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SEA OTTER REPORT

By

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperator: Karl B. Schneider

Project No.: W-17-4 Project Title: Marine Mammal Investigations

Job No.: 8.9R Job Title: Sex and Age Segregation of Sea Otters

Period Covered: July 1, 1971 to December 31, 1971

SUMMARY

Areas used primarily by male sea otters and those used primarily by female sea otters were identified. The sex and age composition of the animals in those areas at different times of year were determined by recording the sex, age class and location of sea otters collected during harvests and transplants and by field observation and counts.

In May, 93 percent of the adults and 73 percent of the subadults in female areas were females while in September and October, 77 percent of the adults and 86 percent of the subadults were females. Summer samples, collected in a different manner, indicate that the percent of adult females is intermediate between the spring high and fall low. The percentage of adult males in female areas varies directly with the percentage of estrous females. Males between the ages of two and six years are almost totally excluded from certain prime female areas in fall.

Certain portions of female areas are favored by females with large fetuses or small pups.

Boundaries of male areas appear well defined and extend offshore. The total numbers and age composition of males using male areas appear to vary seasonally as males move to and from female areas.

Male areas are smaller, fewer in number and more discrete than female areas. There appear to be more females than males in the populations studied.

The percent of subadults captured within the area of most intensive transplant capture efforts has increased while the percent of subadults in an adjacent area appears lower than average. This may indicate that subadults are moving in to replace captured adults.

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BACKGROUND

Workers have recognized for some time that sea otters (*Enhydra lutris*) tend to segregate by sex. Lensink (1962) described this segregation around the southeastern end of Amchitka Island and identified three "male areas" and three "female areas". He speculated that females used areas of more favorable habitat and that younger males were excluded from female areas by territorial males that are scattered throughout the areas. The implication is that male areas contain younger or at least nonterritorial males.

Marakov (1965) mentioned sexual segregation around Medny Island in the USSR's Commander Islands.

Kenyon (1969) gave a more complete description of the sexual segregation around the southeastern end of Amchitka Island and supported it with quantitative data from harvested animals.

Both Lensink (1962) and Kenyon (1969) were primarily describing hauling grounds used by different sexes. While Kenyon's harvested animals included otters near shore, neither study provided much information on the use of off-shore areas.

A knowledge of the degree of sexual segregation and the location of male and female areas is important to the management of sea otter populations. Harvests must be regulated to avoid putting too much pressure on one segment of the population. When capturing animals for transplants, it often is necessary to set nets in specific areas to obtain the desired sex ratio. In case of a localized kill of otters, such as might occur in the area of an oil spill, it is important to know the distribution of sexes to evaluate the importance of the kill to the population.

OBJECTIVES

To determine the degree of geographical segregation of sex and age classes of sea otters.

PROCEDURES

Male areas are smaller, more discrete and fewer in number than female areas (Kenyon, 1969). Efforts have been directed at identifying these male areas under the assumption that most other areas could be assumed to be considered female areas. Field identification of sexes is difficult and time consuming. Therefore, potential male areas were identified by locating concentrations of animals that did not include pups or by selecting exposed points on nautical charts that appeared to have the physical characteristics common to recognized male areas.

The approximate location of each animal captured or killed was recorded during harvests in September and October, 1967 at Adak Island and Amchitka Island; October, 1968 at Kanaga Island and Adak Island; and May, 1970 at Tanaga Island, the Delarof Islands and Amchitka Island and during transplant capture operations in June, July and August, 1968; July and August, 1969 and July, 1970 at Amchitka Island.

The animals captured and killed during these operations were classified as pups, subadults and adults. The ages of the 1968 animals were based on cementum deposition and reproductive condition. The other samples were classified using body size. In general, all males under 25 lb., females under 20 lb. and both sexes with a total curvilinear length of less than 100 cm were considered dependent pups. Females under 35 lb. and shorter than 120 cm and males under 45 lb. and shorter than 130 cm were considered subadults. These criteria probably underestimate the age of some animals. Cementum deposition information for the 1967, 1969 and 1970 samples is not available at this time.

The sexes and age classes of animals captured or killed were compiled by area to show the approximate sex and age composition of animals in different areas at different times of the year.

While the information gathered during harvests and transplants clearly demonstrates differences in sex and age composition between areas, the recorded locations often covered areas that are too broad for precise delineation of male and female areas. A single hunting party might kill 30 sea otters along 10 miles of coast in a few hours, for example. This 10 miles might contain a male area and several female areas. It was not practical to have each animal marked and the exact location recorded. Therefore, during the June, 1971 transplant capture at Amchitka, the exact location of each net and the sex and age class of all animals caught in that net were recorded. Also, during scientific collections made later that month, the exact location of each animal shot was recorded.

FINDINGS

The sex compositions of sea otters harvested in different areas in 1967, 1968 and 1970 are presented in Tables 1 - 4 and of those captured for transplant in Tables 5 - 6. Table 7 presents the combined 1968, 1969

Table 1. Sex Composition of Harvested Sea Otters - By Area - Fall Samples.

	Adults				All Ages			
	M	F	%M	%F	M	F	%M	%F
ADAK ISLAND September, 1967								
Bay of Islands	68	196	26	74	80	220	27	73
ADAK ISLAND October, 1968								
Bay of Islands	16	58	22	78	24	76	24	76
Three Arm Bay	2	10	17	83	3	12	20	80
Mid Point-Blind Point	20	42	32	68	28	55	34	66
Adak Island Total	38	110	26	74	55	143	28	72
KANAGA ISLAND October, 1968								
Round Head-Shoal Point	10	19	34	66	24	27	47	53
Naga Point-Kanaga Bay	12	53	18	82	16	62	21	79
Cape Chlanak-Cape Tusik	11	35	24	76	24	44	35	65
Eddy Rock-Hive Rock	30	54	36	64	57	64	47	53
Kanaga Island Total	63	161	28	72	121	197	38	62

Table 2. Sex Composition of Harvested Sea Otters - By Area - Spring Samples

	Adults				All Ages			
	M	F	%M	%F	M	F	%M	%F
AMCHITKA ISLAND May, 1970								
Crown Reefer Point-Chitka Cove	3	32	9	91	6	37	14	86
West of Chitka Cove	1	32	3	97	5	39	11	89
8-10 miles S.E. of Aleut Point	1	28	3	97	4	32	11	89
10-15 miles S.E. of Aleut Point	4	59	6	94	12	70	15	85
Amchitka Island Total	9	151	6	94	27	178	13	87
DELAROF ISLANDS May, 1970								
Ogliuga Island & Skagul Island	21	67	24	76	41	84	33	67
Ulak Island	2	10	17	83	3	16	16	84
Delarof Islands Total	23	77	23	77	44	100	31	69
TANAGA ISLAND May, 1970								
Cape Sudak-Pendant Point	40	26	61	39	79	40	66	34
Barnes Point-Trunk Point	2	58	3	97	6	66	8	92
Trunk Point-Twin Bays	3	36	8	92	7	43	14	86
Twin Bays-South Bay	4	51	7	93	10	60	14	86
South Bay-Harem Rock	6	84	7	93	9	90	9	91
Lash Bay-Inferno Reef	27	10	73	27	50	17	75	25
Harem Rock-Kulak Point	38	21	64	36	52	24	68	32
Kulak Point-S.E. Bight	5	33	13	87	8	45	15	85
Tanaga Island Total	125	319	28	72	221	385	36	64

Table 3. Sex Composition of Pup and Subadult Sea Otters Harvested - By Area - Fall Sample.

	Subadults				Pups				All Ages	
	M	F	%M	%F	M	F	%M	%F	%M	%F
ADAK ISLAND September, 1967										
Bay of Islands	3	20	13	87	9	4	69	31	27	73
ADAK ISLAND October, 1968										
Bay of Islands	0	15	0	100	8	3	73	27	24	76
Three Arm Bay	0	1	0	100	1	1	50	50	20	80
Mid Point-Blind Point	5	11	31	69	3	2	60	40	34	66
Adak Island Total	5	27	16	84	12	6	67	33	28	72
KANAGA ISLAND October, 1968										
Round Head-Shoal Point	11	7	61	39	3	1	75	25	47	53
Naga Point-Kanaga Bay	0	2	0	100	4	7	36	63	21	79
Cape Chlanak-Cape Tusik	3	8	27	73	10	1	91	9	35	65
Eddy Rock-Hive Rock	24	9	73	27	3	1	75	25	47	53
Kanaga Island Total	38	26	59	41	20	10	67	33	38	62

Table 4. Sex Composition of Pup and Subadult Sea Otters Harvested - By Area - Spring Sample.

	Subadults				Pups				All Ages	
	M	F	%M	%F	M	F	%M	%F	%M	%F
AMCHITKA ISLAND May, 1970										
Crown Reefer Point-Chitka Cove	1	3	25	75	2	2	50	50	14	86
West of Chitka Cove	1	3	25	75	3	4	57	43	11	89
8-10 miles S.E. of Aleut Point	2	2	50	50	1	2	33	67	11	89
10-15 miles S.E. of Aleut Point	4	10	29	71	4	1	80	20	15	85
Amchitka Island Total	8	18	31	69	10	9	53	47	13	87
DELAROF ISLANDS May, 1970										
Ogliuga Island & Skagul Island	16	9	64	36	4	8	33	67	33	67
Ulak Island	1	5	17	83	0	1	0	100	16	84
Delarof Islands Total	17	14	55	45	4	9	31	69	31	69
TANAGA ISLAND May, 1970										
Cape Sudak-Pendant Point	35	13	73	27	4	1	80	20	66	34
Barnes Point-Trunk Point	2	6	25	75	2	2	50	50	8	92
Trunk Point-Twin Bays	3	6	33	67	1	1	50	50	14	86
Twin Bays-South Bay	1	7	13	88	5	2	71	29	14	86
South Bay-Harem Rock	3	3	50	50	0	3	0	100	9	91
Lash Bay-Inferno Reef	22	7	76	24	1	0	100	0	75	25
Harem Rock-Kulak Point	13	2	87	13	1	1	50	50	68	32
Kulak Point-S.E. Bight	0	11	0	100	3	1	75	25	15	85
Tanaga Island Total	79	55	59	41	17	11	61	39	36	64

Table 5. Sex Composition of Sea Otters Captured for Transplants - By Area - Amchitka Island

	Adults				All Ages			
	M	F	%M	%F	M	F	%M	%F
June 23 - August 10, 1968								
Crown Reefer Pt. Area	9	10	47	53	38	18	68	32
(Crown Reefer Pt. only)*	(3)	(1)	(75)	(25)	(14)	(2)	(88)	(13)
Bat I.-Cyril Cove	26	97	21	79	49	128	28	72
Constantine Pt.	5	42	11	89	12	60	17	83
Makarius Pt., W. & Bay	1	18	5	95	3	20	13	87
Total	41	167	20	80	102	226	31	69
July 4 - August 13, 1969								
Crown Reefer Pt. Area	7	13	35	65	24	21	53	47
Bat I.-Cyril Cove	5	20	20	80	10	29	26	74
Constantine Pt.	2	13	13	87	6	19	24	76
Makarius Pt., W. & Bay	10	32	24	76	13	40	25	75
Rifle Range Pt.	9	42	18	82	14	55	20	80
Total	33	120	22	78	67	164	29	71
July 3 - 15, 1970								
Crown Reefer Pt. Area	3	1	75	25	14	5	74	26
Bat I.-Cyril Cove	2	10	17	83	5	17	23	77
Constantine Pt.	2	4	33	67	4	12	25	75
Makarius Pt., W. & Bay	4	18	18	82	8	23	26	74
Total	11	33	25	75	31	57	35	65

* Included in Crown Reefer Pt. Area Total

Table 6. Sex Composition of Subadult and Pup Sea Otters Captured for Transplants - By Area - Amchitka Island.

	Subadults				Pups				All Ages	
	M	F	%M	%F	M	F	%M	%F	%M	%F
June 23 - August 10, 1968										
Crown Reefer Pt. Area	28	5	85	15	1	3	25	75	68	32
(Crown Reefer Pt. only)*	(11)	(1)	(92)	(8)	(0)	(0)	(0)	(0)	(88)	(13)
Bat I.-Cyril Cove	19	26	42	58	4	5	44	56	28	72
Constantine Pt.	6	14	30	70	1	4	20	80	17	83
Makarius Pt., W. & Bay	0	0	0	0	2	2	50	50	13	87
Total	53	45	54	46	8	14	36	64	31	69
July 4 - August 13, 1969										
Crown Reefer Pt. Area	16	8	67	33	1	0	100	0	53	47
Bat I.-Cyril Cove	5	8	38	62	0	1	0	100	26	74
Constantine Pt.	2	5	29	71	2	1	67	33	24	76
Makarius Pt., W. & Bay	1	6	14	86	2	2	50	50	25	75
Rifle Range Pt.	2	12	14	86	3	1	75	25	20	80
Total	26	39	40	60	8	5	57	36	29	71
July 3 - 15, 1970										
Crown Reefer Pt. Area	9	3	75	25	2	1	67	33	74	26
Bat I.-Cyril Cove	3	5	38	63	0	2	0	100	23	77
Constantine Pt.	1	6	14	86	1	2	33	67	25	75
Makarius Pt., W. & Bay	2	4	33	67	2	1	67	33	26	74
Total	15	18	45	55	5	6	45	55	35	65

* Included in Crown Reefer Pt. Area Total

Table 7. Combined Sex and Age Composition of Sea Otters Captured for the 1968, 1969 and 1970 Transplants - By Area - Amchitka Island.

		Adults		Subadults		Pups		All Ages	
		M	F	M	F	M	F	M	F
Crown Reefer Pt. Area	No.	19	24	53	16	4	4	76	44
	%	44	56	77	23	50	50	63	37
(Crown Reefer Pt. only)*	No.	(3)	(1)	(11)	(1)	(0)	(0)	(14)	(2)
	%	(75)	(25)	(92)	(8)	(0)	(0)	(88)	(13)
Bat Island-Cyril Cove	No.	33	127	27	39	4	8	64	174
	%	21	79	41	59	33	67	27	73
Constantine Pt.	No.	9	59	9	25	4	7	22	91
	%	13	87	26	74	36	64	19	81
Makarius Pt., W. & Bay	No.	15	68	3	10	6	5	24	83
	%	18	82	23	77	55	45	22	78
Rifle Range Pt.	No.	9	42	2	12	3	1	14	55
	%	18	82	14	86	75	25	20	80
Total	No.	85	320	94	102	21	25	200	447
	%	21	79	48	52	46	54	31	69

* Included in Crown Reefer Pt. Area Total.

and 1970 transplant capture data with percentages broken down by age class. Table 8 presents the same information with percentages based on area totals. Hunters generally avoided females with pups on harvests and certain animals may be more susceptible to capture during transplants. Therefore, quantitative comparisons of samples must be general in nature.

Identification of Male Areas

Kenyon (1969) identified three male hauling grounds and 13 female hauling grounds on the southeast half of Amchitka Island. This was done by shore observations, collecting beach dead animals, capturing animals on the beach and finally by recording locations of animals shot on the 1962 and 1963 Alaska Department of Fish and Game harvests. The present study indicates that male areas remain discrete in offshore localities. In this discussion, male and female areas refer to the entire area and not just the immediate hauling ground. In general, all areas except male areas can be considered female areas even though there are some areas of marginal habitat that do not completely fit either category. Therefore the most effort has been directed at identifying male areas.

Identification of male areas can be made by shore observations particularly during the winter. However a more rapid technique is desirable for use in remote areas.

In June 1968, a survey of most of Tanaga and Kanaga islands was made by skiff to gather information to be used in planning harvests from those islands. During this survey, females with pups were counted separately from single animals. No special effort was exerted to identify pups. When a female obviously had a pup, it was recorded. Large pups often were separate from the females and some otters were seen only briefly in waves, kelp or at a distance. Therefore, many pups probably were missed and the counts should be considered minimal. A similar count was attempted by helicopter around Adak, but, for various reasons, the results are not considered usable.

From the skiff survey, a number of areas were judged to be possible male areas. Usually these were points or more exposed areas where relatively large numbers of single animals, but no pups, were seen.

Shoal Point, Kanaga Pass (north of Eddy Rock) and possibly Naga Point and Cape Tusik were suspected male areas on Kanaga Island. Cape Sudak and Cape Amagalik were considered male areas on Tanaga Island and the area around Hazard Point and Annoy Rock in Kanaga Pass was believed to blend with the Eddy Rock area.

The best way to confirm the presence of male areas is to collect animals from these areas. Harvests were conducted on Kanaga in October, 1968 and on Tanaga in May, 1970. The sex ratios of the animals harvested are compared with the skiff survey pup counts in Table 9. The harvest areas are fairly broad, whereas male areas are usually only a few hundred yards wide. As a result, a harvest area may include both a male area and portions of female areas to either side.

Table 8. Combined Sex and Age Composition of Sea Otters Captured for the 1968, 1969 and 1970 Transplants - By Area - Amchitka Island

		Adults		Subadults		Pups		
		M	F	M	F	M	F	All Ages
Crown Reefer Pt. Area	No.	19	24	53	16	4	4	120
	%	16	20	44	13	3	3	100
(Crown Reefer Pt. only)*	No.	(3)	(1)	(11)	(1)	(0)	(0)	(16)
	%	(19)	(6)	(69)	(6)	(0)	(0)	(100)
Bat Island-Cyril Cove	No.	33	127	27	39	4	8	238
	%	14	53	11	16	2	3	100
Constantine Point	No.	9	59	9	25	4	7	113
	%	8	52	8	22	4	6	100
Makarius Point W. to Bay	No.	15	68	3	10	6	5	107
	%	14	64	3	9	6	5	100
Rifle Range Point	No.	9	42	2	12	3	1	69
	%	13	61	3	17	4	1	100
Total	No.	85	320	94	102	21	25	647
	%	13	49	15	16	3	4	100

* Included in Crown Reefer Pt. area total.

Hunting pressure is seldom evenly distributed over an area. Often, most of the kill in an area comes from one group of rocks. Therefore, the information in Table 9 must be tempered with some knowledge of how the hunting pressure was distributed.

KANAGA ISLAND

Shoal Point - While a few more females than males were taken in this area, the percentage of males is considerably higher than one would expect in a female area. Because weather was less than ideal, much of the hunting pressure was directed to areas other than Shoal Point. Most of the females probably came from these areas. Therefore, Shoal Point is considered to be a male area.

Naga Point - There is no strong evidence that this is a male area. While no pups were recorded on the survey, the total number of otters counted was not high. Fairly extensive hunting of the area under good conditions yielded a sex ratio that would be typical of a female area. Therefore, it is assumed that there is no male area near Naga Point.

Cape Tusik - Cape Tusik was suspected as a male area more because of the nature of the area than as a result of counts. The count included areas to both sides of the Cape which could contain females. Very little of the hunting was done at the Cape. Therefore, judgment on this area will have to be reserved until more information is available. Extensive hunting indicates that no male areas exist east of Cape Tusik to Cape Chlanak.

Kanaga Pass - From the count, it appears that a male area exists in the Pass, however the harvest area extended to Hive Rock and included a large portion of female areas. The area is too broad, as is shown in Table 9, where the number of pups counted for the whole area is relatively high. The results of the harvest confirm the conclusions drawn from the count. While the sex ratio for the entire area is roughly equal, most of the males came from Kanaga Pass. Some females without pups came from that general area but the majority of the females came from the area northeast of the Pass.

TANAGA ISLAND

The Tanaga harvest showed the male areas more distinctly for several reasons. The total harvest was higher, the entire count area was covered in the harvest and the hunting pressure was recorded more precisely. Also, as will be shown later, sexual segregation is more pronounced in the spring.

Cape Sudak - Most of the hunting pressure was concentrated on the tip of the Cape although some pressure was exerted on the area near Pendant Point which is a female area, as shown by the count. The high percentage of males harvested from this area clearly confirms that the tip of the Cape is a male area.

Table 9. Comparison of Number of Sea Otter Pups Counted with Sex Ratio of Harvest.

Area	June, 1968 Survey	October, 1968 Harvest				
			Adults		All Ages	
KANAGA ISLAND	Pups/100 Indep. Otter	Pups/100 Indep. Otter	%M	%F	%M	%F
Round Head-Shoal Point	0	8.5	34	66	47	53
Naga Point-Kanaga Bay	6.6	16.4	18	82	21	79
Cape Chlanak-Cape Tusik	5.1	19.3	24	76	35	65
Eddy Rock-Hive Rock	6.1	3.4	36	64	47	53

Area	June, 1968 Survey	May, 1970 Harvest				
			Adults		All Ages	
TANAGA ISLAND	Pups/100 Indep. Otter	Pups/100 Indep. Otter	%M	%F	%M	%F
Cape Sudak-Pendant Point	0	4.4	61	39	66	34
Barnes Point-Trunk Point	7.9	5.9	3	97	8	92
Trunk Point-Twin Bays	2.6	4.2	8	92	14	86
Twin Bays-South Bay	9.6	11.1	7	93	14	86
South Bay-Harem Rock	14.8	3.1	7	93	9	91
Lash Bay-Inferno Reef	—	1.5	73	27	75	25
Harem Rock-Kulak Point	0	2.7	64	36	68	32
Kulak Point-S.E. Bight	6.9	8.2	13	87	15	85

Annoy Rock/Hazard Point - The harvest did not confirm this area as a male area. However, the weather was marginal and this area was too rough to hunt. Therefore, the otters taken in the harvest were from either side of the Point and almost none were taken from the portion that is suspected to be a male area. Kanaga Pass is narrow and shallow and otters feed in all parts of the Pass when weather and tide rips permit. This could be considered a single male area that serves both islands.

Cape Amagalik - Two harvest areas overlap this area, Lash Bay-Inferno Reef and Harem Rock-Kulak Point. The kill from both areas strongly reflects the presence of a male area. Most of the hunting pressure was concentrated on Inferno Reef and this is probably the main male area.

As shown above, four major male areas were identified from a relatively superficial pup count. No male areas were located during the harvests that had not already been identified from the count. While more detailed observations, including field identification of males, would be desirable, the pup counting technique appears to be an acceptable method.

Identification of Male Areas from Harvests

Because male areas are usually on well exposed points, it is possible to select likely areas from a nautical chart and then confirm these areas by collecting animals. This method avoids the expense, time and danger involved in surface surveys of remote areas. Actual collection of animals also provides the most concrete proof of the nature of an area.

The following is a description of the sex composition of areas for which no skiff count data were available.

Delarof Islands - No attempt was made to predict the location of male areas in the Delarof Islands. This is a difficult area in which to work. Ogliuga Island, Skagul Island and a portion of Ulak Island were hunted on May 9, 1970. The hunting effort in the afternoon was concentrated around Tag Island and the rocks south of Skagul Island. While the entire kill is lumped together, most of the males were taken in the afternoon. The percentage of males taken for the day is higher than would be expected if only female areas were hunted. Most likely there is a male area near Tag Island.

Adak Island - Portions of Adak were hunted in 1967 and 1968. No attempt was made to identify male areas before or during either harvest. The harvest figures indicate that no male areas have been hunted. The Bay of Islands is a classical female area. Results of extensive hunting in the Bay and around Eddy Island indicate that there is definitely no male area there. The percentage of males taken between Mid Point and Blind Point was higher than might normally be expected in a female area, however the scarcity of subadult males indicates that no male area exists within this region. A large congregation of otters is often seen near Finger Shoals. This could be a male area, but we have no information from there. If it is a male area, a few stray males from there could account for the slightly higher number of males in the kill.

Amchitka Island - The three male areas identified by Kenyon (1969) still exist and are frequently used as a source of males for transplants or scientific collections. Extensive collecting has demonstrated that no other male areas exist within the area intensively studied by Kenyon. Several potential male areas outside of Kenyon's study area were selected by examining the topography shown on nautical charts. These areas are the north side of Vista Island near Chitka Point, either Bird Rock and Oglala Pass or Aleut Point, and Juxta Point. The Oglala Pass area has not been investigated, however collections in June, 1971 demonstrated that Vista Island is a female area with mostly females without pups using the north side (Tables 10 and 11, Area D-5). James Estes (pers. comm.) has concluded from shore observations that both Juxta Point and Sea Otter Point are male areas. Sea Otter Point was included in the 1970 harvest area, but it is unlikely that any animals were shot there and the presence of a male area was not evident in the kill (Tables 2 and 4, Crown Reefer-Chitka Cove). In the June, 1971 collection, Sea Otter Point was confirmed as a male area (Tables 10 and 11, Area C-10). No animals have been collected at Juxta Point.

The numbers of sea otters caught in each net in 1971 were small (Table 12) but tend to confirm that a relatively sharp dividing line occurs between male and female areas even in the water. The eastern boundary of the Crown Reefer male area was sharply delineated, with 100 percent males caught in nets 6 and 7 directly off the tip of the point while net 5, just south of the Point, caught mostly females. Net 14 near Ivakin Point caught more males than females, however this area is known to be a female area from both past information and the collection immediately after this capture. The net was not in operation long and the fact that it caught more males was probably a result of an inadequate sample.

Composition of Female Areas

Kenyon (1969) found that 93 percent of the adult otters and 63 percent of the juvenile otters in female areas were females. The May samples from the 1970 harvest agree with this. The mean percent of adult females in female areas was 93 percent (Table 2). The mean percent of subadults, not including pups, was 73 percent (Table 4). However, in the September and October samples only 77 percent of the adults in female areas were female (Table 1) while about 86 percent of the subadults were female (Table 3).

The seasonal difference in the sex ratio of adults is consistent for all samples. These seasonal changes are most likely due to adult males moving into female areas to look for estrous females. During late winter and spring, breeding activity is at the lowest point of the year and

Table 10. Sex Composition of Sea Otters Collected at Amchitka - By Area - June 24-28, 1971.

Area	Adults					All Ages			
	M	F	(F W/Pup)	%M	%F	M	F	%M	%F
A-2		12	(2)	0	100	2	15	12	88
C-2		2	(2)	0	100	1	3	25	75
C-3		5	(5)	0	100		11	0	100
C-5		2	(1)	0	100	1	2	33	67
C-7		2	(1)	0	100	1	3	25	75
C-8	1	12	(6)	8	92	6	17	26	74
C-10	2			100	0	5		100	0
D-2	1	3	(3)	25	75	2	5	30	70
D-3		3	(1)	0	100		4	0	100
D-4		2	(1)	0	100	1	2	33	67
D-5		4		0	100		5	0	100
M-6		4	(2)	0	100		6	0	100
M-5		1		0	100		1	0	100
Total	4	52	(24)	7	93	19	74	20	80

Table 11. Sex Composition of Pup and Subadult Sea Otters Collected at Amchitka - By Area - June 24-28, 1971.

	Subadults				Pups				All Ages	
Area	M	F	%M	%F	M	F	%M	%F	%M	%F
A-2	0	2	0	100	2	1	67	33	12	88
C-2	0	0	0	0	1	1	50	50	25	75
C-3	0	1	0	100	0	5	0	100	0	100
C-5	0	0	0	0	1	0	100	0	33	67
C-7	0	1	0	100	1	0	100	0	25	75
C-8	0	3	0	100	5	2	71	29	26	74
C-10	3	0	100	0	0	0	0	0	100	0
D-2	0	0	0	0	1	2	33	67	30	70
D-3	0	0	0	0	0	1	0	100	0	100
D-4	0	0	0	0	1	0	100	0	33	67
D-5	0	0	0	0	0	1	0	100	0	100
M-6	0	0	0	0	0	2	0	100	0	100
M-5	0	0	0	0	0	0	0	0	0	100
Total	3	7	30	70	12	15	44	56	20	80

Table 12. Sex and Age Ratios of Sea Otters Captured - By Net Location - Amchitka Island. June, 1971.

Net Location	Adults				Subadults				Pups		All Ages			
	M	F	%M	%F	M	F	%M	%F	M	F	M	F	%M	%F
1	0	3	0	100	0	0	0	0	1	0	1	3	25	75
2	0	3	0	100	0	1	0	100	1	0	1	4	20	80
3	0	3	0	100	0	0	0	0	0	0	0	3	0	100
4	0	6	0	100	0	4	0	100	1	1	1	11	8	91
5	1	2	33	67	1	4	20	80	0	0	2	6	25	75
6	1	0	100	0	6	0	100	0	0	0	7	0	100	0
7	0	0	0	0	2	0	100	0	0	0	2	0	100	0
8	1	3	25	75	0	0	0	0	0	0	1	3	25	75
9	0	1	0	100	1	0	100	0	0	0	1	1	50	50
10	0	1	0	100	0	1	0	100	0	0	0	2	0	100
11,12,13	0	7	0	100	2	12	14	85	0	0	2	19	9	91
14	2	1	67	33	1	0	100	0	0	0	3	1	75	25
15	0	2	0	100	0	0	0	0	0	0	0	2	0	100
16	0	2	0	100	0	1	0	100	0	0	0	3	0	100
Total	5	34	13	87	13	23	36	64	3	1	21	58	27	73

fewer females are entering estrus. In fall, the number of estrous animals is at its peak and presumably more sexually mature males move into the female areas to breed. It is interesting to note that there were about three times as many males in female areas in fall as in winter and spring. Information from female reproductive tracts indicates that approximately three times as many females would be in estrus at any given time in fall. It appears that the number of adult males in a female area is directly proportional to the number of estrous females. From the data collected, there appears to be 1.5 to 2.0 males for each female with enlarged follicles in female areas at any given time, however hunter bias might influence this figure.

Ages have been estimated for otters harvested in 1968 on the basis of cementum layering. These age data indicate that virtually all of the males in prime female areas are either pups (or very young subadults) or are seven years old or older. No males between the ages of two and six were found in the Bay of Islands on Adak Island. This strongly implies some form of territorial behavior among actively breeding males. Fighting among males has not been reported often, however a mature male at the Tacoma Zoo became intolerant of a subadult male in the presence of females. They frequently "fought" although neither seemed to attempt to injure the other. Finally, the young male had to be removed. Under wild conditions, the young male might have moved out of the area without repeated physical encounters.

Kenyon (1969) described the breeding behavior of sea otters. His description indicated that males patrolled an area and two to four males may pass a given point during a three or four hour period. Vandevere (1970) observed some males apparently defending a territory in California, but from his observations, it appeared that successful breeding males were more mobile.

The fact that the number of males does appear proportional to the number of estrous females indicates that competition for these females may play an important part in regulating the number of males in female areas.

The number of subadults in the harvested samples is relatively low, so fluctuations in sex ratio may be due to sampling errors. However, the greater number of subadult males found in female areas in winter and spring may be a true increase made possible by the reduction in the number of breeding males. A subadult male would have fewer encounters with breeding males at that time.

There are areas within what would normally be considered female areas where subadult males tend to congregate, particularly during the winter. These appear to be areas with a marginal food supply that are not heavily used by females. Because there are few mature females in these areas, there are also very few breeding males. The subadult males using these areas seem to be transients that find less pressure from

Table 4. Numbers of Corpora Albicantia and Corpora Lutea found in 55 Mature Females. Amchitka - June-August 1968

	NUMBER OF CORPORA ALBICANTIA										
AGE (Years)	1	2	3	4	5	6	7	8	9	10	11
0-1											
1-2											
2											
3											
4	1	1									
5	2(1)										
6	1	1(1)									
7		2(1)	1								
8		1		1(1)							
9				2(1)	1(1)	1(1)					
10	1(1)	4(3)	2								1(1)
11						2(1)	1				
12	1(1)		2(1)	1(1)							
13									1		
14					1	1(1)					
15					2		1				
16					1						
17											
18											
19					1						

Numbers inside parentheses = Number of individuals with corpus luteum.

Table 13. Reproductive Stage of Sexually Mature Sea Otters Harvested on Tanaga Island - By Area - May 1970.

Area	Nonpregnant	Unimplanted Pregnant No.	Unimplanted Pregnant %	Implanted Pregnant No.	Implanted Pregnant %	Fetus Weight Class* 1	2	3	4	5	Resorption	Total
Cape Sudak-Pendant Point	12	7	26	8	30	0	2	0	3	2	2	27
(Barnes Point-Hot Springs Bay	12	7	24	10	36	3	0	1	4	2	2	29
(Barnes Point-Trunk Point	11	6	25	7	29	0	3	1	3	0	2	24
(Trunk Point-Twin Bays	7	9	39	7	30	2	1	1	1	2	2	23
(Hazard Point-Twin Bays	4	3	27	4	36	0	0	1	1	2		11
(Twin Bays-Herd Rock	12	8	28	9	31	1	1	1	4	2		29
(Twin Bays-South Bay	2	9	45	9	45	3	0	1	1	4	1	20
(South Bay-Lash Bay	6	9	29	16	51	1	0	0	9	6	1	31
((South Bay-Harem Rock	17	14	31	14	31	2	0	1	5	6		45
((Lash Bay-Inferno Reef	4	1	9	6	55	2	1	1	0	2		11
(Harem Rock-Kulak Point	12	6	29	3	14	1	0	1	1	0		22
Kulak Point-S.E. Bight	13	9	28	10	31	2	0	1	2	5		32

Brackets indicate overlapping areas.

* 1 = 0-1 g, 2 = 1-10 g, 3 = 10-100 g, 4 = 100-1000 g, 5 = 1000+ g

waters. In some areas, such as Crown Reefer Point on Amchitka, there is a male area near the tip of a point and males congregate directly offshore. However, to either side of these male congregations, there are females that are not accompanied by a pup and probably do not have large fetuses. In this way, we may find segregation in a single kelp bed off a point. If we set a net near the outer margin of the kelp, we will catch almost all males. However, if we set a net to the side of the bed and closer to shore, we will catch mostly single females. Nets set in a nearby bay will catch more females with pups.

Table 13 shows that an unusually high number of embryo resorptions were found between Cape Sudak and Twin Bays. This is probably a reflection of poor physical condition of the otters in that area and should not be considered an example of segregation within the population.

Composition of Male Areas

As mentioned earlier, the harvest areas were broader than any male area. Harvest areas containing male areas also contained portions of female areas. Our identification of the location at which each animal was collected was not always precise enough to determine the exact composition of these male areas. Kenyon's (1969) data from winter and early spring harvests are more precise. His data indicate that at that time of year, 98 percent of the adults and 80 percent of the juveniles using male areas were males. Of 128 males in male areas, 100 were adults and 28 were juveniles. That the percentage of males in male areas is extremely high in summer is indicated by the limited data collected during the 1971 transplant where nets 6 and 7 were set in the male area at Crown Reefer Point at Amchitka (Table 12).

Other experience from netting in the summer and harvesting in fall indicates that the percentage of males in male areas remains very high all year. While adult females may be very close to male areas, it appears unlikely that a significant number regularly use these areas at any time of year. Adult males enter female areas regularly and in predictable numbers for a specific purpose, but females probably enter male areas only occasionally in stray movements.

Juveniles of both sexes probably move more randomly than adults. While definite sexual segregation exists among younger animals, it is not as pronounced as in adults. Because subadult males are tolerated less by breeding males, they are more strictly confined to small areas than females of the same age. This has been demonstrated in fall harvests where extensive hunting over large female areas will turn up only an occasional subadult male. Then when the hunters move to a definite male area, large numbers of subadult males are taken in a very short time and in a very small area.

While Kenyon's (1969) data indicate that 22 percent of the males in male areas are subadults, our experience indicates that this percentage may be quite a bit higher in fall. Such a seasonal change in the age composition of males is reasonable. We have demonstrated that adult males move into female areas in greater numbers in the fall, perhaps tripling their numbers in these areas. At the same time, fewer subadult males are found in the female areas. Presumably the adult males are coming from male areas and the subadults driven from the female areas move to the same male areas. The result would be a higher percentage of young males in male areas in fall than in spring.

The total number of males of all ages in female areas doubles in fall. About 13 percent of all animals taken in these areas in spring were males while 25 percent taken in fall were males. This suggests that the total number of males in male areas declines in fall. There are more adults leaving than subadults entering the area. A series of shore counts at different times of year has been started at Amchitka Island. Preliminary results indicate that the reduction in total numbers of otters in male areas in fall is substantial. The results of these counts will be reported when more information is available.

Population Sex Ratio

All evidence indicates that there are more females in the population than males. With the sexes segregating and with the degree of segregation changing seasonally and between age groups, it is extremely difficult to get a completely random harvest. As a result, we have not been able to determine the sex ratio of any population as a whole. With female areas being larger and in more protected areas where hunting is easier, there is a strong tendency to take more females than males, particularly in spring. We have found that, through a concentrated effort, the percentage of males harvested can be increased, however even then the lowest percentage of females taken in recent harvests was 62 percent on Kanaga Island in October 1968. Similar results occurred in capturing operations for transplants.

On all islands studied, there are fewer male areas than female areas. The male areas are very small, usually only a few hundred yards wide. In short, that portion of the total available sea otter habitat included in male areas is very small. While the percentage of males is probably greater than that indicated by most harvest statistics, it appears that at least 60 percent of the sea otters in the populations studied are females.

Ratio of Subadults to Adults

Table 14 presents the ratio of subadults to adults taken in various areas from 1962 to 1971. The percentage of subadults varies because of sample size and the fact that the percent varies from area to area. For example, prime female areas probably have the lowest numbers of subadults while male areas and some areas of marginal habitat have a high percentage of subadults. Transplants probably take a slightly higher

Table 14 - Ratio of Subadult to Adult Sea Otters Taken in Transplants and Harvests.

Area		Adults	Subadults	% Subadults
Harvests				
Adak 1967 (Bay of Is.)		264	23	8
1968		148	32	18
Kanaga 1968		224	64	22
Tanaga 1970		444	134	23
Delarofs 1970		100	31	23
Amchitka 1962 & 63 (Kenyon)		344	119	26
Amchitka 1970 Areas C, D, & E		68	8	11
Area I		92	18	16
Amchitka 1971 Area A, C, & D		56	10	15
Transplants				
Amchitka (Area A & B)	1968	189	98	34
	1969	60	44	42
	1970	22	27	55
	1971	39	36	48
Amchitka (Area K & L)	1968	19	0	0
	1969	93	21	18
	1970	22	6	21

Table 15. Ratio of Subadult to Adult Sea Otters Taken in Transplants Between Crown Reefer Pt. and Ivakin Pt., Amchitka Island

	Adults	Subadults	% Subadults
1968			
Crown Reefer Pt. Area	19	33	63
Ivakin Pt.-Cyril Cove	170	65	28
1969			
Crown Reefer Pt. Area	20	24	55
Ivakin Pt.-Cyril Cove	40	20	33
1970			
Crown Reefer Pt. Area	4	12	75
Ivakin Pt.-Cyril Cove	18	15	45
1971			
Crown Reefer Pt. Area	5	14	73
Ivakin Pt.-Cyril Cove	34	22	39

percentage of subadults than harvests, but the numbers caught at Rifle Range Point and Makarius Point (Table 14, areas K and L) indicate that this is not always true.

There has been an increase in the percentage of subadults captured between Crown Reefer Point and Ivakin Point (Table 14, areas A and B). The percentage of subadults taken in male areas is always high. Therefore the Crown Reefer Point data are shown separately in Table 15 so that changes in the remaining female area can be examined.

There were 28 percent subadults caught in 1968 between Ivakin Point and Cyril Cove. This percentage increased to 45 over the next two years. In 1971 the percentage dropped slightly. The increase is probably a result of the high number of animals removed from this area. Most of the animals moving in to replace those removed were probably subadults. Conversely, harvests showed a low percentage of young animals in adjacent areas in 1970 and a slightly higher number in 1971.

The reduction in the number of subadults between Ivakin Pt. and Cyril Cove in 1971 may be due to two things. First, the animals were generally heavier and in better condition in 1971. Some subadults may have been classed as adults because they were heavier. Second, the number of animals removed in 1970 was comparatively small, possibly permitting less influx of new animals. The slight increase in adjacent areas in 1971 may be a result of this second factor, but the difference is too small to yield any definite conclusions. If the second factor is operating, one would expect fewer subadults to be caught between Ivakin Point and Cyril Cove in subsequent years.

RECOMMENDATIONS

More data should be collected whenever animals are being caught or harvested. Efforts should be made to record the exact location where each animal is collected particularly in and around male areas.

When cementum age data for the animals collected during harvests become available, the data presented in this report should be reevaluated for a more precise picture of the distribution of different age groups.

Shore counts should be continued at Amchitka every three or four months with emphasis on male areas to determine seasonal fluctuations in the number of animals using these areas.

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JOB PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Karl B. Schneider		
Project No.:	W-17-4	Project Title:	Marine Mammal Investigations
Job No.:	8.10R	Job Title:	Age Determination of Sea Otter
Period Covered:	July 1, 1971 to December 31, 1971		

SUMMARY

Various techniques for sectioning and staining teeth were tested to develop a method of estimating the age of sea otters from cementum layers. A technique of staining longitudinal sections of decalcified premolars and incisors with Giemsa's stain was selected and slides of approximately 2000 sea otter teeth have been prepared in this manner.

A system of interpretation of the layers of cementum has been developed and this interpretation is currently being evaluated by comparing estimated cementum ages with other potential indicators of age.

A system for recording stages of tooth eruption was adopted and appears to be a more reliable indicator of age for pups and young subadults than cementum deposition.

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BACKGROUND

A technique for determining the age of sea otters (*Enhydra lutris*) would be useful for evaluating the effects of harvest levels through changes in age structure, growth rates and survival rates of populations. It would also be an important aid in evaluating reproduction, behavior and differential distribution of sex and age classes. Lensink (1962) devised a system of ten age classes based on tooth eruption, closure of sutures in the skull and changes in the shape of the skull. This system was useful only for pups and subadults and he had to guess at the ages represented by each class. Kenyon (1969) used body weight to roughly separate pups, subadults and adults during his studies in the late 1950's and 1960's. Kenyon also reported efforts by V. B. Scheffer and the Research Division of the American Dental Association, National Bureau of Standards to locate layering in sea otter teeth that might be useful for age determination. These experiments included such techniques as X-ray photography and ultraviolet radiation. No useful indication of annual growth layers was found.

Klevezal and Kleinenberg (1967) reported that the age of sea otters could be determined from cementum layers in sections of canines stained with hematoxylin. A similar technique was employed at the start of the present study in 1967 (Vania et al 1968). The results with canine cross sections were poor, but the use of other teeth and longitudinal sections produced encouraging results. Evidence from a single, seven year old, known-age animal indicated that light and dark layers were laid down in the cementum annually (Vania et al, 1969). This study has been continued to the present time, however, between January 1, 1969 and December 31, 1970 it was carried on as a Survey and Inventory activity. During this period, efforts were directed at refining the technique for staining tooth sections and learning how to interpret the layers in a large number of teeth. Because the results of this work have not been reported previously, they are included in this report.

OBJECTIVES

To develop a technique for determining the age of sea otters.

PROCEDURES

Teeth were collected from approximately 2000 sea otters that were taken during harvests in 1967, 1968 and 1970 or died during transplant capture operations in 1968, 1969 and 1970. Early experiments showed that the upper and lower PM_1 and the upper I_3 had the most distinct annuli, the lower PM_1 being the most desirable. Therefore only these teeth were collected after 1967.

Teeth were handled in different ways to determine the best procedure. Teeth extracted from raw skulls were compared with those from steam-cooked skulls. Formic, nitric and hydrocloric acids were compared as decalcifying agents; different preservatives were tried for storing whole teeth and decalcified sections. Teeth were sectioned at different angles and different thicknesses. Several different stains and staining techniques were tried. Harris Hematoxylin, Paragon Multiple Stain for Frozen Sections and Geimsa's stain produced usable results and most of the experimentation was with these stains.

Undecalcified sections were examined with ultraviolet light, however results were not encouraging and this technique was not pursued.

Once the best combination of techniques had been selected, slides were made of teeth from all of the animals available. Teeth from the 1967 harvest were viewed under a variety of magnifications using both compound and stereo microscopes and a variety of light sources. Once familiarity with the variety of patterns of cementum layers was gained, all of the teeth collected in 1968 were "read" using the same interpretation. The estimated ages were then correlated with other potential indicators of age including weight, total body length and numbers of corpora albicantia.

One of the weakest areas of interpretation is in the animals' first three years of cementum deposition. A notation system for quickly recording the stage of tooth eruption and Lensink's (1962) age classes has been correlated with early cementum deposition in an attempt to determine when the first cementum layers are formed.

FINDINGS

Preparation of Tooth Sections

The following technique was selected for mass processing of sea otter teeth:

Teeth should be extracted from raw skulls whenever possible. Extraction is easier if the skulls have been allowed to decompose slightly. A "bulb" of cementum often forms at the root tip in older animals and it is necessary to chip the bone away from the tooth to free this portion. This bulb is important and care should be taken not to break it off. Any debris clinging to the root should be left intact as this protects the outer layers of cementum.

Teeth should be stored in Loess' solution. Those stored in one percent formalin or allowed to dry for long periods do not stain well.

The tooth is decalcified in three percent HCl until soft. The time required for sufficient decalcification will depend on the volume of acid used, the number of teeth decalcified in this volume, temperature, and the size of the tooth. When 50 teeth are placed in individual, perforated capsules and decalcified in approximately one liter of acid solution, incisors soften after 18 to 24 hours and premolars after 8 to 24 hours. Teeth are rinsed for a minimum of half a day in a constant exchange of tap water and then stored in water in a refrigerator.

An attempt should be made to section teeth immediately after the water rinse. If teeth must be stored for longer than a week before sectioning, Loess' solution is the most acceptable preservative. Teeth in Loess' solution must be soaked in water prior to sectioning to avoid incomplete freezing in the cryostat.

Longitudinal, sagital sections, 32 microns thick, are cut on an International Equipment Company cryostat at -14 C. Sections are taken as close to the center of the pulp cavity as possible. These sections are stained immediately or placed in Loess' solution for storage. Incisors crowns are trimmed before sectioning, but premolars are sliced untrimmed.

A working solution of Giemsa's stain is made up in small amounts and discarded when signs of heavy precipitation occur (usually after 30 min.) For 25cc of working stain use:

23.5cc distilled HOH

1.0cc Giemsa buffer solution pH 6.5 (Paragon) (PO_4 buffer, pH 6.8 is also usable)

0.5cc Giemsa stock stain (Paragon)

A small amount of stain (approximately 5cc) is poured into a small Petrie dish. Tooth sections are placed in the covered staining dish for 10 to 12 minutes. Sections that have been stored in Loess' solution are first rinsed in HOH. The sections are taken out of the stain, rinsed quickly in water and placed on a slide for viewing. If the degree of staining is acceptable, the slide is air dried vertically for 16 to 18 hours, and then placed in a Copeland jar containing xylene for final dehydration and clearing. The slide is dried with Kim Wipes, and mounted with Permount and a coverslip.

Estimating Age from Tooth Sections

A variable power, stereo microscope is used for viewing tooth sections. A flourescent illuminator produces a soft, uniform light and makes reading easier than an incandescent light source. The sections are usually viewed under 40 to 60X then the magnification is increased to 100 to 120X to examine areas where cementum layers are most distinct.

Sea otter teeth are difficult to read. Cementum layers tend to be irregular, the first few layers are often indistinct, occasionally double lines are formed, secondary dark lines may be difficult to distinguish from the normal dark annuli and very little cementum may be laid down in older animals. Precise age estimation from any single tooth is difficult and even an experienced worker will make errors. In order to reduce this error, it is necessary to carefully look over the entire area of cementum of several sections and to count layers at several different places.

Near the gum line, the cementum appears dense and layers tend to be very even and regular. However, on some teeth, there are many secondary lines in this area which may be impossible to separate from major lines. The first one or two layers may blend with the dento-cementum interphase. On older animals (eg. 8+), the outer layers may not be laid down this high on the tooth. However, this area often provides a good check to compare with other areas and on some teeth it is the only place where distinct layers can be seen.

The best area to count is usually the area near the tip of the dentine where the tooth curves in before forming the bulb of cementum at the tip. This is most pronounced on the anterior side of the tooth (directly below the cusp). At this point, the layers fan out and are easier to distinguish. It is the best and often only point at which the first two or three layers can be sorted out and is often the only area where outer layers on animals over 10 years of age can be found.

The layers in the bulb at the root tip are not distinct. However, broad bands are laid down and it is often possible to check the count from another area against the alternating lighter and darker bands found here.

With light transmitted through the section from below, one sees fine, dark lines separated by broad, light bands. For the purpose of counting, each dark line is considered to be one year.

There is an area of doubt because the first line is not necessarily laid down when the animal is one year old. The width of the band before line one varies. Because the animal may have been born at any time of year, an error of several months may occur.

On younger animals (less than 5 or 6 years), a light band at the outer edge, beyond the last dark line, is often written as a +, indicating that the final year was not yet complete. On older animals where layers are narrow, the outer edge is counted as the last year.

The following is a description of each line and how it has been interpreted in the teeth read to date:

Line 1: This line may blend in with the dento-cementum interphase on the sides of the tooth. It is easiest to distinguish around the tip of the root. A considerable amount of cementum is laid down in the "bulb" and the first line is sharpest just above the bulb. This line is usually easily distinguished on lower PM_1, but difficult to locate on other teeth. In some cases, there is no sharp line, only a slight change in coloration (density?) of the cementum.

Line 2: The band between lines 1 and 2 is usually broader than the band between the interphase and line 1. Line 2 is seldom sharp and is often visible in only one or two places. In some cases, it may be necessary to assume the existence of line 2 on the basis of the pattern of other lines and the width of the light band after line 1.

Line 3: The band between lines 2 and 3 is usually about the same width as that between lines 1 and 2, but may have to be estimated. 4th line will be the first sharp line.

Line 4: Often this is the first sharp line. This appears to coincide with sexual maturity in females. The band between lines 3 and 4 is usually similar in width to subsequent bands and thinner than the previous two bands. The cementum often appears more dense beyond line 3. The spacing between lines from 4 to 8 or 10 (occasionally farther) is fairly regular and the lines are fairly sharp. However, some lines will be sharper than others, some will run together in places and some may be double lines.

Line 8 or 10+: Around line 10 the lines may become irregular and visible at only a few points. Apparently less cementum is deposited after this. In some cases the 10th line may actually represent several years, causing the age to be underestimated. There are exceptions when there is an actual increase in cementum deposition and broad irregular bands are formed. Most of the teeth which have been read to 15 or more are of this type.

Tooth Eruption Notation System

The stage of eruption of each tooth is recorded in tabular form using the following format:

		1_1	I_2	I_3	C_1	PM_1	PM_2	PM_3	M_1	M_2
Upper	Deciduous									
	Permanent									
Lower	Deciduous									
	Permanent									

The right and left sides can also be broken down, however teeth usually erupt at the same time on both sides and it is sufficient to make a special notation when they do not.

The stage of eruption of each tooth is recorded by the following notation:

NE - Not erupted through bone.

E/1 - Erupted through bone but not through the gum.

E/2 - Just through the gum.

E/3 - Eruption 1/4 to 3/4 complete.

E - Fully erupted

O - Deciduous tooth shed.

This system can easily be applied to fresh heads. It is necessary to cut into the gum on some specimens, but complete cleaning of the skull is neither necessary nor desirable. Pups can be assigned to Lensink's (1962) age classes I through VI on the basis of this information.

Evaluation of the Technique

The only known-age tooth available is from a seven year-old female raised in captivity. This animal did not develop completely and sections from her tooth are not easy to read. However, there are seven dark layers indicating that these are laid down annually.

Correlation of estimated ages with measurements of body size, numbers of corpora albicantia, age of sexual maturity and age classes based on tooth eruption fit a pattern that does not indicate any flaws in the estimates. Such correlations compare one unknown with another and cannot be expected to prove the validity of the interpretation. However, any consistent error, particularly in younger animals, should cause irregularities in such things as growth curves. This evaluation is incomplete and the results will be reported when it is complete.

The irregularity of cementum layers, presence of confusing secondary lines, faintness of the early lines and variable birth dates make it impossible to precisely determine the age of most sea otters. Individuals using age data derived from this technique must recognize that estimated ages may be in error by one or two years. However, the data appear to be sufficiently accurate for most purposes, particularly when applied to large numbers of animals.

Tooth eruption appears to be a more reliable indicator of age than cementum deposition in animals in their first year of life.

RECOMMENDATIONS

Correlation of estimated ages with potential indicators of age including body and skull measurements should be completed. Particular emphasis should be put on correlating tooth eruption, suture closure and early skull growth with early cementum deposition to insure correct interpretation of the first few layers of cementum.

ACKNOWLEDGEMENTS

Jeanette Earnest assisted with early attempts at making longitudinal sections. Mary Schneider experimented with staining techniques and refined the final technique. She also processed the teeth collected in 1967 and 1968 and developed the tooth eruption notation system. Nicholas Steen processed the teeth collected in 1969 and 1970 with the help of Ken Pitcher.

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JOB PROGRESS REPORT (RESEARCH)

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Cooperators: Karl B. Schneider

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Job No.: 8.11 R Job Title: Reproduction in the Female Sea Otter

Period Covered: July 1, 1971 to December 31, 1971

SUMMARY

Information collected from the examination of 1358 sea otter reproductive tracts, collected at different times of year, was consolidated and analyzed with previously published data.

Sea otters may breed or pup at any time of year, but there are seasonal fluctuations in activity with the peak of breeding occurring during September, October and November and the peak of pupping during April, May and June. Two and a half to three times as many females breed or pup during periods of highest activity than during periods of lowest activity. The gestation period averages eight to nine months. About half of this time is spent in the unimplanted stage.

Female sea otters become sexually mature when three to four years old. They may ovulate an average of once a year after sexual maturity but normally only produce one pup every two years. More than one fetus develops in two percent of the pregnancies. Females rarely breed while lactating. Several months usually pass between weaning and the next pregnancy, however a female may breed shortly after losing a young pup.

Up to five percent of the pregnancies may fail due to *in utero* mortality of the conceptus.

Birth weights range from 900 g to 2500 g but average 1800 g to 1900 g. Pups born in areas where the population is declining as a result of food shortages may weigh 200 g less than normal at birth because of a shortened gestation period. There is no difference in the size or growth rates of male and female fetuses. The physical condition of the mother does not influence the rate of growth of the fetus. There is a rapid weight gain in the neonate shortly after parturition.

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BACKGROUND

The first observations of sea otter (*Enhydra lutris*) reproduction were made by Steller (1751). Very little new information was collected over the next 200 years. During the next 40 years, a number of isolated observations added to our knowledge, however, and these were summarized by Lensink (1962). No extensive studies of sea otter reproduction were attempted until the Alaska Department of Fish and Game began harvesting sea otters in 1962, making relatively large numbers of reproductive tracts available. Studies of the morphology of the reproductive tract and histological changes associated with the reproductive cycle were accomplished using these specimens (Sinha, 1965; Sinha et al, 1966; Sinha and Mossman, 1966; and Sinha and Conaway, 1968), however. Kenyon (1969) made the first real attempt at determining the rates and timing of reproduction on a population wide basis. These studies were based on fairly large samples from winter and early spring but unfortunately very little information was available for other times of year.

In 1967, the Alaska Department of Fish and Game resumed harvesting and large samples from other times of year became available. The Department began accumulating data at that time and preliminary findings were reported by Vania et al (1968).

PROCEDURES

A total of 1358 female sea otter reproductive tracts collected during harvests and transplants between 1967 and 1970 were examined. Because the only summer samples were from transplant mortalities and they probably are not comparable to samples collected during harvests, a collection was made in June, 1971 to provide a larger sample of summer information. Approximately 50 reproductive tracts from sexually mature females were collected, however these have not been processed and are not included in the following discussion.

Ovaries were weighed and the length of each uterine horn recorded. Ovaries were then sliced with a razor blade and examined macroscopically. Uteri were macroscopically examined both internally and externally. The presence and numbers of corpora lutea, corpora albicantia, large follicles, ovarian and extra-ovarian cysts and placental scars were recorded. Large follicles and corpora lutea were measured. The weight, length, sex, orientation, and location of pregnancy of each fetus were recorded. Each fetus was assigned to one of the following weight classes; Class 1 = 0-1 g, Class 2 = 1-10 g, Class 3 = 10-100 g, Class 4 = 100-1000 g, and Class 5 = 1000+ g. Notes were made on the appearance of the tract and of any abnormalties. From these data each tract was classified as to its stage in the reproductive cycle.

The following criteria were used in the classification:

Nulliparous - Horns of uterus small, thin and smooth. Usually no corpora lutea or corpora albicantia although there occasionally was evidence of a past ovulation, but no evidence of implantation.

Multiparous - Uterine wall thicker, corpora lutea and/or corpora albicantia present. This category includes primiparous animals which are not readily separated from multiparous animals.

Anestrus- Largest follicle under 3.5 mm, no corpus luteum.

Proestrus - Follicles over 3.5 mm.

Estrus - Follicles approximately 10 mm.

Unimplanted Pregnant - Corpus luteum present (usually under 10 mm and with a central antrum), no gross sign of implantation. The presence of a blastocyst was assumed using the criteria established by Sinha et al (1966).

Implanted Pregnant - Visible swelling in uterine horn, usually with fetal membranes, embryo or fetus visible. Corpus luteum usually over 10 mm.

Post-Partum - Uterine horn still noticeably enlarged; fresh, rough looking placental scar, newly formed corpus albicans with some luteal tissue remaining.

The appearance of the uterus was used to confirm the classification. The thickness and shape of horns, thickness and consistency of the uterine walls, coloration of the lining of the horns and condition of the rugae change with each stage. In most cases, it is possible to guess the condition of the tract by a superficial examination of its exterior. The appearance was used only to confirm what was indicated by structures in the ovary, however.

The reproductive data were placed on needle sorting cards which also contained information on the age, size, date and place and cause of death of each female and whether she was lactating or was observed to have a pup at the time of collection.

FINDINGS

Table 1 summarizes the reproductive condition of the sexually mature females in the samples that are large enough for comparison throughout the year. In the following discussion, samples reported by Sinha, et al (1966) and Kenyon (1969) are included where possible. The January and March samples are from their studies.

There may be some problems associated with comparing samples taken from different islands and in different years, but, allowing for sampling errors, the data for the most part fit a definite pattern, indicating that the annual cycle remains fairly constant. The one outstanding exception is the number of pregnant animals in the two summer samples. In 1968, there were many more implanted pregnancies than unimplanted pregnancies and in 1969 the situation was reversed, however the total number pregnant was almost identical. These are the weakest samples, because they are relatively small, they were collected over a longer period of time and they consist of transplant mortalities. An average of the two samples fits the pattern established by the other samples. Until the data from the June, 1971 reproductive tracts are available, we will have to avoid firm conclusions based on these samples. Relatively large samples are necessary because all stages of the reproductive cycle are found at all times of the year. The period from November to early January is not represented, however the rate of pregnancy is changing so rapidly during that period that any information from that time may be confusing unless a large sample was collected in a very short time.

The information in Table 1 is shown graphically with Kenyon's (1969) winter information in Figs. 1 and 2. It has often been demonstrated that sea otters breed and pup at all times of the year. A number of observers have noticed that more pups are born in the spring and summer than at other times and there have been conflicting reports about peak breeding times. Kenyon (1969) was the first to demonstrate seasonal changes in pregnancy rates but only his January and March samples were large enough to be reliable.

Figs. 1 and 2 demonstrate that there are considerable seasonal changes in the numbers of animals in each stage of the reproductive cycle. There is a definite period of increased breeding activity and a

Table 1 Reproductive condition of sexually mature sea otters

		Inactive ovaries			Active ovaries			Fetus Weight Class *					
Dates	Location	Anestrus	Post-Partum	Resorption	Proestrus + Estrus	Unimpl. Preg.	Impl. Preg.	1	2	3	4	5	Total
May 4-8,1970	Tanaga I.	51 (16.8)	41 (13.5)	10 (3.3)	10 (3.3)	88 (28.9)	104 (34.2)	17 (5.6)	8 (2.7)	10 (3.3)	35 (11.4)	33 (10.9)	304
May 9, 1970	Delarof Is.	18 (23.4)	14 (18.2)	1 (1.3)	4 (5.2)	13 (16.9)	27 (35.0)	10 (13.0)	0	3 (3.9)	6 (7.8)	8 (10.4)	77
May 10-12,1970	Amchitka I.	34 (24.6)	18 (13.0)	3 (2.2)	8 (5.8)	27 (19.6)	48 (34.8)	5 (3.6)	6 (4.3)	2 (1.4)	23 (16.7)	12 (8.7)	138
June 23 - August 13,1968	**Amchitka I.	17 (38.6)	2 (4.5)	1 (2.3)	2 (4.5)	4 (9.0)	18 (40.9)	1 (2.3)	2 (4.5)	3 (6.8)	5 (11.3)	7 (15.8)	44
July 6 - August 8,1969	**Amchitka I.	17 (36.9)	1 (2.2)	0	4 (8.6)	14 (30.4)	10 (21.9)	0	1 (2.2)	1 (2.2)	2 (4.3)	6 (13.2)	46
Sept.10-17, 1967	Adak I.	72 (43.9)	5 (3.1)	0	16 (9.8)	31 (18.9)	40 (24.4)	6 (3.7)	6 (3.7)	8 (4.9)	9 (5.5)	11 (6.7)	164
Sept. 25 - Oct. 6,1967	Amchitka I.	55 (47.8)	6 (5.2)	0	18 (15.7)	19 (16.5)	17 (14.8)	4 (3.5)	0	0	10 (8.7)	3 (2.6)	115
Oct. 12-15, 1968	Kanaga I.	58 (41.3)	6 (4.3)	1 (0.7)	13 (9.3)	31 (22.2)	31 (22.2)	4 (2.9)	4 (2.9)	7 (5.0)	11 (7.8)	5 (3.6)	140
Oct. 18-20, 1968	Adak I.	46 (46.0)	6 (6.0)	0	11 (11.0)	24 (24.0)	13 (13.0)	2 (2.0)	3 (3.0)	0	4 (4.0)	4 (4.0)	100

Numbers in parenthesis are percent of sexually mature females.

* Fetus weight class 1 = 0-1g, 2 = 1-10g, 3 = 10-100g, 4 = 100-1000g, 5 = 1000+g

** Transplant mortalities (all other samples from harvests)

Figure 1. Seasonal Fluctuations in the Reproductive Cycle of Female Sea Otters

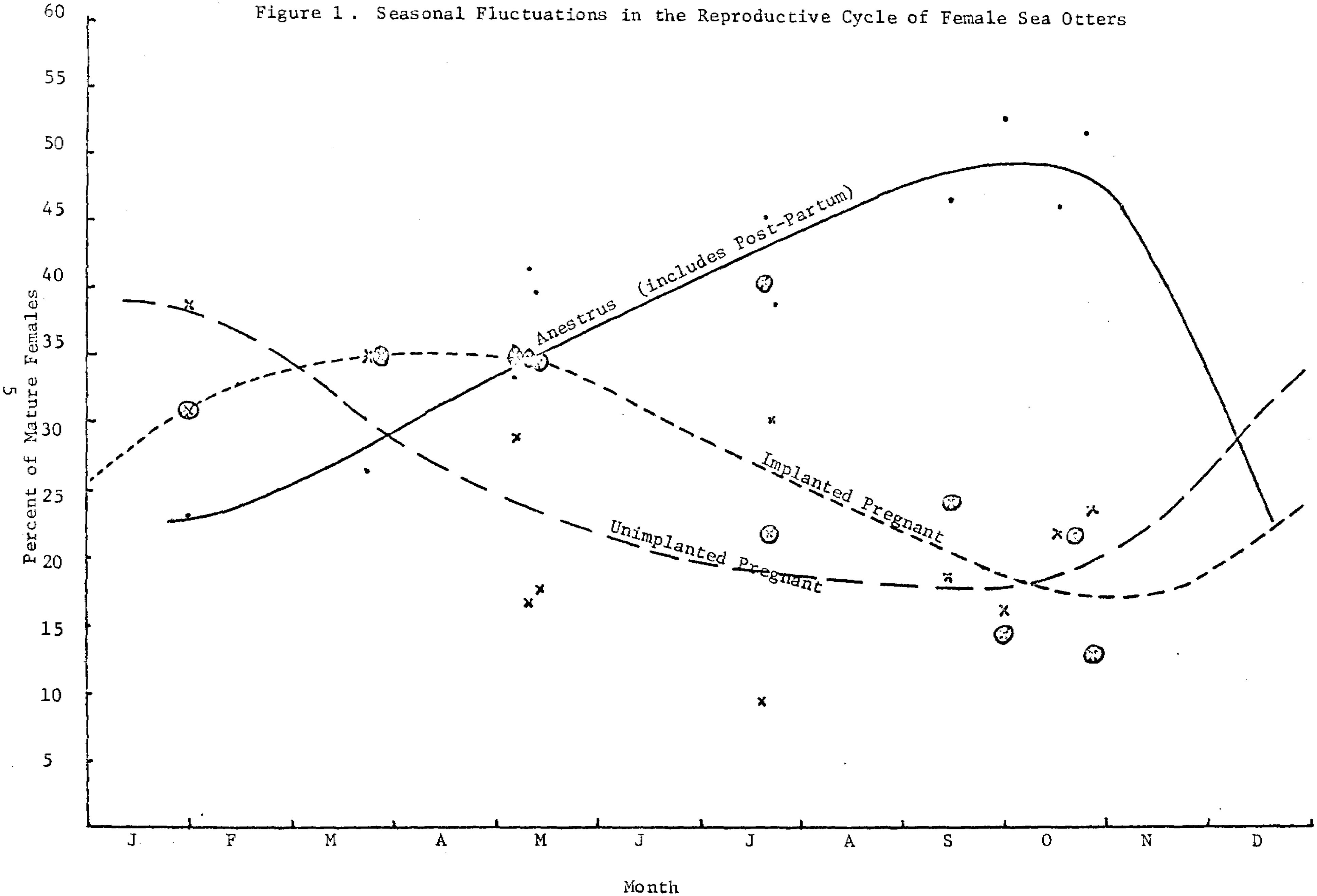
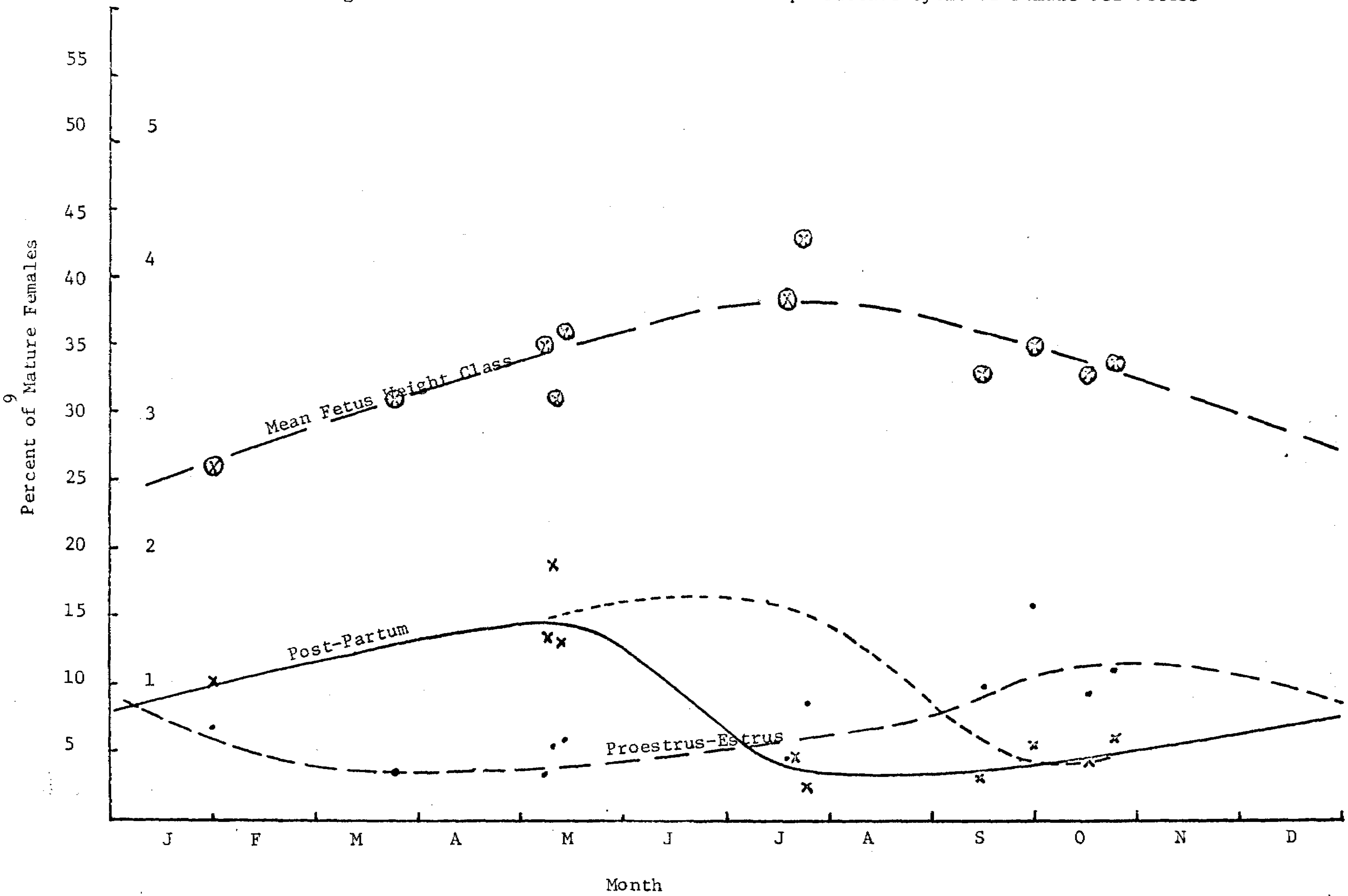


Figure 2. Seasonal Fluctuations in the Reproductive Cycle of Female Sea Otters



definite period of increased pupping. However, some animals are in each stage at all times of the year and periods of increased breeding and pupping do not have distinct boundaries.

Each curve is influenced by two factors so it is difficult to isolate the magnitude of any single factor. For example: the percentage of implanted pregnancies will increase as blastocysts implant and decrease as births occur. The birth rate may be increasing, but if the number of implantations increases at a greater rate the implanted pregnant curve will still rise. The animal remains in the anestrus, implanted pregnant, and unimplanted pregnant categories for a relatively long time and there may be considerable carry-over from one sample to the next. Because the animal spends a relatively short time in the proestrus-estrus and post-partum categories, there is little, if any, carry-over from one sample to the next and the changes between samples are more likely to be absolute changes. The mean fetus weight class probably does not mean much because it does not take into account the actual number of animals in each class. When there are many implanted pregnancies and the mean weight class is low, there actually may be more Class 5 fetuses in the population than when there are few implanted pregnancies and the mean weight class is high. Therefore, the actual percentages of all sexually mature females with Class 1 and Class 5 fetuses have been plotted in Fig. 3. These curves represent the actual number of fetuses in the population. Because the sample sizes become quite small when the fetuses are divided into classes and the summer sample is believed to be biased, two curves for each class are shown. The solid curves approximate the data while the broken curves represent subjective adjustments to correct for suspected sampling errors.

Discussion of the Annual Reproductive Cycle

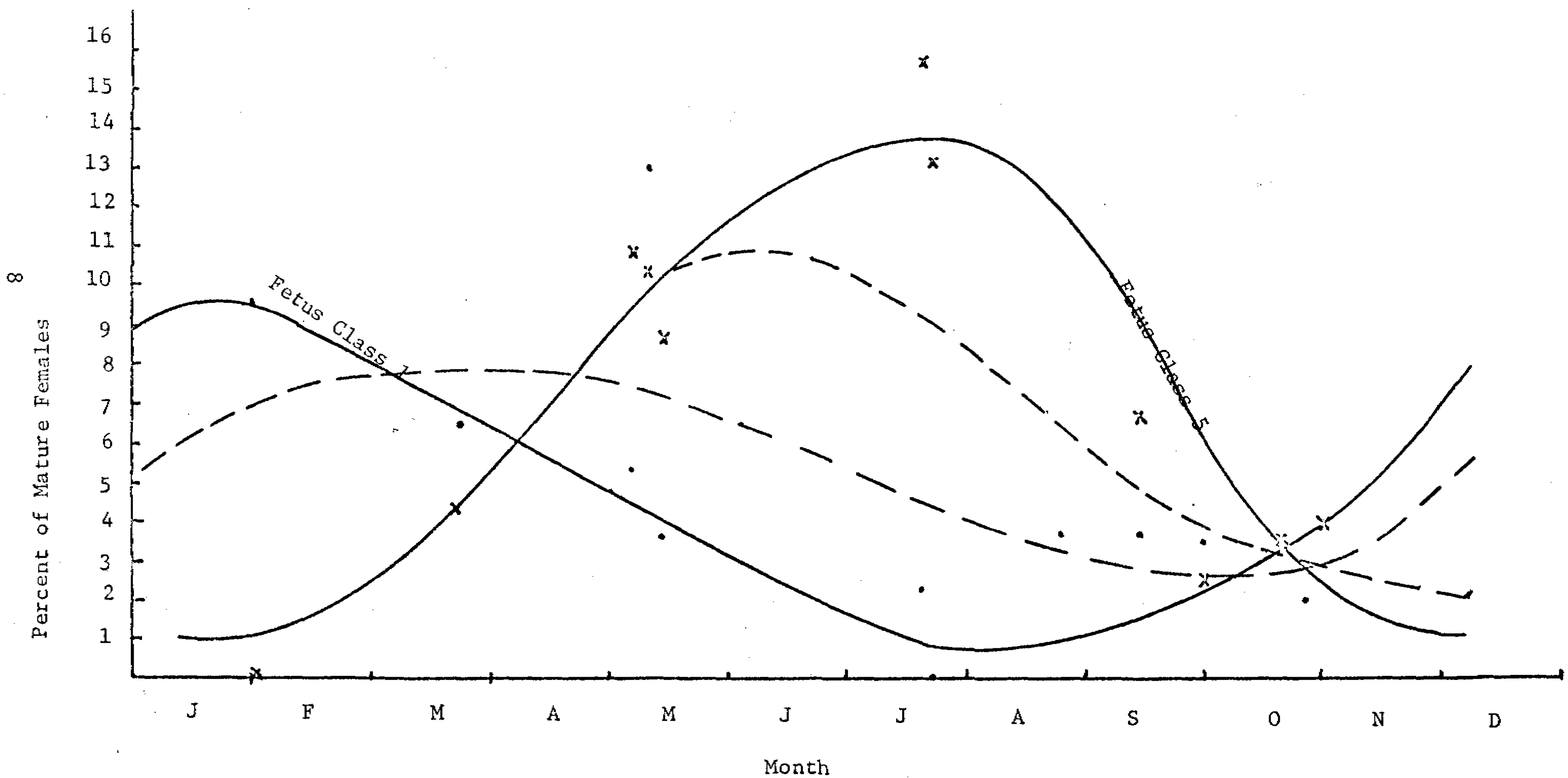
The number of animals entering estrus rises in the fall (Fig. 2). At this time, the pregnancy rate is at its lowest point and a high percentage of anestrous (nonpregnant) animals are in the population. Breeding activity increases and the number of sexually mature males in "female areas" increases.

The peak breeding season occurs during October and November. The number of unimplanted pregnancies begins to rise sharply during those months. At the same time, the number of anestrous animals drops as these animals enter estrus, breed and become pregnant (Fig. 1). The birth rate is at its lowest during this period as is shown by the low number of post-partum animals (Fig. 2) and the low number of large fetuses (Fig. 3).

By late November and December, the implanted pregnant rate is increasing even though the birth rate is increasing slightly. This is due to new blastocysts implanting as is shown by the increase in Class 1 fetuses (Fig. 3).

By January, the period of greatest breeding activity has declined and the number of unimplanted animals reaches a peak as the number of blastocysts implanting equals the number of conceptions. The unimplanted pregnancy rate then begins to decline as fewer animals breed and more blastocysts implant

Figure 3. Percent of Females with Weight Class 1 and 5 Fetuses



(Fig. 1). The greater rate of implantation is reflected by a rise in the Class 1 fetuses as well as an overall increase in the number of implanted pregnancies (Fig. 3). However, the rate of implantation is partially obscured by an increased birth rate removing animals from the total of implanted pregnancies. The increase in the birth rate is shown by the rise in post-partum females and a rise in Class 5 fetuses. This condition of a low rate of breeding, high rate of implantation and increasing rate of birth lasts from February to May.

The summer samples are the least reliable because they are smaller, were collected over a period of seven weeks and were from animals that died as a result of capture and handling. In addition females with very young pups are wary and are probably less likely to be caught in nets.

Females with large fetuses appear to be more likely to die from handling. In several cases, twisting of the reproductive tract containing a large fetus was the actual cause of death. Anestrous females (including post-partum) on the other hand are less likely to die. As a result, although the data show that the post-partum rate decreases sharply indicating a reduction in the birth rate, (Fig. 2), the number of Class 5 fetuses reaches a peak indicating a very high birth rate (Fig. 3). The true birth rate is probably somewhere between.

The birth rate remains relatively high during June and July. Kenyon's (1969) summer sample is limited but shows a large number of Class 5 fetuses. Again the sample is biased in favor of pregnant animals but not to large fetuses only. His field counts as well as observations by most other workers indicate an increase in the number of dependent young throughout the summer. The number of implanted pregnancies declines throughout the summer while the unimplanted pregnancy rate declines at a slower rate and breeding remains fairly constant at a low level (Fig. 1). This indicates that through June there are more implantations than conceptions, however the birth rate is substantially greater than the implantation rate. By late July and August there are relatively few implantations taking place as shown by a leveling of the unimplanted pregnant rate and a low number of Class 1 fetuses. The number of Class 5 fetuses declines as a result of births during June, July and August (Fig. 3).

Therefore the season of greatest pupping may be quite broad, running from April through August, possibly with the peak occurring in late May or June. Until the 1971 summer sample is processed we cannot pin down the peak of this "pupping season" with certainty.

Magnitude of Breeding and Pupping Peaks

If the data were precise, we could compare samples subtracting numbers of pups born and adding numbers of conceptions to determine the actual percent of females breeding, implanting and pupping in each month. Unfortunately, the data are not precise. Each curve is influenced by more than one factor and we do not know the magnitude of any of these factors. However, by comparing some of the major samples we may be able to get a rough idea of how much higher the birth rate is at one time of year than another.

The combined May samples and the combined September and October samples provide the best comparison. Both are large samples containing 519 sexually mature animals each. One occurs near the peak of pupping and a low point in breeding and the other is near the low point in pupping and the peak of breeding.

The numbers of Weight Class 5 fetuses, post-partum females, and proestrous-estrous females come closest to representing particular events. The time spent in each category is comparatively short.

There were approximately two and a half times as many Class 5 fetuses in May than in September-October (Fig. 3). There were also about three times as many post-partum females in May (Fig. 2). In September-October, there were two and a half to three times as many proestrous-estrous animals as in May (Fig. 2). It would appear that the peaks of breeding and pupping are roughly three times as high as the lowest points.

At the lowest period of pupping, two to three percent of the females have Class 5 fetuses (Fig. 3) and should pup within a month. If we assume the post-partum stage lasts 1.5 to 2 months (see Recovery of the Uterus), it also appears that two to three percent pup each month in the lowest months of pupping (Fig. 2).

Similarly, about three percent of the females have enlarged follicles during the lowest period of breeding (Fig. 2). We do not know how long this period lasts, however.

At the peak of pupping, about 10 percent of the females have Class 5 fetuses (Fig. 3) and should pup in the next month. About 15 percent are post partum (Fig. 2) indicating about 8 births per 100 sexually mature females in the preceding month.

These percentages are probably slightly high because hunters tended to avoid shooting females with pups. It appears that at least two to three percent of the mature females breed and two or three percent have pups in any month of the year. In the peak breeding months such as September and October, perhaps 7 to 10 percent breed each month and similarly in peak pupping months such as May, 7 to 10 percent of the mature females pup each month.

Gestation Period

Barabash-Nikiforov (1947) listed the gestation period for sea otter at eight to nine months. This apparently was based on a female mated in captivity as reported by Malkovich (1937). According to Barabash-Nikiforov, a pup was born eight months later although it died. While it was fully formed, it may have beem premature.

A number of births have occurred in captive animals held by the Department of Fish and Game. All of the pups were small, usually less than 1600 g, but larger than the smallest pups found in the wild. All died shortly after birth.

A gestation period of nine months has been repeated in the literature but apparently these statements are based on Barabash-Nikiforov (1947). Lensink (1962) also estimated a gestation period of eight to nine months based on field observations. He felt that the peak of breeding was in August or September and the peak of pupping was in March or April.

The gestation period of sea otters includes a relatively long period of delayed implantation (Sinha 1965, Kenyon 1969, and present study). Therefore any attempt to estimate the length of gestation by examination of reproductive tracts must take both the unimplanted and implanted periods into account.

Kenyon (1969) presented an estimate of the implanted period based on the assumption that the cube roots of fetus weights fall in a straight line after the embryo is established (Hugget and Widdas, 1951) and the assumption that the European otter and American river otter would have similar fetal growth rates. By plotting term fetus weights on a line established by the European otter he estimated an implanted gestation of about 120 days not including the period for establishment of the embryo. Kenyon (1969) then presented an estimate made by Dr. D. G. Chapman using the method of Hugget and Widdas (1951) where a regression line is fitted to the cube roots of the unweighted mean of the mean weights of fetuses in each of five weight classes plotted against the mean time of year.

Using this method Chapman estimated an implanted period of 154 days. From the mean percent of pregnant animals that are unimplanted pregnant, he estimated the unimplanted period as about 7.5 months. Allowing a half month for establishment of the embryo he estimated a total gestation period of 12-13 months.

The data used by Chapman included a January-February sample of 26, a March-April sample of 49 and a May-August sample of only 9. His estimate relies heavily on the small summer sample when fetus size is the greatest.

Table 2 presents a new estimate of the length of the implanted period using the Chapman method but incorporating data from the present study with Chapman's data. Table 3 presents a similar estimate of the length of the unimplanted period.

The following is a comparison of the two estimates:

	Chapman's Estimate	New Estimate
Unimplanted Period	230 days	66 days
Establishment of Embryo	15 days	15 days
Implanted Period	154 days	73 days
Total Gestation Period	399 days	154 days
or about	13 months	5 months

The latest estimate is not necessarily better than Chapman's even though it is based on larger samples. The growth velocity is twice as high as that calculated for fur seal and a five month gestation period is not consistent with other information available.

Table 2. Estimated Length of Implanted Period

Percent of Fetuses in each Weight Class

Time of Collection After January	Weight Class 1	2	3	4	5
1 month n = 26	31	15	15	38	0
3 months n = 49	18	12	22	35	12
5 months n = 179	18	8	8	36	30
7 months n = 28	3	8	16	29	45
9 months n = 47	20	7	10	40	23
10 months n = 44	14	18	12	33	23
Mean Time in Months After January	5.0	5.7	5.3	5.8	7.0
Cube Root of Unweighted Mean Weight	0.63	1.7	3.6	7.4	11.4

Specific Growth Velocity = 0.169/day
Estimated Implanted Period = 73 days

Table 3. Estimate of the Relative Length of Time the Blastocyst Remains Unimplanted

Months After January	Unimplanted Pregnant	Implanted Pregnant	Percent Unimplanted
1 month	35	26	58
3 months	49	49	50
5 months	128	179	42
7 months	22	37	37
9 months	50	57	47
10 months	55	44	56
Unweighted Average			48

Or: The blastocyst remains unimplanted for 48 percent of the total gestation period.

Obviously there is some problem with the samples, the technique or both. A similar calculation, made before the May sample had been collected, produced an estimate of 109 days for the implanted period and about 8 months for the total gestation period.

This method of calculation assumes that there are definite peaks in breeding and pupping. If breeding and pupping occurred evenly throughout the year, the average fetus size would remain constant throughout the year and the technique would not work. An ideal situation would be when all individuals breed and pup within a very short period. Peaks of breeding and pupping do occur in sea otter populations but they are not well defined. Very large samples collected throughout the year would be required in such a case, because there are always fetuses of all sizes and the periods of maximum breeding and pupping are broad.

Obviously Chapman's sample was inadequate. While the number of fetuses available for the new estimate seems large and well distributed throughout the year, the actual number in any one fetus weight class at any one time of year is small. A look at Table 1 shows that there is little consistency in many of the classes. Fig. 3 shows that Class 1 and 5 fetuses do fit a pattern.

All of the estimates rely very heavily on summer samples when the fetuses are largest. These samples are known to be biased, probably in favor of larger fetuses. There are actually more large fetuses at this time of year but it is still exaggerated in these samples.

This technique for estimating the implanted gestation period apparently is not capable of providing a reliable estimate with the available data. Therefore, the 12 or 13 month estimate and any calculations based on it are meaningless.

Much of the discrepancy lies in the estimate of the unimplanted period. My estimate that 48 percent of all pregnancies throughout the year are unimplanted is based on an even distribution of relatively large samples and is probably more accurate than Chapman's estimate of 60 percent, however.

There are several other ways of estimating the length of gestation. Kenyon's (1969) estimate of an implanted period of four months using the cube roots of term fetus weights cannot be relied upon entirely, but it may be closer than the other estimates. If we estimate the unimplanted period from this using the 48 percent unimplanted factor and allow for the establishment of the embryo, we get a total gestation period of about 8.5 months.

Lensink's (1962) method of determining the peak breeding and peak pupping periods and taking the time between the peaks as the total gestation period has merit. While Lensink tried to determine these peaks by field observations, we can determine them more accurately using information from reproductive tracts.

Lensink felt that the peak of breeding was in August or September. The data in Fig. 2 indicate that he may have seen the beginning of the period of greatest breeding activity, but that the peak is probably in September, October or possibly November. Lensink estimated the peak pupping period to be March or April. Again the data indicate that he was seeing the beginning of the period of greatest pupping, but the actual peak is probably in May, June or July. At this time, the number of Class 5 fetuses is greatest. Also at this time the number of post-partum females probably peaks and the number of implanted pregnant females drops from its peak. If the gestation period of the "average" animal lasts from September or October to May or June we get a period of eight or nine months, the lower figure probably being most accurate. While Lensink's timing was early, the duration agrees with the present data.

The peak of implantation when the greatest number of blastocysts are implanting can also be roughly estimated from Figs. 1 and 3. In February, the number of unimplanted pregnancies is dropping and the number of implanted pregnancies rising. Also, at this time the number of Class 1 fetuses probably reaches a peak.

Therefore it appears that the unimplanted period lasts four to five months and the implanted period from four to five months with a total gestation period of eight to nine months. It should be recognized that these estimates are based on general trends and not distinct changes. Therefore they are approximate. However, the relative length of the unimplanted and implanted periods agrees with the percentages noted previously and this estimate agrees with the one based on Kenyon's (1969) comparison with other species of otters.

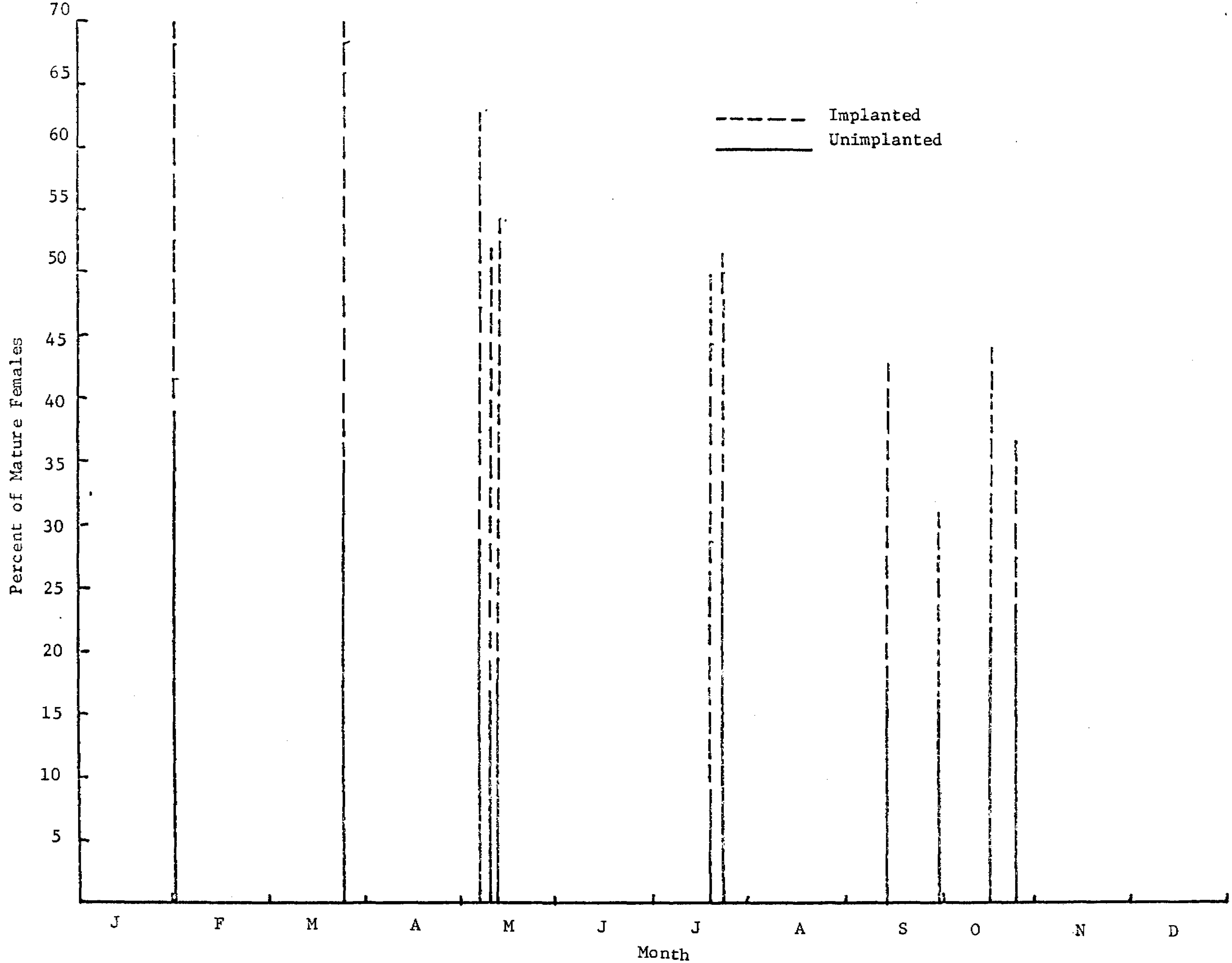
If the gestation period were 12 months, the percentage of pregnant animals would remain constant throughout the year. If it were only slightly longer or slightly shorter, there would be only a slight fluctuation unless there were a distinct breeding period. Fig. 4 indicates a substantial fluctuation which in turn indicates a gestation period substantially shorter or longer than 12 months.

The peak of pregnancy occurs in February after the period of greatest breeding activity. The low point on the pregnancy curve occurs after those animals giving birth during the period of greatest pupping have pupped. That is: the crest of the pregnancy curve occurs after the main breeding period and the lowest point is after the main pupping period. The main breeding and pupping periods actually last for four or five months so the high and low of the pregnancy curve occur well after the peaks of breeding and pupping.

The time between the peak when the highest number of females are pregnant and the low point when the fewest are pregnant should approximate the average gestation period. This is about 8.5 months (Fig. 4). The anestrus curve (Fig. 1) shows the same thing, being a reciprocal of the pregnancy curve.

Using three different methods, we have estimated a gestation period of eight to nine months, with the unimplanted period roughly equal to the implanted period. This agrees with the observed period in captivity (Barabash-Nikiforov, 1947) and with field estimates. Any estimated gestation

Figure 4. Rate of Pregnancy (Total of Unimplanted and Implanted Pregnancies)



period differing greatly from this does not fit the data. Conceivably one could apply a 20 to 21 month period to the same information, however if this were the case females would have to breed while accompanied by a pup or be on a four year reproductive cycle. Field observations indicate that neither is the case.

There is a definite possibility that the gestation period varies in sea otters as in land otters. This most likely would occur through variations in the unimplanted period. The above discussion refers to the average gestation period. Until better information to the contrary is obtained we must continue to assume that the average period is eight to nine months.

Fetal Growth Rate

If the estimates of the gestation curve are correct, Kenyon's (1969) plot of the cube roots of birth weights of various species of otters should approximate the growth curve of a sea otter fetus. Fig. 5 duplicates Kenyon's graph modified to show the actual weights rather than their cube roots. It is possible to estimate the length of time spent in each weight class. Fig. 5 does not take the period for establishment of the embryo into account, so the time spent in Weight Class 1 may be longer than shown, perhaps 15 days if we accept Chapman's (Kenyon, 1969) estimate.

The short time span of Classes 2 and 3 explains the relatively small numbers and the lack of a consistent pattern found in those classes (Table 1).

Using the curve in Fig. 5 and recorded fetus weights it should be possible to predict the time of birth and with less precision the time of implantation and conception of any particular fetus. By plotting the estimated birth dates of a large number of fetuses we should be able to draw curves which approximate the breeding, implantation and pupping rates of the population throughout the year.

Unfortunately there is overlap between samples collected at different times of year. Some of the samples are too small to provide comparison. We would have to weight each sample in order to combine them. Therefore only May, September and October samples are used. Where estimates from both the September and October samples overlap, two separate points are used. Fig. 6 presents the estimated birth dates grouped by month. February and March are not represented and April is an estimate based on post-partum females rather than fetus size (see Recovery of the Uterus after Parturition).

The peak of this curve may be exaggerated. It has been shown previously that fetus size is less consistent between samples than the other categories (Table 1) because the sample size of each grouping is small. Therefore the exact shape of the curve may not be correct. The sharpness of the birth curve indicates that the breeding, implantation and pupping peaks may be more distinct than indicated by the curves in Figs. 1 and 2. It is possible to fit curves with more abrupt changes to the data. If such

Figure 5. Fetal Growth (Based on Kenyon (1969) Does not include period for establishment of embryo)

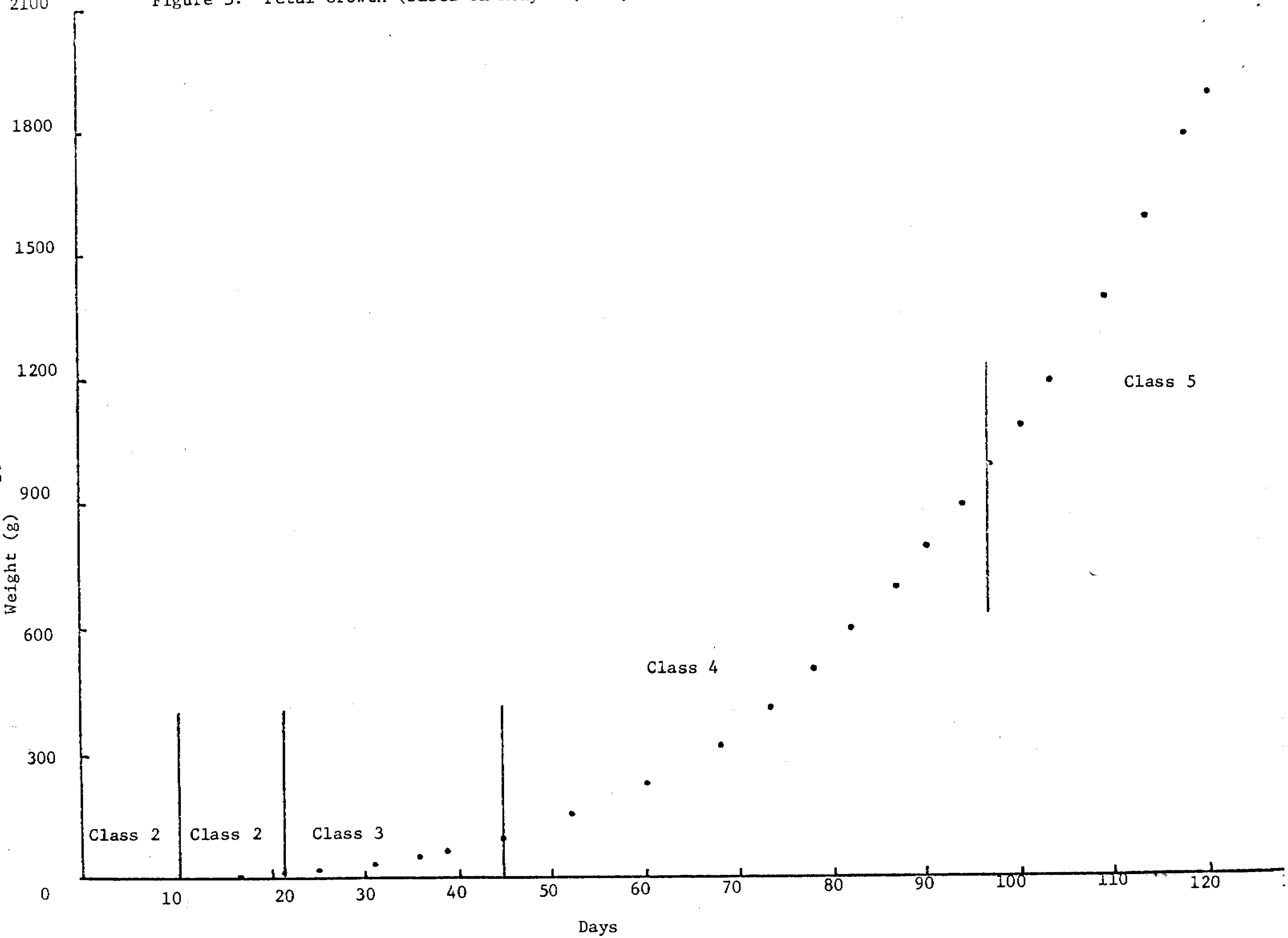
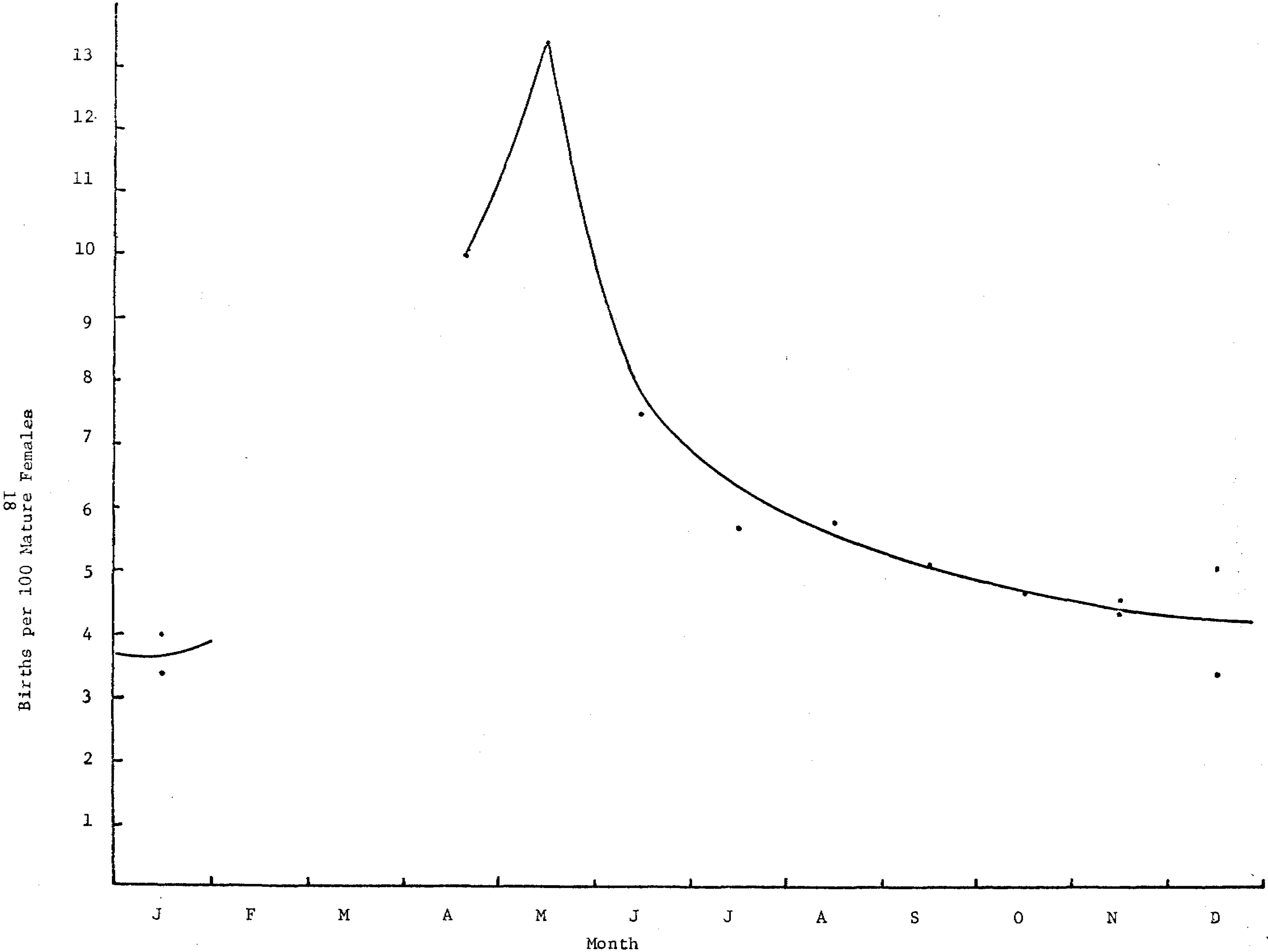


Figure 6. Timing of Births Estimated from Figure 5.



distinct peaks did occur, however, it seems likely that field observers would have seen the effects. Most field observations indicate broader peaks that are not well defined.

Age of Sexual Maturity

Tables 4 - 7 list the numbers of corpora albicantia and corpora lutea found in females of different ages in different areas. It should be recognized that the ages may not always be exact. Until data on the ages of nulliparous females have been analyzed, the age of sexual maturity cannot be clearly defined. It appears though that animals from Amchitka become mature when four years old and those from Adak when three years old.

Frequency of Ovulation

The maximum number of corpora albicantia for each age roughly equals the number of years after sexual maturity and indicates that some animals ovulated once every year after maturity (Tables 4 - 7). It is almost certain that many of the structures classed as corpora albicantia were produced by luteinization of either ruptured or attritic follicles rather than corpora lutea of pregnancy. Some corpora albicantia become indistinct with time and may become invisible macroscopically after several years, particularly if they are not remnants of a corpus luteum of pregnancy. Therefore, it is possible that most females ovulate or at least develop very large follicles every year. This possibility is also supported by the high incidence of large follicles in lactating females (see Frequency of Breeding).

Ovulation

On September 14, 1967 a female was collected while copulating. She appeared to have ovulated shortly before. Because sea otters may copulate several times over a period of two or three days (Kenyon, 1969) ovulation may have been induced by a previous copulation.

Fetal Orientation

Kenyon (1969) found that the number of caudally presented fetuses roughly equalled the number of cephalically presented fetuses. He suggested that this indicates a lack of adaptation for birth occurring in water and infers that sea otters must give birth on land.

Fetuses of all weights in the present study also appeared to be randomly oriented, however 97 Weight Class 5 fetuses (1000 g and over) showed 60 percent cephalic presentation while only 40 percent showed caudal presentation. The orientation of large fetuses should be a better indicator of orientation at birth since smaller fetuses may change position. Therefore, it appears that more sea otters are born head first than tail first.

Table 4. Numbers of Corpora Albicantia and Corpora Lutea found in 55 Mature Females. Amchitka - June-August 1968

	NUMBER OF CORPORA ALBICANTIA										
AGE (Years)	1	2	3	4	5	6	7	8	9	10	11
0-1											
1-2											
2											
3											
4	1	1									
5	2(1)										
6	1	1(1)									
7		2(1)	1								
8		1		1(1)							
9				2(1)	1(1)	1(1)					
10	1(1)	4(3)	2								1(1)
11						2(1)	1				
12	1(1)		2(1)	1(1)							
13									1		
14					1	1(1)					
15					2		1				
16					1						
17											
18											
19					1						

Numbers inside parentheses = Number of individuals with corpus luteum.

Table 5. Numbers of Corpora Albicantia and Corpora Lutea Found in 155 Mature Females. Kanaga - October 1968

	NUMBER OF CORPORA ALBICANTIA										
AGE (Years)	1	2	3	4	5	6	7	8	9	10	11
0-1											
1-2											
2											
3											
4	2(1)										
5	3	4(1)	(Plus 2 with corpus luteum but no corpora albicantia)								
6	6(3)	10(5)	1								
7	4(4)		1(1)								
8	4	5(1)	3								
9	2(1)	3	2(1)	3(3)	1						
10	1	3(2)	5(1)		1(1)		1(1)				
11	1(1)	2	3	3(1)	1(1)	1					
12		1	4(1)	1(1)	2(1)	1			1		
13		1(1)	3(3)	4(1)	2(2)		1(1)				
14			1		1(1)						
15	1(1)		2						1	1(1)	
16		1			1(1)	1					
17										1(1)	
18											

Numbers inside parentheses = Number of individuals with corpus luteum.

Table 6. Numbers of Corpora Albicantia and Corpora Lutea Found in 44 Mature Females. Mid Pt.-Blind Pt., Adak. October 1968

	NUMBER OF CORPORA ALBICANTIA										
AGE (Years)	1	2	3	4	5	6	7	8	9	10	11
0-1											
1-2											
2	1?	(Plus one with corpus luteum but no corpus alibcans)									
3		(One with corpus luteum but no corpus albicans)									
4	2(1)										
5		1			1(1)?						
6	1(1)	1									
7		1(1)									
8			1(1)	1							
9		2(1)			1						
10				1	1(1)		1				
11		1		2	1(1)						
12			1(1)	1			1				
13		1	1		1		1				
14				1							
15	1(1)										
16							1				
17											1
18				1							

Numbers inside parentheses = Number of individuals with corpus luteum.

Table 7. Numbers of Corpora Albicantia and Corpora Lutea Found in 78 Mature Females. Three Arm Bay-Bay of Islands, Adak. October 1968

	NUMBER OF CORPORA ALBICANTIA										
AGE (Years)	1	2	3	4	5	6	7	8	9	10	11
0-1											
1-2											
2		One with corpus luteum but no corpora albicantia									
3		One with corpus luteum but no corpora albicantia									
4	2	1?									
5	1(1)	3	(Plus one with corpus luteum but no corpora albicantia)								
6	1(1)	2(1)									
7	1	2(2)			1						
8		1(1)	2(1)	4(1)							
9	2(1)		2(2)	1(1)	1						
10	2(1)		2	2	3	1					
11	1(1)		2	2	3(1)						
12					1(1)	2(1)					
13			2(1)				1		1(1)		
14	1										
15		1		1							
16											
17											
18											

Numbers inside parentheses = Number of individuals with corpus luteum.

If one accepts Kenyon's premise that caudal presentation is necessary or at least beneficial to birth in water, this more recent information supports the supposition that birth occurs on land. The little information available indicates that birth does occur on land, but there have been unconfirmed reports of birth in water.

At least some sirenians are born head first, indicating that caudal presentation is not necessary for aquatic birth. A large population of sea otters lives offshore north of Unimak Island. There is no evidence that significant numbers come ashore. It seems likely that most of these animals give birth in the water.

Location of Pregnancy

Of 305 implanted pregnancies, 138 fetuses (45 percent) had implanted in the left horn and 167 (55 percent) in the right horn. Most of the difference was in the 1970 Amchitka sample. Without this sample, 48 percent implanted in the left horn and 52 percent in the right horn. Kenyon (1969) found an equal number in each horn. If a real difference exists, it is probably exaggerated by the 1970 Amchitka sample.

Blastocysts rarely cross from one horn to the other. The point of implantation was on the same side of the reproductive tract as the corpus luteum in 302 of 305 implanted pregnancies. In one case, the corpus luteum was in the left ovary and the fetus in the right horn. In the second case, the corpus luteum was in the right ovary, but the fetus was in the left horn. In the third case, there was a corpus luteum in each ovary and two fetuses of different sexes in the left horn.

Because there is usually a relatively long period of time between parturition and the next estrus, there is little if any inhibitory effect on ovulation caused by the corpus of the previous pregnancy. The ovary producing the largest follicle appears to be random and there does not appear to be the tendency for a pregnancy to be from the opposite ovary from the previous pregnancy. In many cases, there are many more corpora albicantia in one ovary than in the other.

When a female loses a pup shortly after birth and enters estrus before the uterus has completely recovered and before the corpus luteum has completely degenerated, there may be some inhibitory effect. However it appears that any such effect lasts for a short time only. Of the 14 such cases identified, six had large follicles in the same ovary as the new corpus albicans and eight in the opposite ovary.

A few cases were found where one ovary was not developed or otherwise not capable of producing ova. Because one ovary may support repeated pregnancies, such animals may be as productive as those with both ovaries active.

Kenyon (1969) reported that most implantations occur within the central third of the uterine horn. This held true for the animals in the present study, however they may implant anywhere.

Birth Weight

Barabash-Nikiforov (1947) listed the weight of a newborn sea otter as 2000 g. Kenyon (1969) presented the best quantitative data published to this time. He found a maximum fetus weight of 1869 g and he found pups as small as 1020 g. Those under 3 lb. (1.4 kg) had died shortly after birth. He estimated that successful birth weights range from 3 to 5 lb. or 1.4 kg to 2.3 kg, and for purposes of calculation assumed an average birth weight of 1850 g to 1900 g.

The weights of Weight Class 5 fetuses, the smallest pups found living in the wild and three pups born in captivity (all of which died within 24 hours) are presented in Fig. 7. These data tend to support Kenyon's (1969) estimate of the weight at birth. Few living pups weighing less than 1350 g or about 3 lb. and few fetuses over 2000 g (4.5 lb.) are found. Kenyon's upper estimate appears to be slightly high although there are extreme cases in both directions. One pup weighed only 2 lb. (900 g) and one fetus weighed 2418 g.

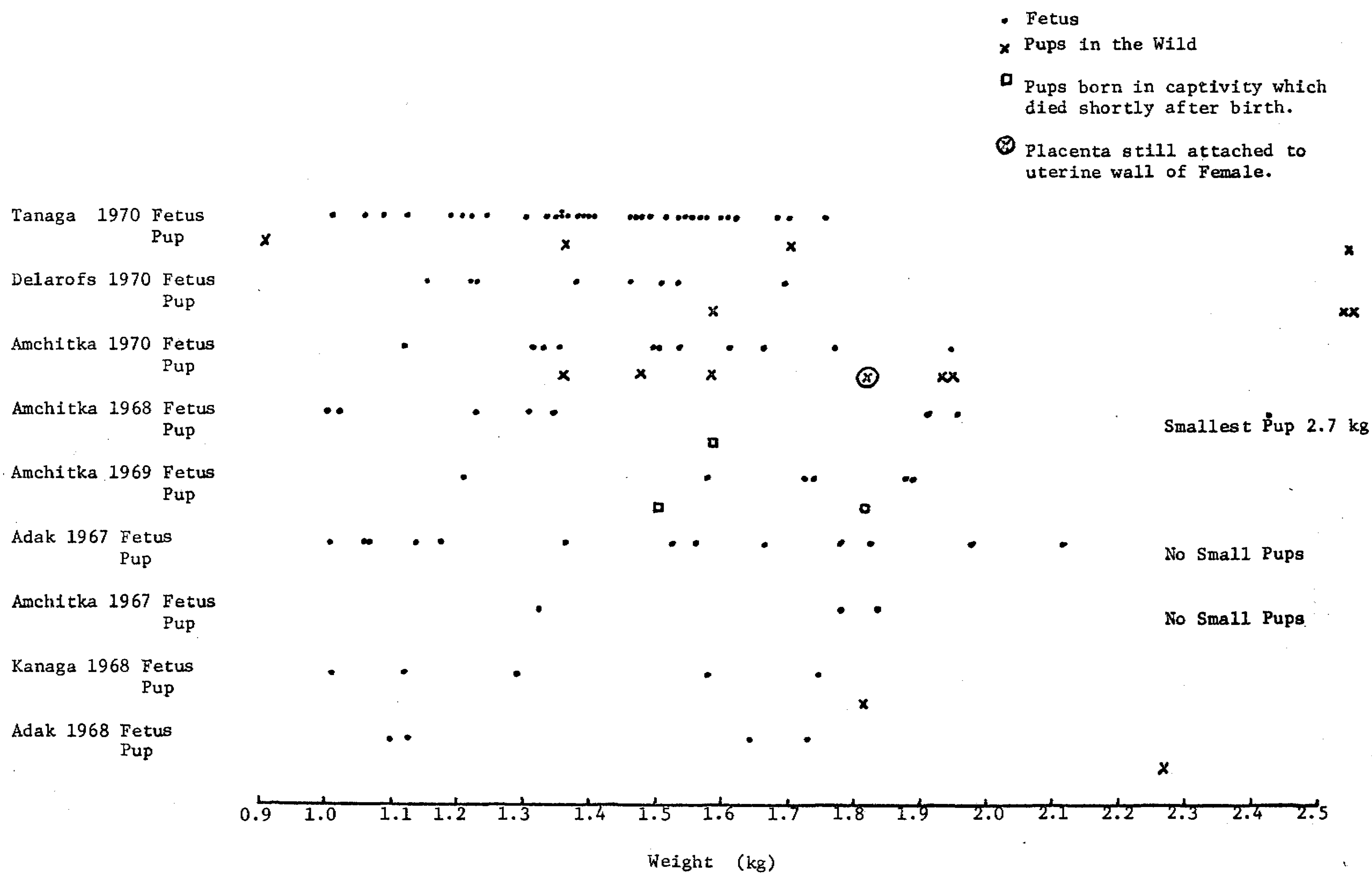
One female with a 4 lb. (1816 g) pup still had the placenta attached to the uterine wall and must have given birth shortly before being collected.

From Fig. 7 it appears that most pups are born when they weigh in the neighborhood of 1800 to 1900 g in most of the populations sampled. However, the Tanaga and Delarof samples indicate a birth weight of between 1600 and 1700 g. The Delarof sample is small, but the Tanaga sample is the largest, containing over a third of the large fetuses collected, and was collected at a time of year when the birth rate is very high.

This may be a reflection of the physical condition of the adult females and indirectly a reflection of food availability. There are other factors indicating that the Tanaga population is declining because of overpopulation.

This lower birth weight raises the question of whether the pups are born earlier or whether they are in poorer condition when born. In an effort to gain some insight into this, the fetal weights of Class 4 and 5 fetuses from Tanaga were plotted against their total lengths. Fetuses from other populations including eastern Adak, which appears to be a very healthy population, were checked against this curve formed by the Tanaga fetuses. In all cases they fell well within the limits of the Tanaga data, indicating that there is no difference in the weights of fetuses of a given length. It seems unlikely that a reduction in the rate of weight gain would be completely proportional to a reduction of linear growth. It appears that the rate of growth of fetuses is relatively constant, but that females in poor physical condition may not be able to support as large a fetus as those in good condition, so parturition occurs earlier. This may have some effect on early pup survival, however we have no information on this.

Figure 7. Weights of Large Fetuses and Small Pups



The comparison of weights and lengths of fetuses demonstrated some other interesting points. There is no difference in the weight-length ratio and the maximum fetus size of males and females. This suggests, but does not prove, an identical growth rate and birth weight for males and females. The weight-length ratios of pups fall below the curve formed by fetus weight-length ratios, indicating that pups of a given length are somewhat heavier than fetuses of the same length. This indicates an increase in weight immediately after parturition.

Fetal Sex Ratios

Kenyon (1969) found that, of 58 fetuses for which sex could be determined, 45 percent were male and 55 percent were female. He assumed an equal sex ratio until a larger sample could be obtained.

In the present study, 111 fetuses were male and 144 were female. When this sample is combined with Kenyon's, the sex ratio of 313 fetuses is 44 percent male and 56 percent female.

Litter Size

Sea otter normally produce one young at a time. This has been recorded by almost every observer since Steller (1751). Barabash-Nikiforov (1947) reported twins in *in utero* and mentioned other reports of twin fetuses from the early days of hunting. Snow (1910) recorded a set of newborn twins. In more recent studies, both Sinha et al (1966) and Kenyon (1969) found reproductive tracts with two corpora lutea but in all cases only one fetus was present. In thousands of hours of observation by many observers, no twin pups have been reported. In the present study, 24 instances of multiple ovulations were recorded. Five of these resulted in twin fetuses and one in triplet fetuses (Table 8). From these data, it appears that in over four percent of the estrous cycles more than one ovulation takes place. Of these, about half result in the development of more than one fetus. In most cases, the fetuses were of a relatively large size and probably would have been born normally.

All multiple fetuses appeared to be the result of separate ovulations. All had separate placentas and in some cases they were of different sexes. Four tracts with twins had both fetuses in the same horn, one had one in each horn and the tract with triplets had one fetus in one horn and two in the other. Another tract had skeletal remains of triplets in one horn that were being resorbed. Another tract appeared to have had five fetuses in one horn, but they were almost completely resorbed. One might infer that physically there is not enough room in one horn to accommodate more than two fetuses for the entire gestation period.

With the exception of the newborn twins reported by Snow (1910), there are no documented records of female sea otters with twin pups. There are occasional unconfirmed reports of twin pups, but, as Kenyon (1969) points out, a female may tolerate a pup in addition to her own, but it is unlikely that a female could care for more than one pup. It is unlikely that more than one pup survives. In any case, only two percent of the pregnancies produce more than one pup. Multiple births cannot be a significant factor in the productivity of sea otter populations.

Table 8. Multiple Corpora Lutea and Fetuses.

Total Pregnant Females	565
Implanted Pregnancies	316
Unimplanted Pregnancies with 2 CL (corpora lutea)	9
Implanted Pregnancies with 2 CL and 1 Fetus	8
Implanted Pregnancies with 3 CL and 1 Fetus	1
Implanted Pregnancies with 2 CL and 2 Fetuses	5
Implanted Pregnancies with 3 CL and 3 Fetuses	1
Total Multiple Ovulations	24
Percent Multiple Ovulations	4.2%
Percent of Pregnancies with Multiple Fetuses	1.9%
Corpora Lutea per Pregnancy	1.05
Fetuses per Pregnancy	1.02

In Utero Mortality

The presence of a corpus luteum, without gross evidence of implantation, was assumed to be an unimplanted pregnancy. No attempt was made to locate unimplanted blastocysts. As a result, we have little information concerning the survival of the blastocyst. Of 206 reproductive tracts classified as nulliparous on the basis of the appearance of the uterus, 12 had one corpus albicans-like structure and one had two. Some of these may have been large attritic follicles. Others may have ovulated and even conceived, but implantation did not occur. All of these cases represent the failure of the animals' first estrus.

A total of 16 resorptions or possible abortions were identified (Table 1). The following is a brief description of these with possible causes of some:

Description	Number
Resorption of blastocyst or ovum (corpus luteum degenerating, no evidence of implantation).	4
Failure at time of implantation (possibly because of a growth inside horn adjacent to implantation site).	1
Resorbed or aborted fetus (implanted at end of horn).	3
Resorbed fetus (umbilicus twisted tightly).	1
Resorbed fetuses (three or more fetuses in one horn).	2
Resorbed fetus (cause unknown)	5

Six of these resorptions may have occurred because other placentas, a growth or the end of the uterine horn did not permit the placenta to reach its full size. These six cases and the one with the twisted umbilicus are probably the result of random events or accidents.

The number of resorptions is too small to accurately measure the frequency of such occurrences, although the relatively large number in the Tanaga sample (Table 1) may be a reflection of the physical condition of the animals. Part of this number is probably due to the simple fact that there are more pregnant animals in the sample. In general, the samples with the most pregnancies also contained the most resorptions. Half of the Tanaga resorptions can be attributed to random events, but five were due to unknown causes. Eight of the 10 resorptions found on Tanaga came from a 20-mile stretch of shore, about 25 percent of the harvest area.

While concrete conclusions cannot be drawn from these data, they do raise the possibility that under certain conditions five percent of the pregnancies may fail.

Mortality at or near Parturition

Collecting methods were such that the presence of a pup with a female was often overlooked. Therefore the lack of record of a pup with a post-partum or lactating female did not mean that the pup had died. However, 14 females showing signs of recent pregnancy were entering estrus, presumably having lost their pup shortly before or shortly after parturition.

Again the magnitude of this mortality cannot be determined, but it appears to be of the same order as the *in utero* mortality.

Recovery of the Uterus after Parturition

Reproductive tracts were subjectively classified as post-partum or anestrous on the basis of degeneration of the corpus luteum (or appearance of the corpus albicans), the size of the horn of pregnancy and appearance of the placental scar. In an effort to provide an idea of how long it takes for the tract to return to normal, the sizes of pups accompanying females in each category are listed in Table 9. It appears that females were classified as post-partum until the pup weighed about 10 lb. and was around 75 to 80 cm. long.

We do not know a great deal about the early growth of a sea otter pup but, judging from the growth curve based on cementum deposition tooth eruption, a 10 lb. pup is probably in its second month of life.

Frequency of Breeding

Steller (1751) reported seeing female sea otters with newborn pups being accompanied by another pup that seemed to be no more than a year old. Murie (1940) recorded an instance of copulation by a female accompanied by a pup, and Jones (1952) caught a young pup with a copulating pair. Lensink (1962) felt that few females breed until the pup is a year old but mentions females with small pups also accompanied by large pups.

I believe that some of these observations may be misinterpretations of the situation. Females will occasionally leave small pups for a time, often near other animals. The pups Lensink mentions would be two years old and probably weigh 30-35 lb. Sea otters are gregarious and subadults may remain near other animals appearing to be accompanying their mother. I suggest that most of Steller's and Lensink's large pups were such cases.

Females with dependent pups probably do breed occasionally, but the most recent evidence indicates that this rarely occurs except when the pup is almost ready to leave its mother. Kenyon (1969) records no instances of females accompanied by pups copulating and states that he found no pregnant females known to be accompanied by a pup. This holds true for the animals collected in the present study. However, the nature of the harvesting operation is such that many females accompanied by pups were not

Table 9. Pups Accompanying Post-partum Females.

Sex	Weight	Total Length
M	2 lb	47 cm
F	3	52
F	4	56
M	5	60
F	5.5	65
F	6.25	65
F	7.75	70
M	10	81 (borderline-post partum-anestrous)
F	11	82 (late post-partum)

Pups Accompanying Anestrous Females.

Sex	Weight	Total Length
F	10 lb	78 cm
M	11	79
M	12	84
F	13	83
M	13	92
M	16	83
M	17	91
M	19	87
M	19	90
F	21	107
F	22	96
M	22	101
M	24	97
M	26	100
F	28	103

recorded as such. Therefore, we are forced to look at lactating females and assume that they were accompanied by a pup at the time of collection or shortly before. The reproductive condition of these lactating females is summarized in Table 10. In the 1967 and 1968 samples, some animals with enlarged mammary glands were listed as lactating. As a result, some females with near-term fetuses were included. Because this condition is considered to be associated with the unborn pup rather than a previous pup these animals were lumped with the anestrous animals in Table 10. In 1969 and 1970, the presence of milk was used as the sole criterion and no term animals were in the sample.

Of 246 lactating females, only one had an implanted fetus (excluding the near term animals from 1967-1968). Several others had small corpora lutea indicating that they had recently become pregnant or possibly had large follicles which had luteinized, but were not actually pregnant. The remainder had enlarged follicles.

This information indicates that females accompanied by a pup may enter proestrus and even ovulate, but that they rarely mate. The fact that the number of corpora albicantia in many tracts equals the age of the animal minus the three years prior to sexual maturity (see Table 4 - 7) indicates that large follicles tend to develop each year after sexual maturity is reached, whether the female is accomanied by a pup or not.

Some of those lactating females with new corpora lutea may have recently weaned or otherwise lost a pup and were already pregnant again. Malkovich (1937) took a pup (at least three months old) away from a female in captivity. She mated 12 days later although she had previously ignored a male.

Eleven tracts of the 1970 sample and two of the 1968 Kanaga sample showed signs of being pregnant recently, but were in proestrus. These animals had an enlarged horn usually with a slightly pigmented area (but no actual placental scar) and a recently formed corpus albicans. However, they also had enlarged follicles and the walls of the uterus were typical of proestrus animals. Another tract was similar but appeared to have already ovulated and a corpus luteum was present. In these cases, the female had lost a pup either through abortion or within the first weeks after parturition and had started another estrus cycle. Three or four of these had follicles which may have started to become attritic. This may be because the uterus had not recovered sufficiently from the last pregnancy.

The implication of this information is that with a normal pregnancy and successful rearing of a pup, the female becomes pregnant only after the pup has been weaned. This may be a year after parturition. However, if the pregnancy fails or if a pup dies, even at birth, the female may become pregnant again in a few weeks rather than wait the full year.

Kenyon (1969) suggested that the period between weaning and the next estrus may be long because he had found animals that were not lactating but had a faint placental scar and an indistinct, but recent, corpus albicans.

Table 10. Reproductive Condition of Lactating Females.

Location	Date	Inactive [1/]	Active [2/]	% Active
Bay of Is., Adak I.	Sept. 1967	9	1	10.0
Amchitka I.	Sept.-Oct., 1967	17	2	10.5
Mid Pt. - Blind Pt., Adak I.	Oct. 1968	19	3	13.6
Bay of Is., Adak I.	Oct. 1968	22	4	15.4
Kanaga I.	Oct. 1968	32	5 [3/]	13.5
Amchitka I.	July-Aug., 1969	4	2	33.3
Tanaga I.	May 1970	56	10	15.2
Delarof Is.	May 1970	18	3	14.3
Amchitka I.	May 1970	36	3	7.7
TOTAL		213	33	13.4

1/ Anestrous or pregnant with term fetus.

2/ Large follicles or corpus luteum present.

3/ Includes one implanted pregnancy with small fetus.

These animals were classified as anestrous in the present study. They are undoubtedly between weaning of their last pup and the next estrus. The number of such animals is greatest during September and October. At this time the number of estrous animals increases, and the number of anestrous animals decreases sharply during the next few months. Therefore, many of these anestrous animals become pregnant within a month or two. Kenyon (1969) suggested that if the female keeps the pup for about a year the period between births may be somewhat greater than two years. He assumed a 12 - 13 month gestation period. Estimates in the present study put this period at closer to eight or nine months. Presumably the anestrous, nonlactating females are in the three to four month period remaining.

This does not change Kenyon's (1969) point that the period between weaning and the next estrus may be long. It indicates that in a normal reproductive cycle it may be several months. However, as was shown previously, it is possible for a female to enter estrus very shortly after losing a pup.

We have demonstrated that sea otters breed at all times of year and that it is possible for a female to become pregnant again after losing a pup sooner than she would have if the pup had survived. However, we have also demonstrated that annual peaks of breeding and pupping occur and that these peaks are similar in different years and in different populations. The assumption can be made that the average length of the entire reproductive cycle is some multiple of a year.

Kenyon (1969) assumed that the pup remains with its mother for about a year. Weights and measurements, cementum deposition, skull changes and observations in the wild and in captivity, all support this assumption although it cannot be said with certainty that it averages 12 months. It could be slightly more or less.

Assuming about 12 months for rearing the pup, eight or nine months gestation plus a few months rest between weaning and the next estrus, the average reproductive cycle takes two years.

This is supported by the data in Fig. 4 which show that slightly over half the mature females are pregnant in a year. Kenyon (1969) pointed out that his January and March samples were biased against females with pups and therefore in favor of pregnant females because of selective hunting. This bias applies to the fall samples as well. The summer samples were biased similarly because pregnant females appeared to be less resistant to handling during capture. Therefore, the percent of pregnant females is shown to be higher than it actually was. While no correction factor can be applied to all samples, the evidence indicates that the percent of pregnant females is usually 10-15 percent lower than in the sample. For example, the 1970 Amchitka sample was less biased and was about nine percent lower than the Tanaga sample which is known to be more biased. On a survey made from a skiff in June, 1968, seven percent of the animals counted had pups that were readily identified. If we assume that this is the number of animals avoided, it can be calculated that 15 percent of the sexually mature females, all of which are nonpregnant, were avoided. Actually this will vary with the hunter, weather, time of year, and other factors. However, it indicates the order of magnitude of the bias.

Using this as a rough correction for the data in Fig. 4, we find that about half or slightly fewer of the sexually mature females are pregnant each year or, as indicated previously, the average female has a pup every two years.

RECOMMENDATIONS

The reproductive tracts collected in June 1971 should be examined. The description of the annual cycle should be reevaluated with this sample to delineate the end of the peak of pupping and resolve the current contradictions. The samples from transplant mortalities should be discarded from this analysis.

When cementum age data are available the age of sexual maturity should be reviewed. Also the age of weaning for pups should be estimated.

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