VITAMIN A IN LIVER OF THE ALASKA FUR SEAL

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ABSTRACT

In the economic management of the fur-seal herd of Alaska, it is necessary to kill a considerable proportion of the young males when they are three years old. The pelts are sold for tanning and the carcasses are rendered for oil and meal. This investigation of the livers of these seals was made for the purpose of ascertaining whether or not the supply of vitamin A-bearing oils could be augmented by rendering them separately from the carcasses. The results of this study indicate that there is some question as to the value of seal livers as a source of vitamin A-bearing oil. The most valuable of these livers from the standpoint of vitamin A was one containing $4.25 worth of vitamin A, while others were valued at as low as $0.25.

INTRODUCTION

Every summer, about 3,500,000 fur seals (Callorhinus ursinus) come to the Pribilof Islands, Alaska, to rest and breed. About 1,000,000 young, known as pups, are produced each year. From December to April, the seals are widespread at sea, and the Islands are deserted. Government employees, during the months of June and July, kill about 65,000 seals for the fur trade. The men attempt to select bachelors from the 3-year class but, for reasons beyond their control, they take a number of other young males as well as a few females. It is safe to assume that 80 percent of the kill consists of males whose true age is 3 years. For commercial purposes, the age of a male seal is estimated by reference to certain age-length standards. The standards were established years ago on the basis of branded seals of known age. About 80 percent of the annual harvest of seal skins comes from St. Paul Island and 20 percent from St. George Island.

Table I - Output of Fur Seal Byproducts, St. Paul Island, Summer of 1948

Seals Killed	Seal Carcasses Rendered	Output of Seal Meal: Amount	Output of Seal Meal: Value f.o.b. Seattle	Output of Seal Oil: Amount	Output of Seal Oil: Value f.o.b. Seattle
Number	Number	Lbs.	Dollars	Gals.	Dollars
58,280	54,746	684,000	$37,000	48,100	$50,500

A byproducts plant on St. Paul Island salvages nearly all of the skinned carcasses there. On St. George, and to a limited extent on St. Paul, the carcasses are left on the killing fields, are eaten by the resident Aleut natives, or are saved for fox food. The byproducts plant at St. Paul not only handles the carcasses from the killing fields, but also renders oil from the blubber which is scraped from the skins. From 3 to 20 hours after the kill, the carcasses are hauled to the plant. The blubber reaches the plant on the day after the kill. The bachelor seal of commercial size, 2 to 4 years old, weighs about 55 pounds. Of this weight, the freshly stripped pelt with attached blubber accounts for 10 pounds, and the carcass, 45 pounds.

Statistics of the operations on St. Paul for 1948 are given in Table I. While statistics of meal and oil production for the years preceding 1948 are available,

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they do not give as clear a picture of the byproducts operations as do the data for 1948. This is because, during the war and shortly thereafter, the flow of materials through the plant was irregular.

REEF FUR-SEAL ROOKERY ON ST. PAUL ISLAND, ALASKA

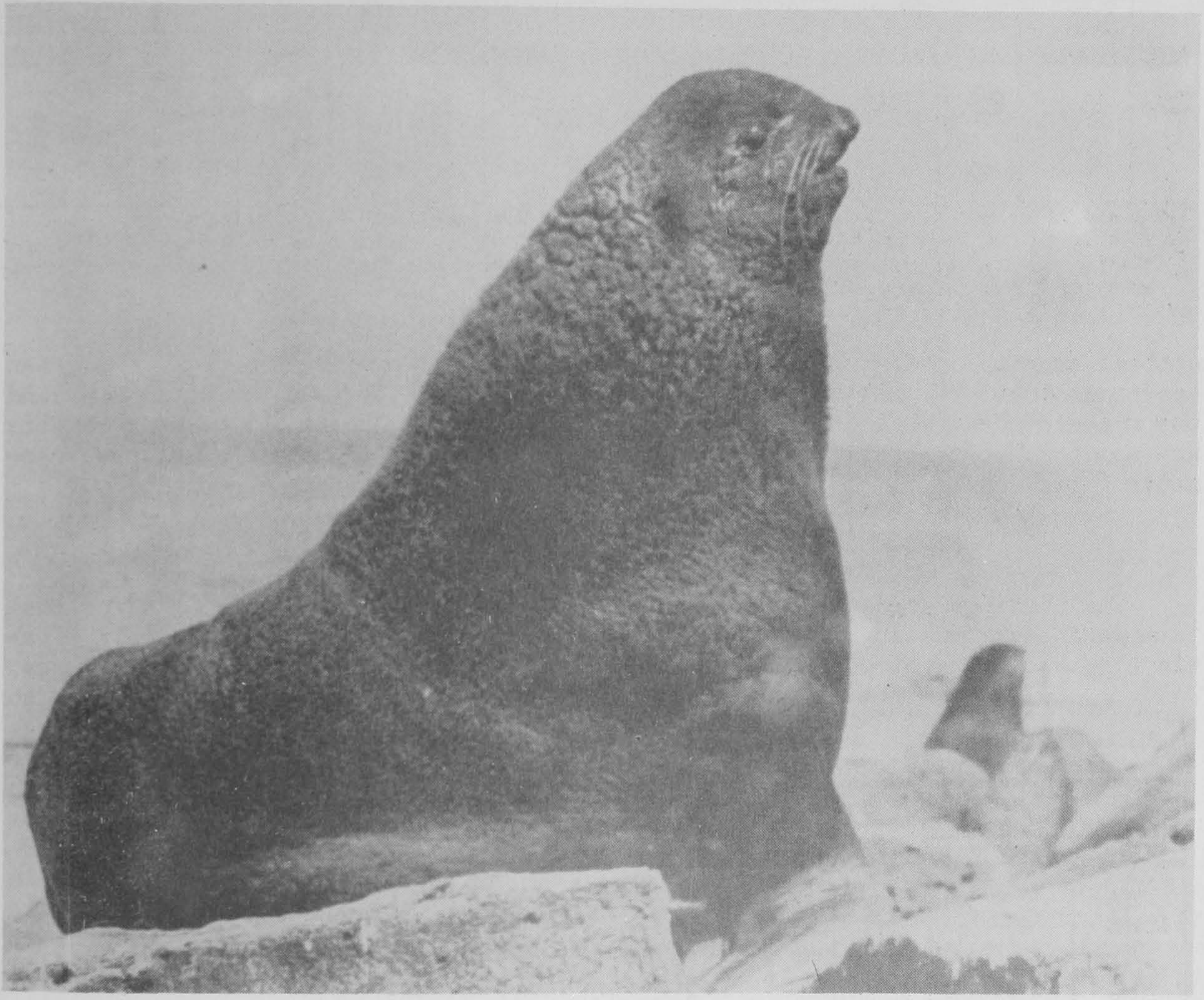
The value of a seal carcass in terms of its reduction products f.o.b. Seattle is about $1.60. In 1946, an investigation was started to explore the possibility of increasing this value through the recovery of vitamin A from seal liver. Studies at that time revealed the need for a better method of estimating vitamin A in low-fat livers and a need for larger samples (Miyauchi and Sanford, 1947A). As a result, the 1947 studies were on a revised and expanded scale.

COLLECTING THE SAMPLES

From June 16 to July 31, 1947, 196 fur seal livers were collected systematically on St. Paul Island. (Also collected, for comparison, were the livers of 4 sea lions and 3 porpoises.) On the killing field, the livers were removed from the seals at the rate of 1 per man per minute, within 1 hour after the death of the animal. Sand, blood clots, and grass were washed off the livers with cold water. The livers were then placed in waxed-paper and cellophane bags in a refrigerator at 14° F. to 26° F. After 24 hours, the bags were packed in barrels and held at the same temperature. In August, the samples were shipped, at temperatures of 20° F. to 25° F., to Seattle.

ANALYTICAL PROCEDURE

At the laboratory, the livers were stored at approximately 0° F. The analyses were started in February and completed in early June 1948. Since the livers had been taken in the preceding summer, they were in storage for from 6 to 12 months.



A BREEDING BULL, PRIBILOF ISLANDS, ALASKA

However, if the rate of decomposition of vitamin A in seal livers is similar to that in grayfish livers, it seems unlikely that any appreciable amount of vitamin A was lost during this time. In an earlier experiment, no measurable loss of vitamin A was found in grayfish livers stored for 9 months at -8.5° F. (Miyauchi and Sanford, 1947.)

The livers were put through a meat chopper and then further homogenized in a Waring Blendor. Approximately 5 g. of the homogenized sample were weighed in a tared 2-ounce shaking bottle, and about 10 g. powdered pumice, exactly 25 ml. ethyl ether, and about 20 g. anhydrous sodium sulfate were added. The bottle was then shaken for 2 hours. At the end of this time, it was centrifuged and an aliquot of 5 ml. was removed for oil analysis and another of 1 ml. was taken for vitamin A analysis.

The 5 ml. aliquot was placed in a tared, 50 ml. beaker and carefully evaporated on an air bath over a hot plate. Three minutes after the ether was gone, the beaker was removed and allowed to stand at least 45 minutes at room temperature before it was weighed. The 1 ml. aliquot was diluted with isopropanol and the

Table II - Oil and Vitamin A in Livers of Male Fur Seals, Summer of 1947

Age[1]	Livers in Sample	Weight of Liver			Oil Concentration in Liver			Vitamin A in Liver Oil		
		Mean	Standard Deviation	Coefficient of Variation	Mean	Standard Deviation	Coefficient of Variation	Mean	Standard Deviation	Coefficient of Variation
Yrs.	No.	Grams	Grams	%	% by weight		%	"Spec."[4] units per gram of oil		%
2	29	649	131	20	3.21[2]	0.602	19	42,590	40,500	95
3	95	980	159	16	2.99	0.372	12	57,430	38,800	68
4	24	1,243	177	14	2.97	0.222	7	91,670	59,160	65
6	9	1,977	479	24	3.40[3]	1.420	42	84,900	92,830	109

1/The age is known for the 2- and 6-year olds; estimated for the 3- and 4-year olds.
2/Omitting the two highest percentages in this group, 4.92 and 5.17, the mean would drop to 3.07.
3/Omitting the highest percentage in this group, 7.12, the mean would drop to 2.93, the standard deviation to 0.267, and the coefficient of variation to 9.
4/2000 x E (1%, 1 cm., 328 mmu., isopropanol).

optical density of the solution at 328 mmu. was measured by means of a Beckman spectrophotometer. All measurements were in duplicate. For both the oil and the vitamin A estimations, the mean range of error of the duplicate measurements was about 2.7 percent. The vitamin A measurements are reported in spectrophotometer (spec) units.

RESULTS

The findings are summarized in Tables II and IV. The liver of the fur seal is moderately variable in weight and oil content and extremely variable in vitamin A potency. The wide fluctuation in potency (found also in the liver of fishes) obliges the researcher to collect and analyze a large number of samples. The mean weight of the seal liver in males of known age increases from 1.43 pounds in the 2-year-old to 4.35 pounds in the 6-year-old. (A female pup in the collection had a liver weighing 0.75 pounds.)

Table III - Oil & Vit. A in Livers, Selected for Pale Color, of 10 Male Fur Seals, July 12, 1947

Weight of Liver	Oil Concentration in Liver	Vitamin A in Liver Oil
Grams	Percent by weight	"Spec." units per gram of oil
1,245	14.33	1,900
795	3.16	14,100
1,180	2.66	37,800
900	3.68	46,200
930	3.11	54,000
990	3.14	66,700
890	3.72	66,800
1,255	3.86	367,000
1,010	3.87	415,000
1,065	4.56	584,000

Seasonal variation in weight, oil content, and potency is not demonstrable in our material. While the June livers were found to be richer in vitamin A than the July ones, the difference is not significant. Given a larger sample and a longer study period, the difference might prove significant.

The vitamin A potency of the liver oil shows variation with the age of the seal. The potency increases as the seal grows older. This seems to be true, at least, within the age range of 2 to 6 years. The potency in the combined 4- and 6-year classes is significantly greater than the potency in the combined 2- and 3-year groups. The differences between the individual year groups; 2 and 3, and 4 and 6, are less, and are not statistically significant. It seems to be true among marine mammals and fishes that, as the individual matures, the vitamin A potency of the liver increases.

BARRELING FUR SEAL SKINS ON ST. PAUL ISLAND, ALASKA, FOR SHIPMENT

Sex variation in the vitamin A potency of the liver is suggested by the findings. The potency of the liver oil in 3-year males is significantly higher than that in females of unknown age, but of similar body weight. Without knowing the age of the females, it is not possible to establish the true difference in potency between males and females. Sufficient to say that, of the seals killed in the natural course of the harvest, the males were richer in vitamin A than the females. The females from which we recovered liver samples were neither the youngest or the oldest females on the killing grounds. They were probably 4 to 8 years old. This makes it increasingly probable that the concentration of vitamin A in the male liver is greater than in the female, since the comparison was made with males which were undoubtedly younger than the females. (In the soupfin shark, the male commonly yields a liver oil of higher vitamin A potency than does the female.)

In male and female fur seals of similar body size, the livers are of similar weight. The mean weight of the liver in 3-year males was 980 g. and in killing-ground females, 911 g. While their age is not known, the females accidentally killed are the same size as the 3-year males.

Certain puzzling variations associated with the color of the livers were noted. Bearing in mind that we examined only 10 pale, yellowish livers as compared with 186 "normal," maroon-colored ones, it was noted that:

1. The pale livers are slightly richer in oil than are the livers of any other group. (One pale liver containing 14.33 percent oil, nearly 5 times the mean value for fur seals, is perhaps pathological, and we have treated it specially in preparing Table IV.)

2. The vitamin A potency of pale-liver oil is significantly greater than that of 3-year-male liver oil. (We make this comparison because the average weight of a pale liver is close to that of a 3-year-male liver.)

3. Three out of the ten pale livers yielded oil of unusually high potency (Table III). In this group of 10 livers, the highest potency is 307 times that of the lowest. (Hence, the danger of drawing conclusions from a sample containing only a few livers is readily apparent.) The variation in potency within the pale-liver group is so extreme that we are inclined to believe the group is heterogeneous and should not be compared with any other group. Possibly, the apparent relationship between paleness and potency is a spurious one. Certainly, the data at hand do not show that a pale liver is invariably rich in vitamin A.

The values for oil content and vitamin A potency in the liver of the Dall porpoise and the Steller sea lion correspond roughly to the values for fur seal liver. We must emphasize, though, that our samples of porpoise and sea lion

Table IV - Oil and Vitamin A in Livers of Miscellaneous Marine Mammals, Summer of 1947

Species	Sex	Livers in Sample	Weight of Liver: Mean	Weight of Liver: Standard Deviation	Weight of Liver: Coefficient of Variation	Oil Concentration in Liver: Mean	Oil Concentration in Liver: Standard Deviation	Oil Concentration in Liver: Coefficient of Variation	Vitamin A in Liver Oil: Mean	Vitamin A in Liver Oil: Standard Deviation	Vitamin A in Liver Oil: Coefficient of Variation
		No.	Grams	Grams	%	% by weight		%	"Spec. units per gram of oil		%
Fur seal[1]	M	9	1,012	141	14	3.53	0.571	16	183,600	212,300	116
Fur seal[2]	M	1	625	-	-	3.30	-	-	35,600	-	-
Fur seal[3]	F	1	340	-	-	3.01	-	-	15,300	-	-
Fur seal[4]	F	27	911	146	16	3.12	0.405	13	21,800	13,700	63
Porpoise[5]	-	3	1,578	475	30	3.79	0.455	12	16,500	11,100	67
Sea lion[6]	-	4	1,206	161	13	3.92[7]	1.820	46	23,300	9,400	40

1/Livers selected for pale color; mean units of vitamin A per pound, 2.94 million. There were originally 10 livers in the sample (see Table III). One was omitted from the tabulation because it contained 14.33 percent oil, twice as much as any other, and nearly five times the mean. This particular liver was also unusual in that its oil contained only 1,900 units of Vitamin A per gram.

2/A seal with reddish-orange blubber.

3/A pup, or first-summer young.

4/Assorted females of medium age.

5/*Phocoenoides dalli*, adult male, adult female, and sub-adult male from British Columbia and Alaska.

6/*Eumetopias jubata*, sex unrecorded, pups, St. Paul Island, Alaska, July 22.

7/Omitting the highest individual percentage in the group, 6.71, the mean would drop to 2.99.

livers are very small and are not truly representative of age and sex groups. Consequently, we can draw no conclusions from them.

CONCLUSIONS

The average vitamin A content of fur seal liver is so low that it is questionable whether the liver could be handled profitably under existing conditions. At the prevailing price for vitamin A, about 15 cents per million units, the bachelor seal liver is worth about 25 cents. On the other hand, a few livers, representing perhaps 10 percent of the total, seem to be rich enough in vitamin A to warrant commercial exploitation at present prices. These are the pale yellowish-colored livers. Of 10 such livers examined, the most valuable one contained $4.25 worth of vitamin A. It remains to be seen whether the relationship between pale color and high potency is accidental or real. It also remains to be seen whether color can be used as a practical basis for segregating, on the killing field, the profitable from the unprofitable livers.

Other criteria which might be used for separating livers are the size (or age) and sex of the seal. We find measurable differences in vitamin A potency related to these criteria. But there would be no point in segregating the livers by size and sex, as long as the mean potency for neither group is high enough to warrant exploitation.

LITERATURE CITED

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THE FISH LIVER OIL INDUSTRY

In considering the sources of raw materials for the production of liver oils, the volume of livers and viscera available from the fish landed from an active fishery can be readily approximated. Fishermen usually have some general ideas about the types of fish that are taken on their gear but are not brought to port. The abundance of such bothersome species may not always be properly estimated by the fishermen since they may be biased unduly by a relatively small number of valueless fish appearing in the catch. For example, to the early halibut fisherman, grayfish were a pest, since they were not salable then and each one on the hook cut down the potential haul of halibut per skate of gear. In such cases, the fisherman may overestimate the abundance of these nuisance species. Unless accurate biological studies have been made of a fishery, the level of sustained production that may be expected cannot be predicted. For example, the halibut fishery of the North Pacific is believed to be sufficiently well regulated as a result of years of study that in the future a definite annual poundage can be reasonably expected. For such a fishery, the livers and viscera available can, therefore, be rather accurately estimated. On the other hand, the abundance, life cycle, etc., of albacore tuna are not known well enough to give even a general idea as to the probable catch in future years.

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