weather and the number of seals staying on land.

- ; Fine
- ; Cloudy/foggy
- ◐; Fine/cloudy or fine/foggy
- ◎; Very fine
- Max.
- Mean
- Min.

In the upper part of the figure the weather is classified into four categories and the change of temperature at each observation according to the passage of days at each weather is shown. The figure shows the minimum, maximum and average values of temperature in a day.

According to the investigation concerning the change of the number of female seals staying on land as days pass (Fig. 12), it was found out that the number of female seals staying on land increases as days go, and after decreasing once, it increases again. In Fig. 13, the same pattern was seen in any weather. Looking at the positional relation of the increase/decrease curve by each weather, one can see that they are in order of a cloudy/foggy day, fine/cloudy or fine/foggy day, a fine day, and very fine day.

Based on this fact, one can say that the finer the weather is, the smaller the number of female seals staying on land is. However, what one should notice here is that as Fig. 13 shows in its upper part, in a fine day, the temperature is always high. Also, this figure shows the co-relation that when the temperature is high, the number of female seals staying on land becomes small, and it becomes more when the temperature becomes low.

Accordingly, it must be fair to consider that both factors, i. e., weather and temperature, has some affect on the change in the number of female seals staying on land. BYCHKOV (1964) also stated the similar thing in his study of female seals on Robben Island.

### III-9 Relation between the number of female seals staying on land and temperature

During the short period it is considered that the number of female seals staying at fixed area counted at same time is constant. Also, it is considered that the factor make the number of seals change is meteorological factor mainly, and especially on occasion of fur seal it seems it is the temperature because the fur seal hard to controll his body temperature without a sweat gland. On this point of view relation between the number of female seals staying on land and temperature was examined.

It was found out through the investigation of the change in the number of female seals staying on land during a day (Fig. 11) that the number of female seals is that at about 14:00. It was also found out through the investigation of the change in the number of female seals staying on land according to the passage of days (Fig. 12) that the number of female seals during the period of investigation increases from July 25 until August 4, decreases from August 4 until August 9 and then increases again from August 9 until August 20.

Since the number of female seals changes greatly according to the passage of days, the period of investigation was divided into three blocks according to the state of increase and decrease (Jul. 25-Aug. 4; Aug. 5-Aug. 9; Aug. 10-Aug. 20). The total of the number of female seals staying at location B and C shown on Fig. 1 were calculated at each observation time (at 08:00, 12:00, 16:00, 20:00) by three blocks, and the ratio of the number of female seals staying on same place at each observation time to its total were shown in Fig. 14 by temperature.

According to Fig. 14, the number of female seals staying on land slightly decreases at 08:00 in each three block when the temperature becomes high. At 12:00 and 16:00, the percentage of the number of the female seals staying on land hardly changes even if the temperature becomes high. Also, in terms of the way the number of female seals staying on land decreases, it gradually decreases as the temperature rises, but one can say that it sharply drops when the temperature rises above 14°C. Based on this the upper limit of inhabitable temperature for the female seals on Robben Island can be assumed to be 14°C.

It is reported that the temperature of Robben Island in July 1980 was slightly higher than in 1979 (All-Union Research Institute of Marine Fisheries and Oceanography, Pacific Research Institute of Fisheries and Oceanography 1981). Therefore, one can say that the temperature in July 1980 was not abnormal. BARTHOLOMEW and WILKE (1956) stated that the upper limit of inhabitable temperature for fur seals on land is at around 12°C at St. Paul

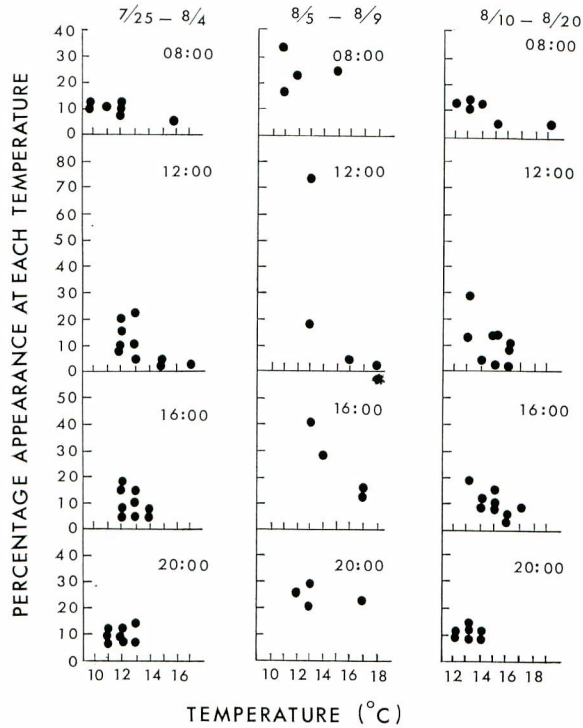


Fig. 14. Correlation between the temperature and the number of female seals staying on land.

Island of Pribilof Islands. In the study of bachelor's behavior that the authors conducted in 1978 at St. George Island of the Pribilof Islands a trend was observed that the number sharply dropped when the temperature rose above 13°C. From these facts, it seems that the upper limit of inhabitable temperature for fur seals on Robben Island is slightly higher than that of those on Pribilof Islands.

### Summary

A study of behavior and ecology of female fur seals during their breeding season was conducted by radio wave telemetry and visual observations from July 20 to August 24, 1980 at Robben Island, which is situated at the tip of the northern Shiretoko Peninsula, Sakhalin, U. S. S. R.

A transmitter for activity observation was tagged to six female seals respectively and a transmitter for situation observation to 20 female seals, and data were collected continuously while they were staying on the island. Visual observations of the seals were also periodically conducted four times a day as well as meteorological observations.

As a result of the analysis of these data, some information was obtained, concerning the feeding cycle of mother seals and non-mother seals, the activity time and activity cycle, the

ratio of the number of female seals staying on land and in the sea, and correlation between the number of female seals staying on land and environmental factors.

1. The average duration of mother seals' staying on land, which were nursing the pups, was 2.1 days, the average duration of their staying in the sea was 4.7 days. The average period of staying on land of mother seals for which nursing seems to have become unnecessary for some reason was 2.2 days and the average period of their staying in the sea was 7.0 days. The average period of staying on land of female seals which seem to have not had delivery was 6.2 days and the average period of their stay in the sea was 11.2 days. Based on these results, it was found out that the feeding cycle of mother seals nursing the pups is shorter than other types of female seals. One can say that the feeding cycle of female seals is greatly affected by whether they do nursing their pups.
2. About 20 per cent of the female seals with transmitter were always staying on land and about 80 per cent in the sea.
3. The place of stay of female seals with pups is influenced by pups. However, the place of stay of female seals without pups greatly changes.
4. The number of bathing of female seals was five times at maximum and its average was 2.1 times a day. The bathing time was six minutes at minimum, 33 hours at maximum and about 3 hours at average. The peak of bathing hours was between 12:00 and 14:00. It was made also clear that female seals go out for bathing during the period between 22:00 and 04:00. Especially the number of bathing at around 00:00 was relatively high.
5. The activity time of female seals per day ranged from 18.5 minutes to 368.5 minutes. The activity time of female seals, when assumed that there were staying on land whole day, was about 5 to 6 hours. When compared between mother seals and non-mother seals, the activity time of the latter is more than that of the former. The activity time per activity is most often one to two minutes. The peak of activity was seen at around 00:00, between 11:00 and 14:00, and at about 21:00.
6. The number of female seals at the harem ground is the least at around 14:00 in a day. Also from the result of the activity cycle, one can say that female seals have a habit of going into the sea in day time.
7. The number of female seals at a harem ground changes as days go. In terms of the change, it increases up to early August, and then decreases for a while, and then increases again. The decreasing period at early August corresponds to the period of breakdown of the harem, and the increase seen from the mid-August is caused by the addition of immature seals.
8. The finer the weather is, the less the number of female seals staying on land become. The number of female seals staying on land gradually decreases as the temperature rises, and when the temperature becomes above 14°C, the number drops sharply.

### Acknowledgement

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電波テレメトリー及び目視による繁殖島上の  
オットセイ雌獣の行動生態の研究

吉田 主基・馬場 徳寿

## 摘 要

1980年7月20日から8月24日までの間、Robben Islandにおいて、電波テレメトリーシステムを使用し、目視観察と合せて繁殖期の雌オットセイの行動生態調査を行なった。

6頭の雌獣には活動観測用発信器を、20頭の雌獣には位置観測用発信器を装着し、陸上滞在中のデータを連続的に収集した。又、1日に4回、定期的な目視によるオットセイの観察と気象観測を行なった。

これらのデータを解析した結果、母獣と非母獣の摂餌周期、活動量とその周期について、又、雌獣の陸上対海上の滞在比率、陸上滞在数と環境要因との相関について幾つかの知見がえられた。

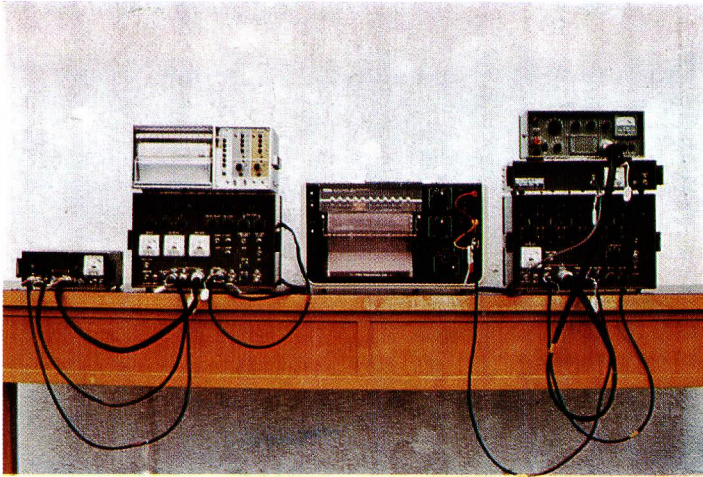
1. 仔獣へ授乳を行なう母獣の陸上滞在期間の平均は2.1日、海上滞在期間の平均は4.7日であった。何らかの理由で仔獣へ授乳を行なう必要がなくなったと思われる母獣の陸上滞在期間の平均は2.2日、海上滞在期間の平均は7.0日であった。非出産と思われる雌獣の陸上滞在期間の平均は6.2日、海上滞在期間の平均は11.2日であった。以上の結果より、仔獣へ授乳を行なう母獣の索餌周期は、それ以外の雌獣より短いことがわかった。雌獣の索餌周期は、仔獣への授乳の有無により大きく左右されると言える。
2. 発信器装着雌獣の約20%は陸上に、約80%は海上に滞在した。
3. 仔獣を持つ雌獣の滞在場所は仔獣により左右されやすい。しかし、仔獣を持たない雌獣の滞在場所はさまざまに変わる。
4. 雌獣の1日の水浴回数の最高は5回であり、その平均は2.1回であった。水浴時間の最小値は6分、最大値は33時間、その平均は約3時間であった。水浴時間のピークは12:00から14:00であった。又、22:00時から04:00時の間に雌獣は水浴へ行くことが明らかになった。特に00:00時頃における水浴回数は比較的多かった。
5. 雌獣の1日当りの活動量(時間)の範囲は18.5分から368.5分であった。雌獣が1日中陸上にいると仮定した時の1日の活動量は約5~6時間であった。又、母獣と非母獣では、非母獣の方が活動量が多い。1回当りの活動時間は、1~2分が最も多かった。活動のピークは00:00時頃、11:00時から14:00時の間、21:00時頃にみられた。
6. Harem groundにおける雌獣数は、1日の内で14:00時頃が最も少ない。この結果と活動周期の結果から、雌獣は昼間海に出る習性があると言える。
7. Harem groundにおける雌獣数は、時期の経過に伴い変動する。その変動内容は、8月上旬頃まで増加し、その後しばらくの間は減少するが、それ以降再び増加する。8月上旬頃の減少時期はHaremの崩壊時期と一致し、8月中旬頃からの増加は、未成熟獣の加入による。
8. 天候がよい日ほど陸上滞在雌獣数は少ない。又、陸上滞在雌獣数は気温の上昇に伴ない徐々に少なくなるが、14°C以上になると減少が急速になる。

### Explanation of Plate I

**Fig. 1.** Receiving apparatus installed in a room in the laboratory.

**Fig. 2.** Harnessing of transmitter to a seal.

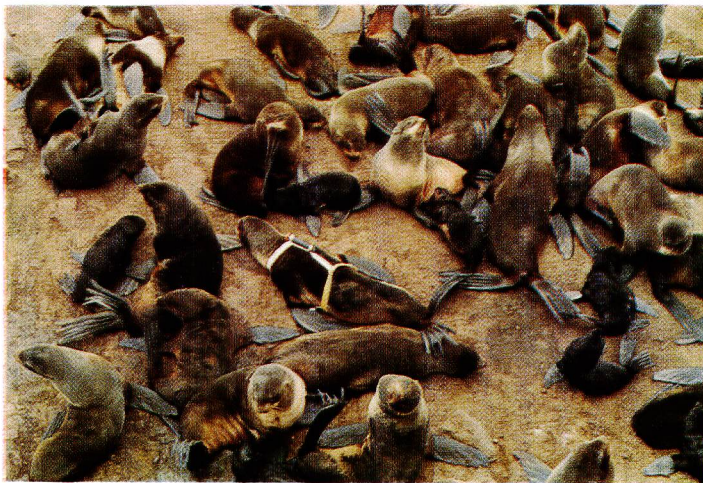
**Fig. 3.** A female seal with a transmitter at the harem ground.



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