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Studies on Captive Fur Seals. Progress Report No. 2

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Fisheries and Marine Service

Manuscript Report 1471

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STUDIES ON CAPTIVE FUR SEALS.

PROGRESS REPORT NO. 2

by

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ABSTRACT

M. A. Bigg, I. B. MacAskie, and G. Ellis. 1978. Studies on captive fur seals. Prog. Rep. No. 2. Fish. Mar. Serv. MS Rep. 1471: 21 p.

Studies were conducted on reproduction and feeding of captive northern fur seals. The estrous cycle of nonpregnant adult females is described from an examination of vaginal smears. Preliminary results indicate only about half the females exhibited estrus and none ovulated. Social factors are probably important in initiating estrus and ovulation. From records of daily food intake and weekly body weight change, the average daily food requirement to maintain stable body weight in active nonpregnant adult females is 5-6,000 K cal.

Key words: northern fur seals, reproduction, feeding, live-capture.

RÉSUMÉ

M. A. Bigg, I. B. MacAskie, and G. Ellis. 1978. Studies on captive fur seals. Prog. Rep. No. 2. Fish. Mar. Serv. MS Rep. 1471: 21 p.

Les auteurs ont étudié la reproduction et l'alimentation d'otaries à fourrure en captivité. Ils décrivent le cycle oestral des femelles adultes et non fécondées après avoir examiné des frottis vaginaux. Les résultats préliminaires montrent que seulement environ la moitié des femelles avaient atteint l'oestrus et qu'aucune n'avaient ovulé. Les facteurs sociaux tiennent probablement une part importante dans le déclenchement de l'oestrus et de l'ovulation. D'après les données sur l'absorption quotidienne d'aliments et la modification hebdomadaire du poids, la ration quotidienne nécessaire au maintien du poids de femelles adultes, non fécondées et actives d'établit entre 5 000 et 6 000 Kcal.

Mots-clés: otaries à fourrure; reproduction; alimentation; capture.

INTRODUCTION

This is the second annual report on reproduction and food requirements of captive northern fur seals. The studies are part of Canada's research contribution to the North Pacific Fur Seal Commission and are needed to improve interpretation of field data on causes of infertility and consumption rates of fish and squid in the North Pacific. The annual estrous cycle of nonpregnant adults is investigated to establish the seasonal timing of estrus, whether ovulation is induced or spontaneous, whether pseudopregnancy occurs and to determine the effect of social activities on the cycle. Concurrently, the daily food intake and associated changes in body weight are monitored.

The first annual report (see Bigg, MacAskie and Ellis, 1977) described the experimental facilities at the Pacific Biological Station, animal husbandry procedures, experimental methods and initial results collected during 1976. The current report gives results of studies during 1977 and includes an examination of the incidence of estrus and ovulation in postpartum females on St. Paul Island, Alaska; the estrous cycle and food requirements of nonpregnant adults held at the Pacific Biological Station; and a pelagic survey off southwestern Vancouver Island to capture live fur seals for captive studies and to record relative abundance.

METHODS

Table I lists the seals used and details for each.

Nine females at term pregnancy were captured on St. Paul Island at Zapadni Reef rookery by Dr. M. Keyes and staff, National Marine Fisheries Service, Seattle. The seals were held individually in dog cages. Newborn pups were removed to simulate an infertile cycle. Vaginal smears were taken at 3 - 4 day intervals with the assistance of Dr. M. Keyes and staff. All animals were killed 14 - 16 days post-partum and the genital tracts preserved in 10% formalin for examination of ovarian condition and histological studies on the uterine endometrium and vaginal mucosa.

Nine females, including 3 pregnant, were held at the Pacific Biological Station for varying times during the year. Each pregnant seal gave birth to a stillborn. Vaginal smears were taken once a week. Three seals were killed for an examination of re-productive organs and 1 seal was released. Three animals were kept individually in tanks while the remainder were held for some time with other seals. Daily food intake and weekly body changes were determined in the 3 seals kept individually from January to December.

During 20 April - 7 May, the 45 ft. gillnetter-trawler GAMBLER I was chartered for pelagic studies on La Pérouse Bank. The location and number of seals seen and the observation effort were noted. Seals were captured live using a monofilament tangle net described in our first report.

PELAGIC SURVEY

a) Live-capture procedure

In 1976 the scarcity of seals on La Pérouse Bank did not provide an adequate test for the effectiveness of capturing seals with the tangle net. However, in 1977 there were more seals and we conclude that they can be easily captured, particularly the sleeping individuals.

The procedure involved 3 men, a boat operator, a net tender and a small boat operator for driving seals into the net. For driving seals we used a 14 ft. rubber inflatable (Zodiac) equipped with a 20 H.P. motor. Sleeping seals were approached at a speed of about 5 knots and the small boat launched to wait quietly near the end of the net as it unwound from the gillnet drum. The net was set in a circle around the seal at a distance of about 50 - 75 meters, generally starting to the S.W. or N.W. to first block the usual direction of escape. After the set, or whenever the seal began swimming, the small boat was used to drive the seal into the net. Seals which escaped could usually be driven back into the net. To recover the captured seal, the net was wound back on to the gillnet drum, the seal lifted on to the large boat with a dip net, cut free and placed in a dog cage. The capture procedure generally took 15 - 20 minutes.

b) Live-capture success

Table II gives the results of the live capture operations. Of 26 seals seen 24 were solitary animals and 2 together. Net sets were made on 16 (62%) seals of which 12 (75%) were captured. The catch included 5 immature males, 3 immature females, 3 pregnant females and 1 nonpregnant adult female. Six seals were taken to the Pacific Biological Station and the remainder released.

c) Distribution and relative abundance

Figure I shows the areas surveyed and number of seals seen and captured. The 26 seals were seen during 85 hours of survey for an average rate of 0.31 seals seen/hour.

While abundance was higher than the 0.13 seals/hour seen during the same period in 1976 it was still considerably lower than during pelagic surveys of the late 1960's when 1 - 3 seals/hour were usually seen.

ESTROUS CYCLE

Preliminary results from data collected in 1976 and 1977 indicate that estrus can be detected from an examination of vaginal smears. Estrus is defined here as the period when the genital organs of the fur seal undergo typical mammalian changes associated with mating. These changes include the development of a large ovarian follicle and a corresponding estrogenic appearance in histology of the uterine endometrial and vaginal mucosa. Craig (1964) showed a good correlation between follicular development and uterine histology during the pregnancy cycle of the fur seal although did not examine vaginal tissue. Estrus in this study is thus defined in physiological terms and presumably includes proestrus, behavioural estrus (mating receptivity) and postestrus stages preceding anestrus.

a) Cytology of vaginal cycle

During anestrus (quiescence) the vaginal smear contained mucus, many leucocytes and a few degenerating basal (immature) epithelial cells. The vaginal mucosa consisted of about 5 cell layers of cuboidal epithelium with little cellular exfoliation. Some of the outer cuboidal layer was usually scraped free during vaginal examination and appeared in the vaginal smear as small sheets of dense cuboidal cells. The vaginal mucosa invaginated into the underlying stroma to form shallow open pits characteristic of anestrus. The ovaries contained a few small follicles and the mucosa of the uterine endometrium was lined with cuboidal epithelium and usually had straight glands.

During estrus the vaginal smear contained mucus, leucocytes and a large number of basal, intermediate (maturing or mature) and superficial (mature) epithelial cells. The vaginal mucosa consisted of 10 - 15 layers of squamous epithelium, the outermost exfoliating. The shallow open pits found in the mucosa during anestrus were filled with layers of growing epithelial cells during estrus. The ovaries generally contained a large follicle, of 10 mm or more in diameter, and the uterine endometrium was lined with tall columnar or pseudostratified epithelial cells. The uterine glands were usually large and intensely coiled, their lumina lined with tall columnar or pseudostratified cells.

In the vaginal smear of early estrus, basal cells were more abundant than intermediate and superficial cells. The sheets of surface cells scraped free from the vaginal mucosa during examination contained cells obviously larger and more loosely held together than in anestrus. At about one third to one half way through estrus intermediate cells predominated and leucocytes were fewer. This phase was abruptly ended by a massive increase in number of leucocytes in the vaginal smear and was associated with regression of the vaginal mucosa to an anestrus state. Behavioural estrus presumably preceded tissue regression. Epithelial cells, many of which were dead, gradually decreased in number during regression.

b) Duration of estrus

The duration of physiological estrus lasted 3 - 7 weeks in 4 females with the interval from onset of estrus to onset of regression lasting 1 - 3 weeks in 13 females.

c) Postpartum estrus

Only about one half of captive seals exhibited the expected postpartum estrus. Of 19 females which pupped during the normal breeding season 11 (58%) exhibited estrus within 2 - 3 weeks postpartum. Also, 2 females which spontaneously pupped stillborn 1 - 2 months prematurely did not show a postpartum estrus.

d) Ovulation

Ovulation appeared to be induced rather than spontaneous. None of 6 females which exhibited a postpartum estrus had ovulated when killed 14 - 16 days postpartum. Evidence for ovulation was the presence of a new corpus luteum.

e) Nonpregnancy estrous cycle

In captive seals kept at the Pacific Biological Station, the incidence and seasonal timing of estrus was irregular although did not occur more than once a year. Of 4 females kept from July 1976 to October-December 1977, 1 had a postpartum estrus in July 1976 and no other estrus thereafter; 1 had a postpartum estrus in July 1976 and second estrus 12 months later; 1 had no postpartum estrus in July 1976 but did exhibit estrus 3½ months later and a second estrus after an additional 12 months; and 1 exhibited no estrus in 1976 or 1977. A female which had a stillborn on 23 August 1977 had no postpartum estrus but did have an estrus 2½ months later.

f) Discussion

The irregularity of incidence and seasonal timing of estrus and the absence of ovulation in captive females was unexpected. Behavioural observations on the pregnancy cycle of wild fur seals, indicate that mating occurs within 7 days postpartum, mainly during July and samples collected pelagically indicate that essentially all adults have ovulated by August (Bartholomew and Hoel, 1953; Anon, 1961; Marine Mammal Division, 1975). Also, Craig (1964; pers. com.) kept 9 females with their newborn pups isolated from the rookeries for 5 - 19 days and reported 4 seals ovulated.

Probably captive fur seals in the current study lacked the appropriate social cues to initiate and synchronize estrus and stimulate ovulation. For most of the year the social environment of captive seals was similar to that of wild seals which generally migrate alone. However, during summer breeding season wild fur seals are highly social while captive seals remained solitary or only in the company of one other adult female. The fact that some females with nursing pups ovulated in Craigs' study, while none of those without pups ovulated in the current study suggests that nursing pups may aid in stimulating ovulation.

FOOD REQUIREMENTS

a) Food

Seals were fed herring captured off southeastern Vancouver Island on 5 occasions during the winters of 1975 - 77. The calorific value of herring captured on each occasion was determined from proximate analyses of body constituents in 12 fish. Proximate analyses, noted in Table III, were made by Dr. E. Donaldson and staff, Fisheries and Marine Service, West Vancouver, British Columbia. Calorific value was calculated from the conversion values of 8.66 K cal/gm for fat and 5.65 K cal/gm for protein as reported by Brett and Groves (1978). Where duplicate samples were analyzed average calorific values were used.

Figure 2 gives the seasonal variation in calorific content of herring taken from southeastern Vancouver Island as calculated from published proximate analyses. A marked seasonal variation occurs, due largely to changes in fat content, with a high in June and a low when spawning in March. Values from the current study agree well with published data.

Herring from each capture date were fed to fur seals during the following times in 1977:

Date caught	Date fed
Dec/75	1 Jan. - 4 Feb.
Jan/77	5 Feb.- 17 Aug.
Jan-Feb/77	18 Aug.- 1 Dec.
Dec/76	2 Dec.- 15 Dec.
Dec/77	16 Dec.-31 Dec.

b) Annual body weight change

Seals were generally fed more than they consumed to let body weight fluctuate in a natural manner. Figure 3 shows that the seals exhibited an annual variation in body weight with a peak in early winter and a low in late spring-early fall. The weight of Seal #5 in January 1977 was probably lower than it should have been because its food was restricted during December 1976 in an attempt to produce a stable body weight of 44 Kg. There was also a shortage of food for all seals in late August which resulted in a loss in body weight.

The variation in body weight was due to changes in blubber reserves as all seals were full grown. Seals in early winter were obviously fat while those in late spring - early fall were much thinner. This weight change has not been described previously for the fur seal and was unexpected. While the annual variation in body weight is not known for nonpregnant wild seals, pregnant animals are known to be fat at term pregnancy during June - August and adult males are fattest at the onset of breeding in June.

c) Food intake

Figures 4 - 6 show the relationship between average food intake in K cal/day and average change in body weight/day for these seals. Much of the variation in the relationship was probably due to daily changes in swimming activity of each seal. Although the seals swam actively around their tanks throughout the year, the number of hours spent swimming each day varied and thus changed food requirements.

The average number of K cal/day required to maintain stable body weight for each seal was determined from the intercept of the functional regression line (Ricker, 1973) through the line of zero change in body weight. For stable body weight, 5977, 6118 and 5055 K cal/day were needed by Seals #'s 2,5 and 7 (Figs. 4 - 6) respectively. Seal #7 weighed 10 - 15 Kg. less than #'s 2 and 5 (Fig. 3) and thus required fewer K cal/day.

Assuming an average energy content for winter herring of 2.0 K cal/gm (Fig. 2), the average consumption rates/day were 3.0, 3.1 and 2.5 Kg of herring or 6.7%, 7.6% and 8.5% of the average annual body weight for Seal #'s 2,5 and 7 respectively.

d) Food-blubber relationship

The slopes of functional regression lines in Figures 4 - 6 describe the relationship between rates of calorific intake and change in weight of blubber gained or lost. A change in food intake of 1000 K cal/day altered blubber weight by .088, .110 and .091 Kg/day in Seals #2,5 and 7 respectively for an average of .096 Kg/day.

ACKNOWLEDGMENTS

This study, although carried out at the Pacific Biological Station, was part of marine mammal research programs conducted by the Arctic Biological Station, Ste. Anne de Bellevue, Quebec. The Pacific Biological Station kindly provided numerous support services associated with the study. Gratitude is expressed to Dr. M. Keyes and staff, National Marine Fisheries Service, Seattle for capturing and maintaining the fur seals for studies on St. Paul Island; and also to Dr. E. Donaldson and staff, Fisheries and Marine Service, West Vancouver, B.C. for determining proximate analyses of herring.

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Table I. Record of northern fur seals kept at the Pacific Biological Station and on St. Paul Island in 1977.

Seal #	Captured Date	Captured Place	Sex	Age	Last weight (kg)	Status	Comment
2	2 July/76	St. Paul Is.	♀	adult	50	At Pac. Biol. Stat.	
5	2 July/76	St. Paul Is.	♀	adult	49	At Pac. Biol. Stat.	
7	2 July/76	St. Paul Is.	♀	adult	33	At Pac. Biol. Stat.	
3	2 July/76	St. Paul Is.	♀	16 yr.	46	Killed 13 Oct/76	
11	23 Apr/77	S.W.Van. Is.	♂	4-5 yr.	55	At Pac. Biol. Stat.	
12	28 Apr/77	S.W.Van. Is.	♀	adult	34	At Pac. Biol. Stat.	Stillborn Pup 1 May/77
13	28 Apr/77	S.W.Van. Is.	♀	adult	35	Killed 13 Oct/77	
14	28 Apr/77	S.W.Van. Is.	♀	adult	35	Killed 13 Oct/77	Stillborn Pup 10 Aug/77
15	29 Apr/77	S.W.Van. Is.	♀	adult	36	At Pac. Biol. Stat.	Stillborn Pup 23 Aug/77
16	7 May/77	S.W.Van. Is.	♀	adult	41	Released 20 May/77 Pac. Biol. Stat.	
A	8 July/77	St. Paul Is.	♀	12 yr.	-	Killed 24 July/77	Pupped 10 July/77
B	8 July/77	St. Paul Is.	♀	11 yr.	-	Killed 24 July/77	Pupped 9 July/77
C	8 July/77	St. Paul Is.	♀	10 yr.	-	Killed 24 July/77	Pupped 9 July/77
D	8 July/77	St. Paul Is.	♀	7 yr.	-	Killed 24 July/77	Pupped 10 July/77
E	8 July/77	St. Paul Is.	♀	10 yr.	-	Killed 24 July/77	Pupped 9 July/77
F	8 July/77	St. Paul Is.	♀	6 yr.	-	Killed 24 July/77	Pupped 9 July/77
G	8 July/77	St. Paul Is.	♀	12 yr.	-	Killed 24 July/77	Pupped 9 July/77
H	8 July/77	St. Paul Is.	♀	13 yr.	-	Killed 24 July/77	Pupped 9 July/77
I	8 July/77	St. Paul Is.	♀	12 yr.	-	Killed 24 July/77	Pupped 8 July/77

Table II. Success of capturing fur seals live in a tangle net off southwestern Vancouver Island, 1977.

Date	# Seen	# Sets	Caught					Released
				♂		♀		
			#	#	Age	#	Age	
23 April	5	4	2	2	immat.			1
24 April	3	2	1	1	immat.			1
25 April	1	0	0					
27 April	2	1	0					
28 April	5	3	4	1	immat.	2	adult	1 immat. ♂
						1	immat.	
29 April	4	1	1			1	adult	
6 May	4	4	3	1	immat.	2	immat.	3
7 May	2	1	1			1	adult*	
Total	26	16	12	5		7		6

* later released, see Table I, #16.

Table III. Proximate analyses and calorific values of herring caught off southeastern Vancouver Island and fed to fur seals during 1977.

Date herring caught	# herring analyzed	% H_2O	% Fat	% Protein	Calories (K cal/gm wet wt.)
Dec/75	6	65.14	14.87	16.94	2.24
	6	65.41	15.15	16.02	2.22
Dec/76	12	68.84	12.43	16.87	2.03
Jan/77	6	69.37	10.36	17.73	1.90
	6	68.43	11.33	17.70	1.98
Jan-Feb/77	6	70.83	8.89	18.10	1.79
	6	71.01	9.44	17.31	1.80
Dec/77	12	67.89	13.77	15.14	2.05

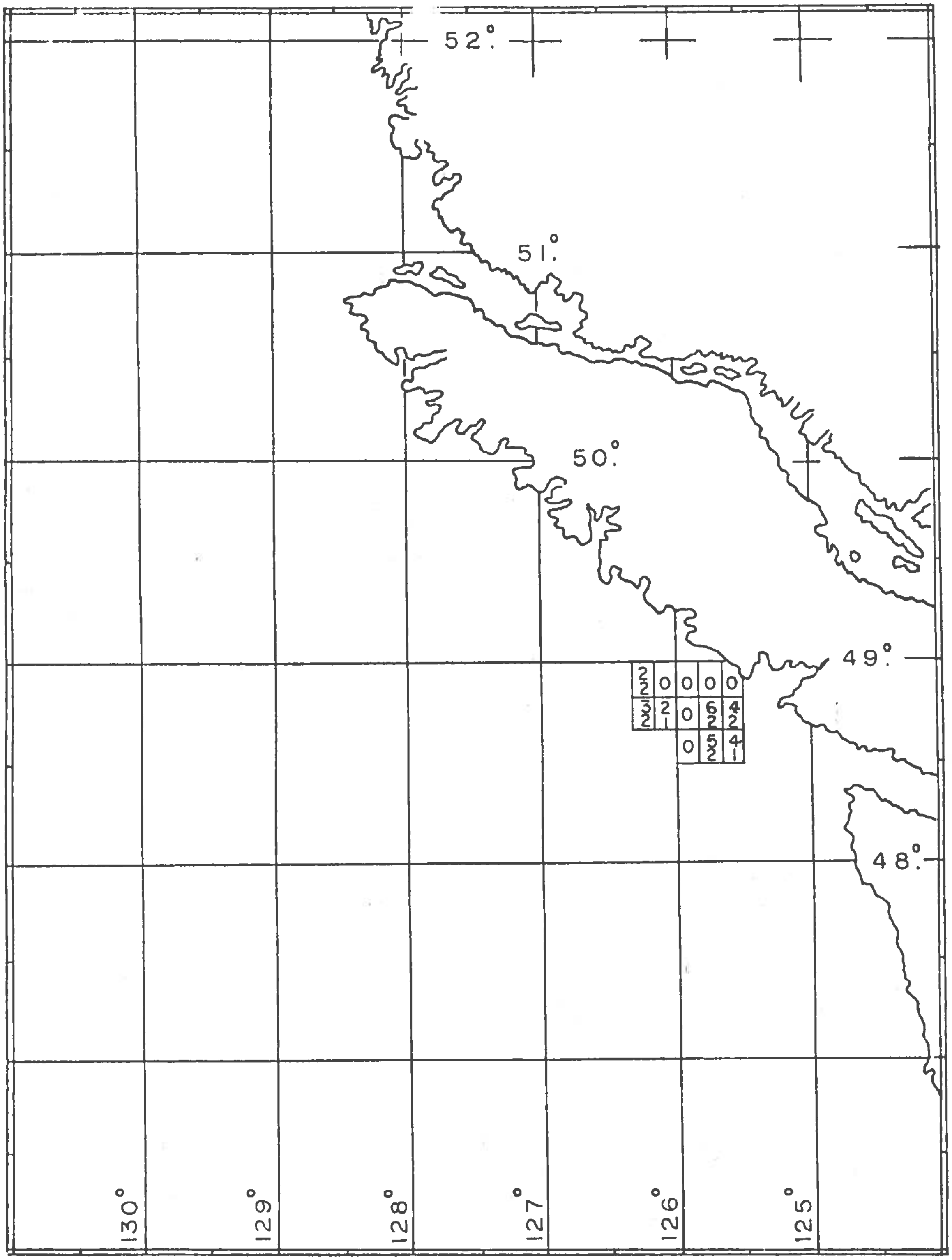

Figure 1. Distribution of fur seals seen (upper figure) and taken (lower figure) by net 23 April - 7 May 1977.

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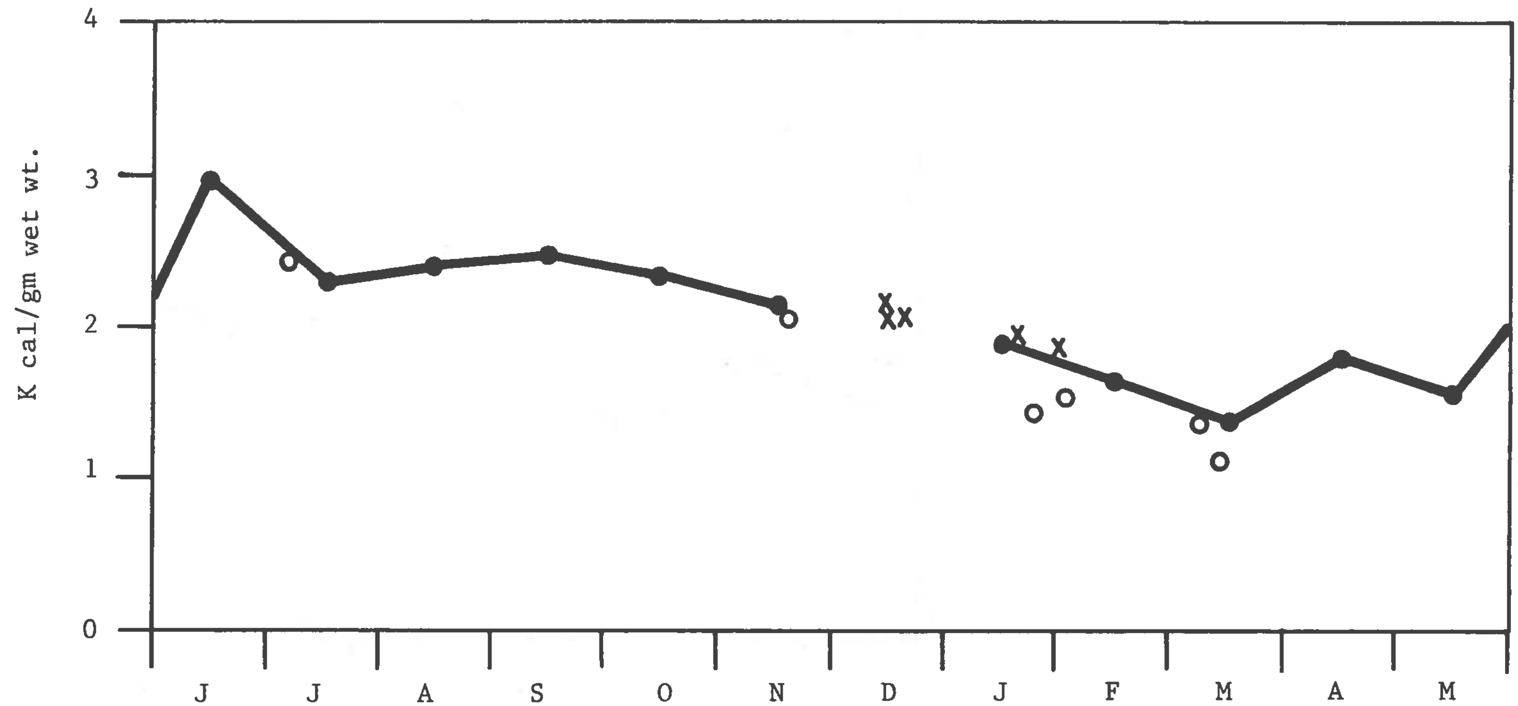

Figure 2. Monthly variation in calorific value of whole herring from southeastern Vancouver Island. ●, Hart et al (1940); O, McBride et al (1959); and X, current study.

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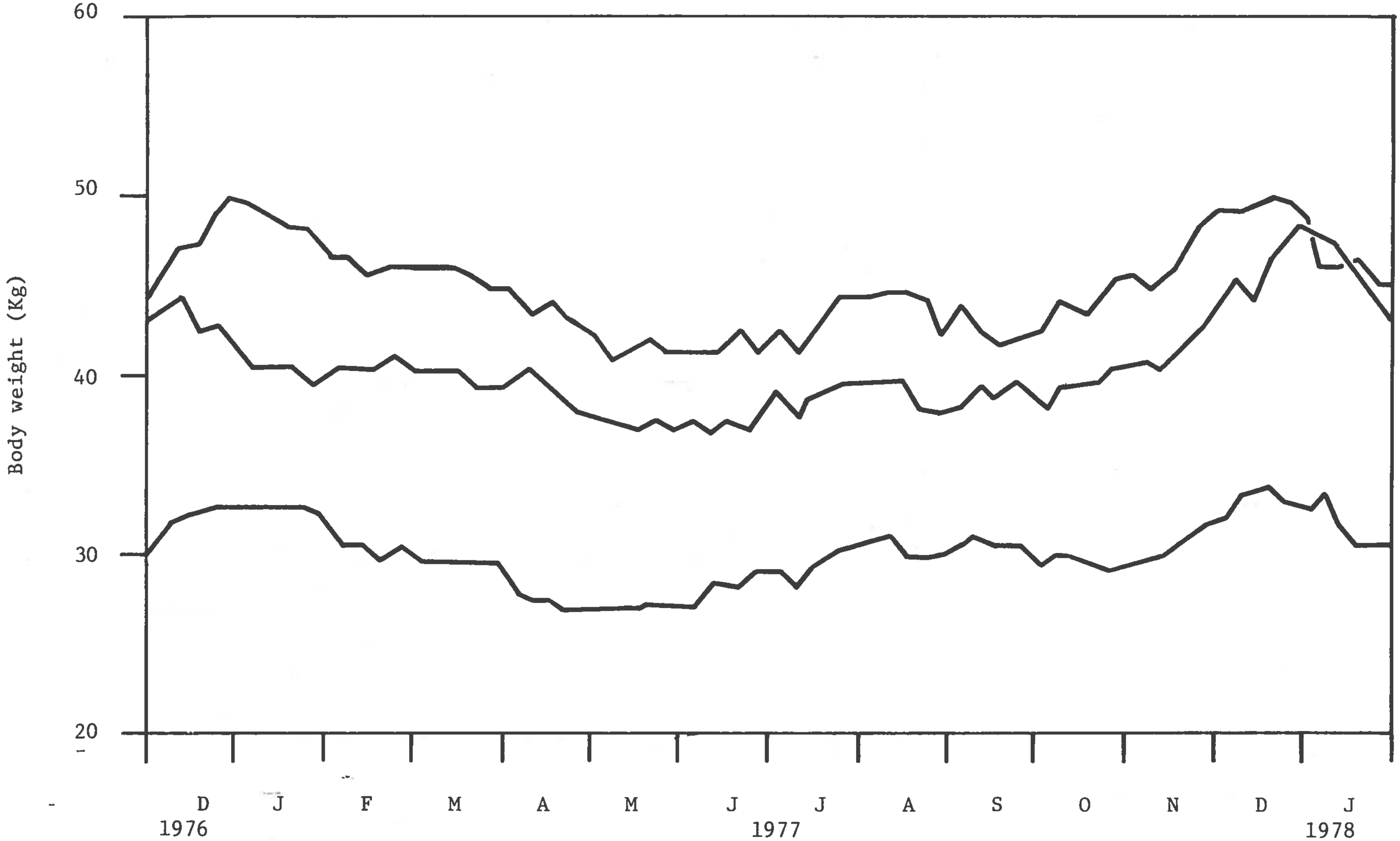

Figure 3. Monthly variation in body weight of Seal #'s 2 (upper line), 5 (middle) and 7 (lower) from December 1976 to January 1978.

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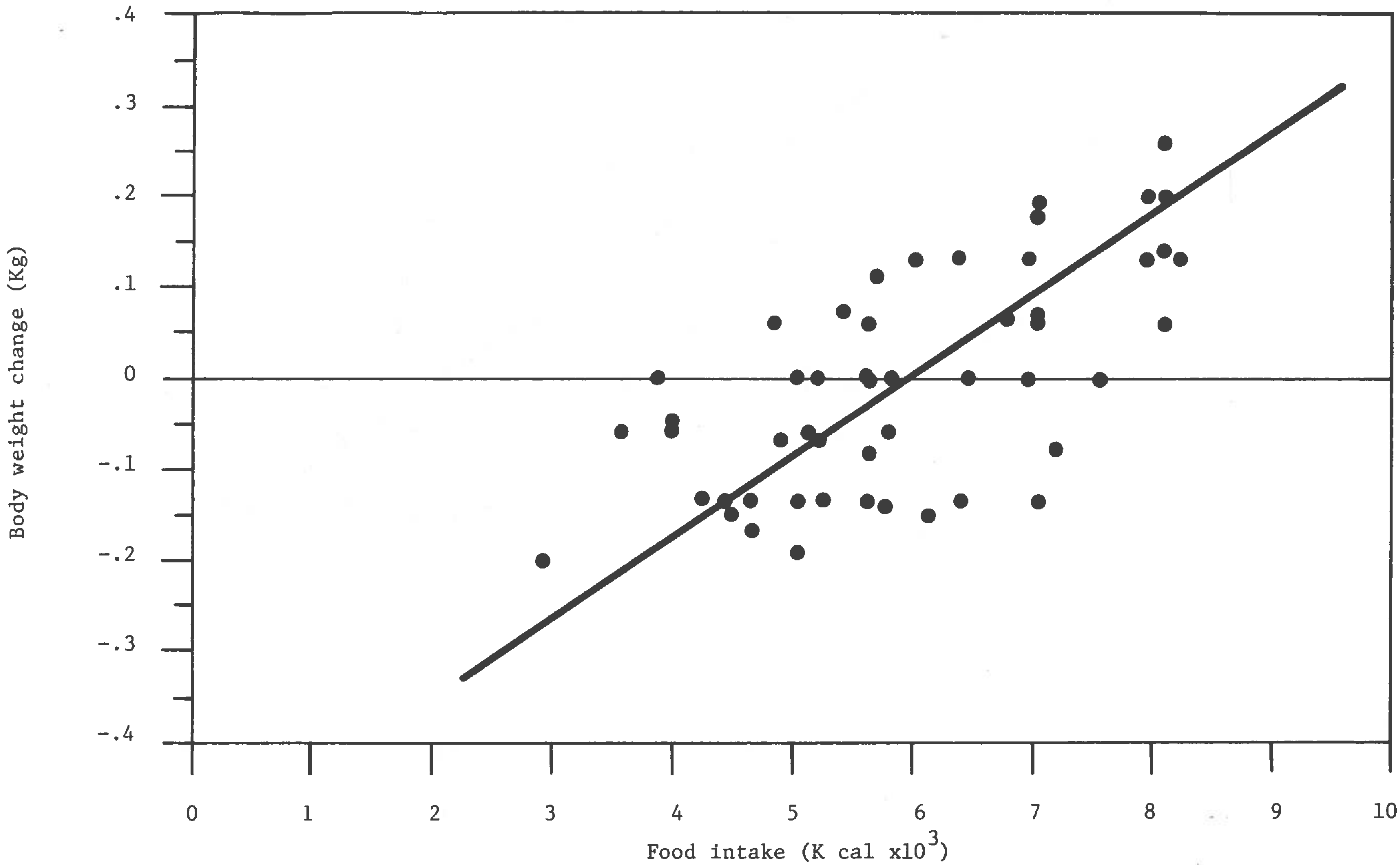

Figure 4. Relationship between average daily food intake and average daily change in body weight for Seal #2 in 1977. Functional regression line Y= -.526 +.000088X.

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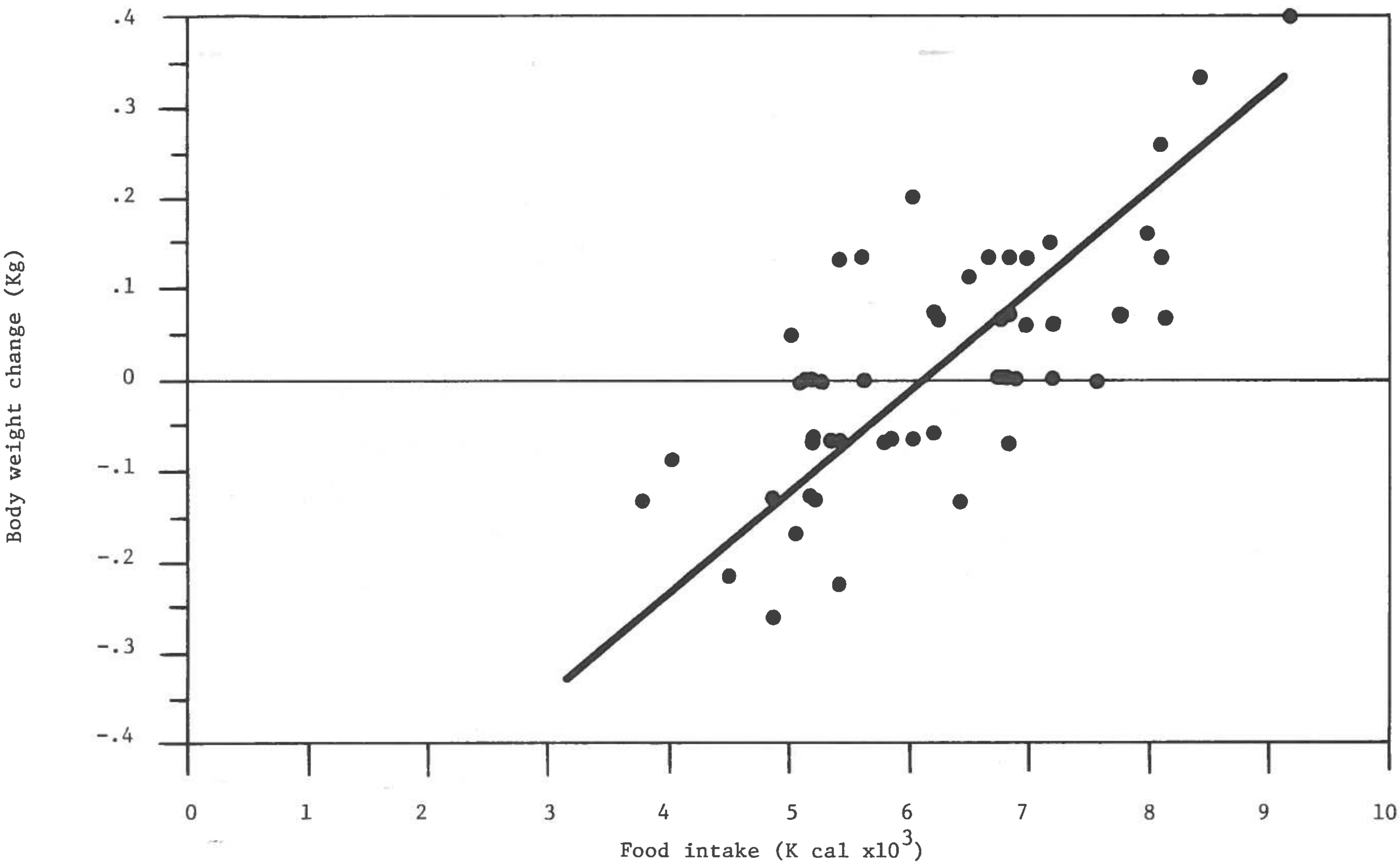

Figure 5. Relationship between average daily food intake and average daily change in body weight for Seal #5 in 1977. Functional regression line $Y= -.673 + .00011X$.

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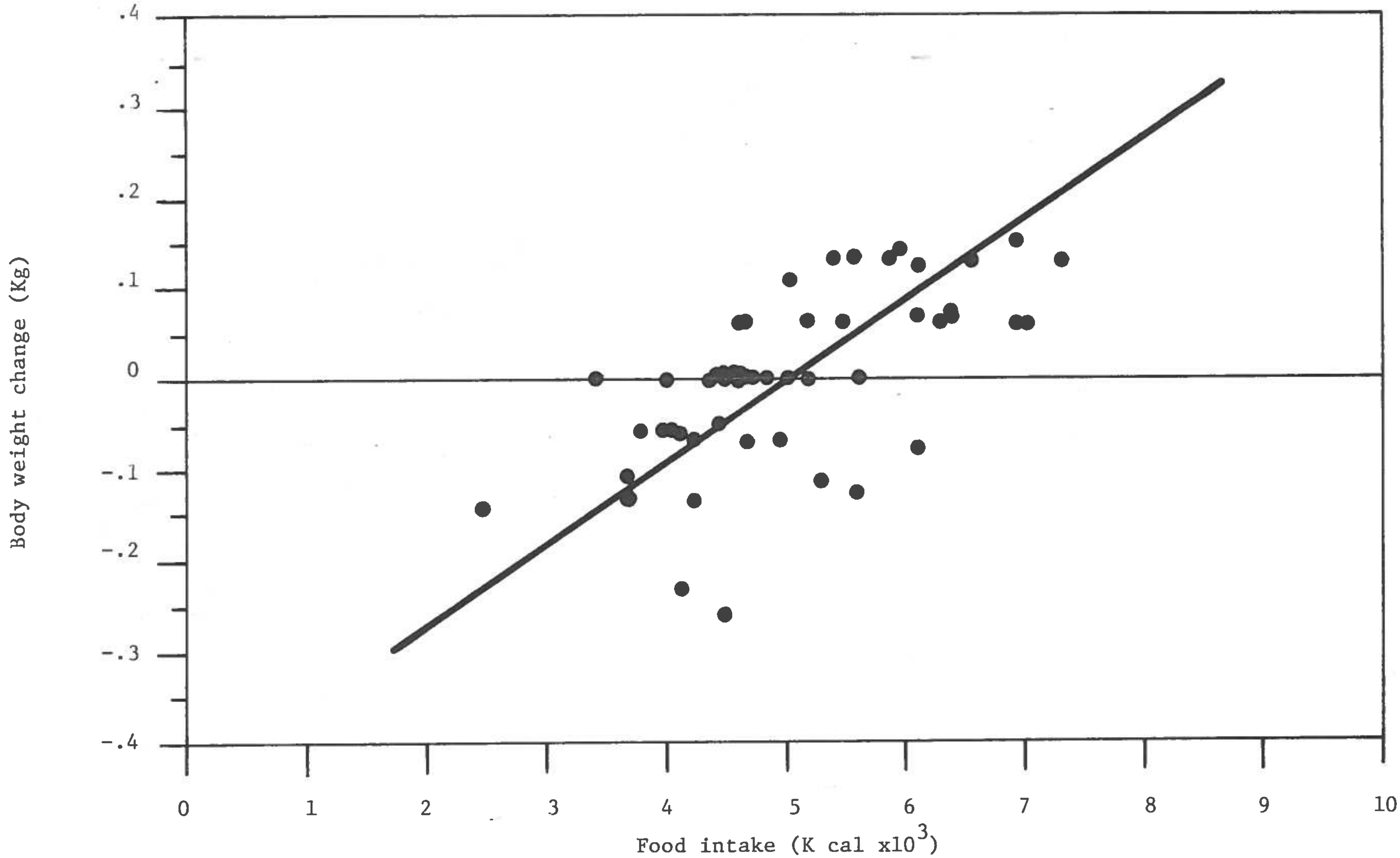

Figure 6. Relationship between average daily food intake and average daily change in body weight for Seal #7 in 1977. Functional regression line Y= -.46 + .000091X.