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INDIAN FISHERIES PRODUCTIVITY IN PRE-CONTACT TIMES IN THE PACIFIC SALMON AREA[1]

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ABSTRACT

The significance of the primitive subsistence fishing of the Pacific Salmon Area is analyzed in order to arrive at reasonable estimates of the aboriginal consumption of salmon. Salmon consumption has been selected as the best general measure of the use of fishery resources which can be applied both to the aboriginal and commercial periods. From this we shall proceed to the consideration of the evidence for a "resting" period, following the decline of the native fishing, and before the full establishment of commercial fishing, during which stocks of certain species actually may have become more abundant than they had been for many previous centuries. Further, we shall suggest that if such an increase occurred, part of the early high productivity of the commercial fisheries (in terms of expenditure of effort) might be attributable to the temporary existence of a fish surplus.

Significance of the Primitive Subsistence Fishery

Estimates of Aboriginal Salmon Consumption

For many centuries, perhaps for several millenia, parts of the Salmon Area were occupied by primitive peoples subsisting on aquatic foods where these were available. There is no reason to suppose that the aboriginal population of the area in 1770 or 1780 (whenever one chooses to end the prehistoric period) had been growing very rapidly in the several centuries preceding, so we may assume that the exploitation of the fisheries had been continuing at a fairly even rate at the time of the first white contact. We are, therefore, in a position to project certain known demand factors against the known resources of the fisheries. Using the figures in the second column of Table 1, taken from Mooney (1928) and Kroeber (1939:136-38) for California, we can make estimates of aboriginal food consumption for the area, or for parts of it, and of its salmon consumption in particular.

We may start with a crude estimate of total food consumption, measured in calories, based on the normal calorie requirements of average populations. The figure of 2000 calories per day per capita for the Salmon Area as a whole does not seem excessive, if the high fuel consumption of the human body in cold winter climates is considered. The figure would be too low for some Eskimo and Athabaskan groups, and possibly too high for groups on the southern periphery of the area. Using the total estimated aboriginal population of 338,150 given in Table 1 times a daily calorie requirement of 2000 times 365 days, we obtain a crude annual caloric demand estimate of 245,740,000,000 calories. This unwieldy figure might better be comprehended in terms of weight, though caloric values of food are not directly expressible as weight units. Arbitrarily, we may take an average daily ration of two pounds with a caloric value of 2000 for the sake of example.[2] Such a ration would yield an annual demand, for the entire Salmon Area, of 122,804 short tons of food.

The satisfaction of this demand must have been largely up to the fisheries (including sea-mammal hunting), since other natural foods available in the area in quantity are notoriously low in fuel value.[3] When available, the flesh of certain game animals, but not all of them, could provide adequate fuel values.

If, for the sake of argument, we assume that somewhat less than one-half of the caloric requirement of the average native consumer of the area was satisfied by eating salmon, this would yield an annual consumption of about 365 pounds of salmon per capita. This is based on the fact that the caloric value of salmon flesh is nearly 1000 per pound (903 to 915 Tressler 1923:270-271). Eulachon and some other fishes caught in the area may equal or exceed this value, but the commoner marine fishes have lower fuel value per pound, and the mollusks even less. The caloric value of the flesh and blubber of sea-mammals, however, is at least equivalent to fat beef, and is probably much higher (Tressler 1923:642).

Using the figure of 365 pounds of fresh salmon per person per year, the crude estimate of the pre-commercial salmon catch of the area would be approximately 123,424,750 pounds, or about 15 percent of the modern commercial salmon catch, 800,000,000 pounds. Instead of basing our estimate on calorie demands, we may take another minimal dietary requirement for protein. The daily protein intake of a normal individual cannot fall much below 60 grams without jeopardizing his health (Elvehjem 1942:289-98). Using 16 percent as the protein factor in salmon flesh (actually higher in the better portions), we find that 305 pounds per year would satisfy the native consumer if all or nearly all of his protein were obtained from salmon.[4] At this rate, the natives of the area would have consumed about 103,135,750 pounds per year. It must be noted that this is based on minimal requirements, and that in the native environment there were no very good vegetable sources of energy. The intake of animal flesh had to cope with calorie

TABLE 1

ESTIMATES OF ABORIGINAL SALMON CONSUMPTION
(IN POUNDS OF FRESH FISH PER YEAR)

Native Groups	Estimated Population	Estimated Consumption	
		Per Capita	Total by Groups
Western Alaska			
Nuwuk, Kopak, Numatak	3,000	100	300,000
Malemiut	1,600	200	320,000
Kinugumiut, Kaviagmiut	2,800	300	560,000
Unaligmiut	1,600	200	320,000
Ikogmiut	500	800	320,000
Magamiut, Kaialigmiut	5,000	365	1,855,000
Nuniwagmiut	1,500	100	150,000
Kuskokwagmiut	7,200	1,000	7,200,000
Togiagmiut, Chingigmiut, Nushagak	1,300	500	650,000
Ogulmiut	3,700	500	1,850,000
Subtotal	28,000	Avg. 396	13,525,000
South-Central Alaska and Aleutians			
Aleut	16,000	280	4,480,000
Koniag	8,800	500	4,400,000
Tanaina	1,200	500	600,000
Chugachmiut	1,700	500	850,000
Eyak	800	300	240,000
Subtotal	28,500	Avg. 416	10,570,000
Northern Interior			
Alaska Kutchin	1,600	475	760,000
Yukon Territory Kutchin	2,200	200	440,000
Ahtena	500	600	300,000
Khotana, Kalchana (except Tanaina)	3,200	690	2,208,000
Tahltan, Taku-tine	2,500	260	650,000
Subtotal	10,500	Avg. 445	4,358,000

TABLE 1--Continued

Native Groups	Population	Estimated Consumption Per Capita	Estimated Consumption Total by Groups
Northwest Coast			
Northern Tlingit	2,000	500	1,250,000
Southern Tlingit	7,500	500	3,750,000
Haida	9,800	400	3,920,000
Tsimshian Proper	3,500	400	1,400,000
Niska, Gitksan	3,500	500	1,750,000
Haisla	1,300	500	650,000
Heiltsuk	1,400	500	700,000
Bella Coola	1,400	500	700,000
Kwakiutl	4,500	365	1,645,000
Nutka	6,000	300	1,800,000
Makah, Quilleute, Quinault	4,000	365	1,460,000
S.E. Vancouver Island	9,200	500	4,600,000
North of Fraser River	7,400 a	600	4,440,000
Fraser Delta	3,900	1,000	3,900,000
Nutsak, Lummi	800	600	480,000
Clallam, Chimakum	2,400	365	876,000
Skokomish, Nisqualli, Twana, Puyallup, Snoqualmi, Snohomish, Skagit	6,000 b	350	2,100,000
Subtotal	75,100	Avg. 485	34,779,000
Columbia-Fraser Plateau			
Tlatskanai	1,600	365	584,000
Lower and Upper Chehalis, Owilapsh, Cowlitz	1,200	365	438,000
Klikitat, Yakima, Wanapum, Palus	11,200	400	4,480,000
Nez Perce	4,000	300	1,200,000
Tenino, Umatilla, Wallawalla	2,900	500	1,450,000
Wailatpu (Cayuse)	500	365	182,500
Wenatchi, Sinkiuse, Spokan (part)	3,500	500	1,750,000
Wenatchi-Spokan (part)	2,400	500	1,200,000
Kalispel, Coeur d'Alene, Pend d'Oreille, Flathead	2,800	100	280,000
Okanagan, Lakes	2,200	500	1,100,000
Kutenai	1,200	300	360,000
Chilcotin	2,500	600	1,500,000
Lillooet	4,000	600	2,400,000
Thompson, Nicola	5,150	900	4,635,000

TABLE 1--Continued

Native Groups	Population	Estimated Consumption	
		Per Capita	Total by Groups
Columbia-Fraser Plateau (Continued)			
Shuswap	5,300	500	2,650,000
Carrier, Babine	8,500	600	5,000,000
Bannock, N. Paiute, N. Shoshone	3,000	50	150,000
Subtotal	61,950	Avg. 438	29,459,500
Oregon Coast to N.W. California			
Chinook	22,000	400	8,800,000
Tillamook	1,500	320	450,000
Yaquina, Alsea, Siuslaw	6,000	320	1,920,000
Kus	2,000	300	600,000
S.W. Oregon Athabaskans	8,800	300	2,640,000
Tolowa	1,000	365	365,000
Kupa, Chilula	1,500	365	547,000
Yurok	2,500	365	912,000
Karok	1,500	450	675,000
Wiyet	1,000	300	300,000
Nongatl, Mattole, Lassik, Wailaki, Kinkyone	4,000	200	800,000
Subtotal	51,800	Avg. 335	18,039,000
Willamette Valley-Klamath Lakes			
Kalapuya	3,000	100	300,000
Takelma	500	300	150,000
Shasta, Chimariko	3,000	300	900,000
Klamath, Modoc	1,200	20	24,000
Achomawi, Atsugewi	3,000	100	300,000
Mountain Maidu	1,000	77	77,000
Subtotal	11,700	Avg. 149	1,751,000
California			
Kato	500	247	123,500
Yuki, Coast Yuki	3,000	100	300,000
Wintu (Sac'to drainage)	2,000	300	600,000

TABLE 1--Continued

Native Groups	Population	Estimated Consumption	
		Per Capita	Total by Groups
California (Continued)			
Wintu (Trinity	1,500	300	450,000
Wintun	2,500	365	938,000
Yana	1,500	300	450,000
F'thill Maidu, Ninenan	4,000	200	800,000
Plains, F'thill Miwek	9,000	200	1,800,000
Costanoan, Esselen	7,500	10	75,000
Valley Yokuts	11,000	50	550,000
F'thill Yokuts	7,000	50	350,000
Western Mono	2,000	5	10,000
Pome (except Lake)	6,000	100	600,000
Wappe, Coast Miwok	3,000	75	225,000
Patwin	6,000	300	1,800,000
Valley Maidu	4,000	300	1,200,000
Subtotal	70,500	Avg. 182	10,271,500
Grand Total	338,150	Avg. 356	127,755,800

[a]Gulf of Georgia

[b]Puget Sound

demands that in our own diets are met in part by sugar, starch, eggs, and dairy products. At least, these two crude estimates are an indication of the order of magnitude of the total salmon and/or fish consumption of the area.

There are data indicating that the actual consumption of salmon by natives in some parts of the area were much higher per capita than we have assumed above, while in other, less favorable districts, the annual per capita intake of salmon may have been as little as 10 to 25 pounds, representing the meals which might be prepared from half a dozen fish in the course of a year.

The most complete series of estimates of aboriginal fish consumption are from Alaska. The earliest figures seem to be those of Dall (1870:485, 537), who stated that "The number of salmon annually consumed by the natives of Alaska cannot be less than 12,000,000, at the lowest estimate." Converting this figure into terms of weight using the factor of five pounds for the average salmon of all species, we obtain 60,000,000 pounds, which, apportioned among the 26,843 natives then enumerated in the territory, yields a per capita annual consumption of 2220 pounds. Using the figures given in another of Dall's references, for Kodiak Island and Cook Inlet, the more moderate estimate of 930 pounds per person per year is obtained. In his report on the population and resources of Alaska for the 1880 census, Ivan Petroff devoted several pages to the native fish catch, which he considered in nine separate areas (Petroff 1881:69-70). For Southeastern Alaska with a predominantly Indian population in 1881 of 7000, Petroff states that each individual consumed "the equivalent of 3,000-4,000 pounds of fresh fish per year," with halibut and salmon as the basis of supply. At Prince William Sound, he estimated a consumption of 300,000 pounds of fish, mostly salmon, or 500 pounds per year per capita. At Belkofsky, near the southwestern tip of the Alaska Peninsula, the Aleuts consumed about 290-300 pounds of salmon "fresh and dried" per capita per year. Petroff's estimate comes to 312 pounds for salmon on Cook Inlet, and on Kodiak the mixed white population annually packed 200,000 pounds of salt salmon, equivalent to 624 pounds per person of fresh fish. The Kodiak figure was in addition to the consumption of fresh (unsalted) salmon; if the dried salmon pack at Kodiak, averaging 312 pounds per person, were added to the salted pack and to the amounts consumed fresh, the per capita total would rise above 1000 pounds. Petroff's estimate for Unalaska is not allocated by species. For Bristol Bay, Petroff's estimate of 500 pounds of salmon per person is a rough estimate, for the population there is given in round numbers. Including the consumption of salmon by sled-dogs, the natives of the Kuskokwim are stated to have consumed the astonishing total of 6000 pounds of fish per capita annually. Three tons appears excessive, even if dogs outnumbered humans five to one. In this instance, not all the consumption was of salmon; whitefish, trout, and blackfish were included. An equally high figure, species unstated, is given for the natives of the Yukon Valley (Petroff 1881:33).

Sources quoted by Bean (1887:93-94), apparently independent of Dall's and Petroff's estimates, give us additional data for fish consumption by the natives of Alaska. For Kodiak and Afognak, the dried salmon or "ukali" put up by each family for winter use averaged between 930 and 958 pounds per person, in equivalent fresh weight of fish. This was, of course, in addition to fish eaten fresh, and to salmon preserved by salting, which was not an aboriginal process. Bean (1887:87) quotes another source for the parish of St. Paul on Kodiak, which yields a figure of 1875 pounds per person. For Cook Inlet, Bean's figures amount to 925-940 pounds per capita.

At a much later date, when the white population of the Yukon basin "in some measure" dependent on local fisheries was greater than the Eskimo and Indian population, Cobb (1930) presents some figures for salmon consumption. Using standard conversion factors based on Gilbert and O'Malley's later Yukon study, per capita utilization of salmon in 1918 was 910 pounds per person per year. To each human consumer, however, must be added the fish eaten by 0.6 of a husky dog. The Yukon statistics included 11,000 people and 6,183 dogs. In 1920, according to Gilbert and O'Malley, salmon consumption in the same area was 3100 pounds per capita, counting the dogs owned. There was a decline in the population of Alaska between 1918 and 1920, partly caused by the ravages of the pandemic influenza, the recession of the gold fever, and above all by the attraction of war industries in the United States. In all, this decrease amounted to 9320, but the greater part of the discrepancy between Cobb's and Gilbert and O'Malley's estimates may be due to a different ratio for converting weight of dried salmon to its fresh equivalent. We learn from Gilbert and O'Malley that the average Alaskan work-dog consumes an amount equal to 1080 pounds of fresh salmon each year.

Sullivan (1942:29) provides additional information to gauge the reliability of the foregoing estimates. Dealing with a group of Ten'a (Koyukon) in the villages of Kaltag, Nulato, and Keyukuk, he notes that practically every family has a team of at least seven sled dogs, many having nine or eleven. When the animals work on the trail in winter, their ration consists of "at least one good-sized, dried salmon a day." In summer, and when not working, they are fed only half a salmon each day. Assuming that 100 days a year are working days for these animals, they would consume 232-1/2 fish. If the salmon were of the species commonly fed to dogs, *O. keta*, which average 8 pounds apiece, each dog should consume 1860 pounds a year. Multiplying this by the minimal seven-dog team, the quantity needed to supply the dogs of each family would be 13,020 pounds, or 3255 pounds for each person of the average family, over and above what is required for human food consumption. In pre-white times, however, the Athabaskans of the interior of Alaska did not use dog sleds (Osgood 1940:357). Without the dog teams which now must be reckoned in the fish consumption of the Yukon Valley, the use of salmon there in the past must have been considerably lower.

The writer discussed these high figures for salmon consumption with Dr. Cornelius Osgood, whose ethnographic work in the Yukon Valley and at Cook Inlet would make him a good judge of their reliability. Osgood did not feel that amounts over 1000 pounds per capita were excessive, stating that during his own residence in the interior of Alaska he consumed several pounds of fish each day, mostly dried salmon.

From farther south, in British Columbia, we have a general estimate for the per capita Indian consumption in 1879 of 583 (Carrothers 1941:5).[5] For the Indians around the headwaters of Skeena River and at Babine Lake, an observer in 1904 reported that each native family used about 1000 salmon each year. Taking 4 pounds as the lowest average weight of salmon in that district, this amounts to an annual per capita consumption of 1000 pounds (Carrothers 1941).[6] Still farther south, we have the rough estimate of 365 pounds per year for the natives of the Columbia Basin, used by Craig and Hacker (1940) and a figure of 307 pounds per capita derived from statistics of the modern Indian catch at Celilo Falls, which is shared by a population of 13,000 natives enjoying treaty rights in its salmon dip-net fishery (Pacific Fisherman).

The various estimates of annual per capita consumption of salmon by native groups within the area are combined in Table 2, below.

TABLE 2

ESTIMATES OF NATIVE CONSUMPTION OF SALMON
(UNIT: FRESH SALMON IN POUNDS PER CAPITA PER YEAR)

Estimate	Area or Group	Remarks and Source
290-300	Belkofsky Aleut	Salmon less important than cod. (Petroff 1881)
307	Celilo Falls	Modern catch by Indians with treaty rights. ("Pacific Fisherman")
312	Cook Inlet natives	(Petroff 1881)
365	Columbia Basin in aboriginal times	(Craig and Hacker 1940)
500	Prince William Sound natives	Includes some fish besides salmon. (Petroff 1881)
500	Bristol Bay Eskimo	(Petroff 1881)
583	Indians of entire Province of British Columbia in 1879	(Carrothers 1941)
910	Natives and whites of Yukon Valley	Includes fish eaten by dogs. (Cobb 1930)
930	Kodiak and Cook Inlet natives	(Dall 1870)
925-940	Kodiak, Afognak, Cook Inlet, and adjacent areas	Dried salmon only. (Bean 1887)
1000	Indians around Babine Lake and upper Skeena	(Carrothers 1941)
1000 or more	Kodiak natives and whites	Includes fresh, dried, and salt salmon. (Petroff 1881)
1875	St. Paul Parish, Kodiak Island	Dried salmon only. (Bean 1887)
2220	Natives of entire Territory of Alaska	(Dall 1870)

TABLE 2--Continued

Estimate	Area or Group	Remarks and Source
3000-4000	Southeastern Alaska Indians	Includes halibut, etc. (Petroff 1881)
3100	Natives and whites of Yukon Valley	Species of fish net stated. (Petroff 1881)
3255	Koyukon	Salmon eaten by sled dogs, apportioned among members of dog-owning families. (Sullivan 1942)
6000	Yukon and Kuskokwim natives	Includes species other than salmon. (Petroff 1881)

This table indicates that we must weight the salmon consumption of some aboriginal groups or areas much more heavily than others. While we have very few quantitative hints for the regions south of Alaska, it is reasonable to suppose that per capita consumption among intensive fishing peoples in parts of the Plateau and on the Northwest Coast reached amounts equivalent to at least the lower estimates given above. It seems hardly necessary to add that the per capita consumption of salmon or any other natural product was subject to the variability of supply from year to year due to climatic and other factors. Even the best estimates can only be generalizations, rarely coinciding with actual experience in any particular year. In the case of salmon, the annual fluctuation in their availability was very marked in some areas, as with the sockeye of the Fraser Basin, with its four-year cycle of abundance.

Table 1 represents an attempt to refine the crude estimate of aboriginal salmon consumption for the whole Salmon Area by adding separate estimates for each group, instead of simply multiplying the entire population by the arbitrary factor of 365 pounds per year. While the method still rests on guesswork more than on factual evidence, every effort has been made in the table to arrive at reasonable figures, based on the available ethnographic data presented in Hewes (1947). Tribes which are known to have spent little time in fishing, or which depended more on the hunting of land mammals or the collection of wild plant foods, have been rated as low consumers of salmon. Where marine aquatic foods other than salmon were present in abundance, as on the Northwest Coast, or among the sea-mammal-hunting peoples of the Bering Sea region, estimates of salmon intake have been reduced. Thus, the Karok are considered to have eaten more salmon per capita than the Yurok, and the Lower Chinook less than the Tenino. The grand total estimated salmon consumption obtained by this addition of local figures is 127,755,800 pounds, as against our earlier crude estimate of 123,424,750 pounds, or 103,135,750 pounds based on minimal protein requirements. Considering the degree of reliability of the original population estimates upon which the whole assumption rests, and our ignorance of many factors which may have affected the aboriginal use of salmon in the area, 100,000,000 to 130,000,000 pounds per year probably comes as close to the truth as we shall ever be able to reach.

We can use this quantitative value as an indication of the order of magnitude of the fraction of the salmon resource of Northwestern North America which was removed each year, possibly for many centuries, with no serious danger to the future productivity of the fishery. Observations based on the catch of the commercial period alone are of too short duration, and complicated by such external factors as erosion, blockage, and pollution, to be entirely conclusive.

Consumption of Other Aquatic Foods

No attempt has been made here to reckon the consumption of food fishes other than Pacific salmon, even though in some localities they may have been of greater subsistence importance. (Carrothers [1941:85] gives estimates for the aboriginal consumption of halibut in British Columbia.) This is because the main scientific interest in the fisheries of the area so far has been on problems related to the salmon species, both because of their economic value and their migration and spawning in fresh water, which has made it easier to study the conditions which determine their abundance or threaten them with depletion. The life histories of many of the important food fishes which spend their entire life cycle in deep sea waters are little known by contrast, because of obstacles to observation. For salmon we have not only a good body of statistical data, covering nearly all the large streams of the area, but reliable studies of their biology and distribution. Finally, the nutritive values of the various species of salmon can be equated on a calories-per-pound basis. Were we to deal with several unrelated food species, the reduction of their nutritive values to a common factor would be far more difficult.

Patterns of Growth and Decline of Commercial Fisheries

In Hewes (1947:196-205) is a sketch of the rise of the commercial fishing industry of the Salmon Area, from the early endeavors to establish dependable food supplies for fur trading posts and for sale to the occasional merchant vessels visiting the coast, to the development of the canning of salmon and the more recent growth of the halibut, pilchard, and albacore fisheries. Confining our attention to the salmon fishery, let us first examine the pattern of initial rapid growth and eventual decline which has characterized the industry on the rivers of the Pacific Coast, beginning with the Sacramento in 1864.

After a peak production reached in 1882, the first marked decrease set in on the Sacramento in the ensuing decades.[7] This was the first decline on any salmon fishery stream on the coast, except for the Smith

River, where the commercial fishing was never of real importance. In 1883 the salmon yields on the Eel River reached a peak. The only California salmon stream to maintain a rising curve of production was the Klamath, where a decline did not become apparent until after 1912.

To the north, the fisheries on the eleven rivers of the Oregon coast culminated in 1911, when the district yielded 250,000 cases. Since then production has fallen to about 15,000 cases a year.

On the Columbia River, depletion was foreseen as early as 1888 (Bancroft 1888:758). The pack there reached its maximum in 1895, but the signs of decline were masked by the substitution of chinook salmon for the sockeye, which formerly constituted the bulk of the Columbia River pack, and by greatly increased output of fishing effort. The magnitude of the pack in any year is determined to a great extent by the market outlook, but when greater and greater expenditure of the labor of fishermen fails to increase the yields under the pressure of market demands, then the depletion is real. In 1930 the salmon pack of the Columbia was down to less than half of the 1895 total (Freeman and Martin 1942:209-10). (A 48-pound case is equal to 68-70 pounds of fresh salmon [Bancroft 1888, Cobb 1930].)

The declines on the streams of western Washington entering Willapa Bay and Grays Harbor set in after 1902 and 1911, respectively. The Quinault, Queets, Hoh, and Soleduck fisheries culminated in 1915. The catch in Puget Sound is based largely on the huge runs of salmon into the Fraser River. The heyday of Puget Sound salmon fishing was from 1899 to 1919, when the catch averaged nearly one million cases a year, with a peak pack in 1913. In 1939 the pack had dropped to 400,000 cases, and in 1940, to 121,000 cases (Freeman and Martin 1942). On the Fraser River, the pack reached its peak in 1901. The fisheries on the Skeena, Rivers Inlet, Smiths Inlet, and Nass, and outlying streams of British Columbia culminate much later, in 1918-1920, with the increased fishing effort to satisfy the booming market following the end of the First World War.

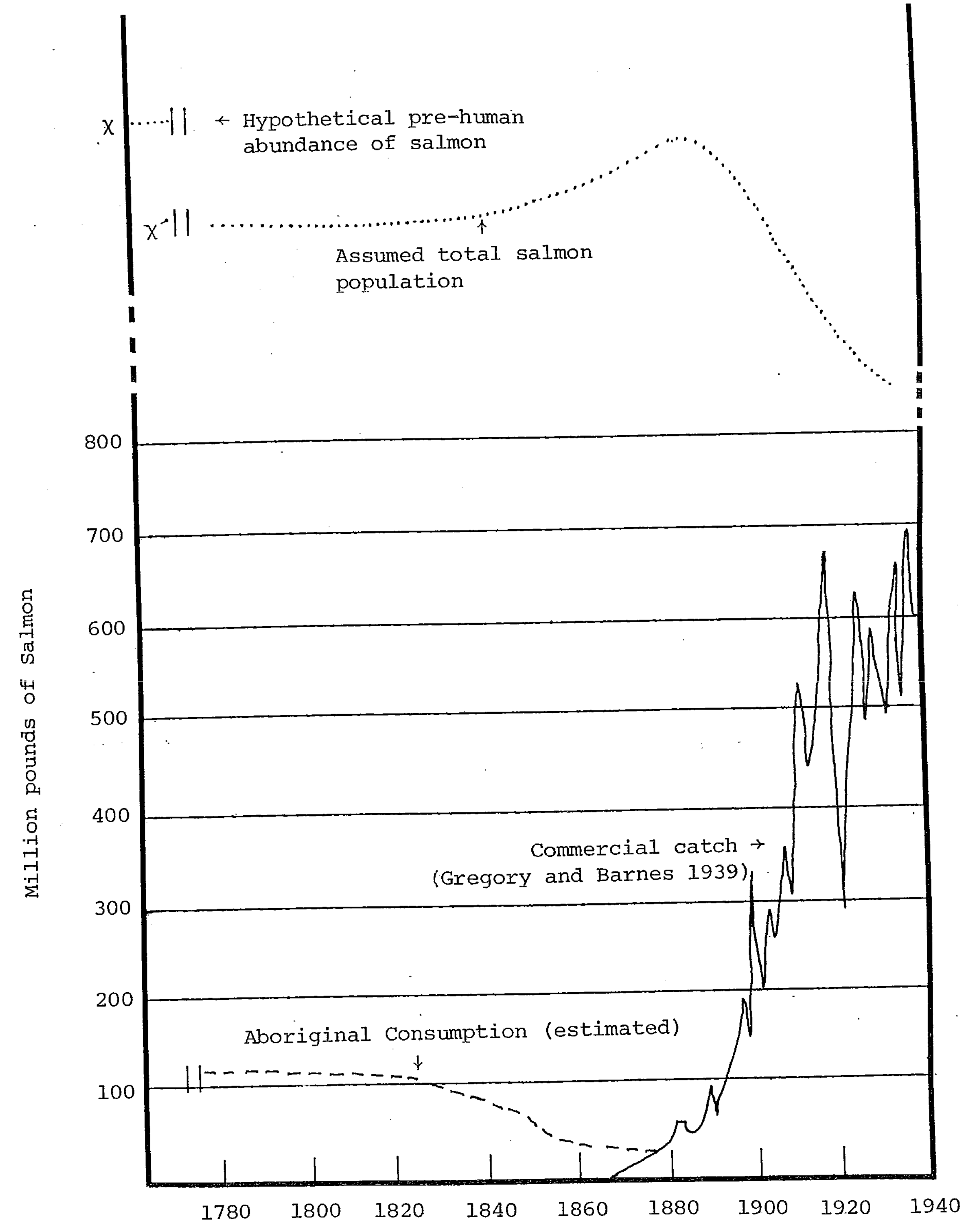
The Alaskan salmon pack surpassed that of the Columbia as early as 1888. It has had two maxima, one coinciding with the First World War market in 1919 and the other in World War II. Since 1924 the Federal Government has regulated the Alaskan catch by requiring an escapement of 50 percent of the salmon to their upstream spawning beds (Freeman and Martin 1942, Bower 1944:25-27).

In Table 3 we have plotted the combined production curve for all the salmon districts, from 1864 to the present, against which may be compared our estimate of the aboriginal catch and the assumed total salmon population in the Salmon Area. The commercial catch statistics have been converted to their fresh equivalent weight.

Some species were far more sensitive to commercial exploitation than salmon, and depletion has been more serious. Of these, the sturgeon, native oyster, shrimp, and halibut (Babcock 1930) may be mentioned. In many instances, depletion has been postponed by expansion of the fishery to more and more distant banks, or by the greatly increased expenditure of labor in relation to yield. In almost every case of a commercial fishery

TABLE 3

Assumed Relationship of Curves of Total Salmon Population, Aboriginal Consumption, and Commercial Catch for the Period 1780-1940



resource intensively exploited, however, the pattern of growth and decline has resembled that of the salmon industry, with the same interplay of economic and biological factors.

Indirect Destructive Effects of White Settlement on the Fisheries

In addition to the direct causes of depletion of fishery resources discussed above, which we may consider "over-fishing," there are many conditions, apparently unconnected with the exploitation of aquatic resources, which have contributed to the declines in abundance of fresh-water species, and to a limited extent of species dwelling entirely in marine environments. These conditions may be classified either as pollution or as blockage. Activities like mining, agriculture, the felling and milling of timber, and many other industries produce both types.

Mining was the first major cause of fisheries depletion, not related to over-fishing, in the Salmon Area. The early methods of placer mining and the later dredging operations on the streams of California have accounted for the obliteration of perhaps 50 percent of the available salmon spawning beds. Van Cleve (1945:101) estimates that mining, plus more recent installations of irrigation, water supply, and power dams, has been responsible for a decrease of 73 percent of the salmon spawning beds. The Indians of California were apparently the first to voice complaints about the deleterious effects of mining on the fish supplies (Cook 1943:33-34). California was not the only region to suffer from pollution and blockage of streams by mining. On a smaller scale, equally drastic biotic changes were wrought by the gold seekers in the Cariboo district of British Columbia, in Idaho, and in parts of Alaska (Marsh 1885:606-07, Goode 1887:[4]44).

The chief effect of placer mining is to increase the amount of silt in suspension in the water flowing from the diggings, which reduces the penetration of light to aquatic photosynthetic micro-organisms, thus lessening the total amount of food available in a given body of water (Needham 1938). Heavy silting on salmon spawning beds may simply smother the spawn under a deep layer from which the young cannot emerge. A slight turbidity in the lower courses of rivers, on the other hand, may be of value to the survival of the salmon fry. Light placer mining might cloud the water of a stream sufficiently to hide the fry from the predatory birds which normally subsist on them.

The lumber industry, a characteristic activity of much of the area, has had a well-known destructive effect on the fishing resources of streams and lakes. Removal of the forest cover bordering small streams exposes the shallow water to direct sunlight, raising the temperature above the toleration of cold-water fauna. The toleration is based on the amount of dissolved oxygen in the water, which is greater at lower temperatures. On a larger scale, lumbering promotes erosion and flash floods, which, with the debris left from trimming, etc., physically obstruct the migrations of fish to their spawning grounds. The effects of agricultural and pastoral occupance of the land adjacent to streams are similar to those of the lumber industry. Increased run-off follows plowing or grazing, leading to the cycle of floods, silting, and choking of streams with impassable blocks of debris. Direct blockage of fish migration is more often due to the construction of dams, diversion ditches, railway embankments, and highway embankments with culverts which fish cannot enter from below. Grand Coulee Dam, 350 feet high, has eliminated at one stroke some 1100 miles of salmon streams in the upper Columbia Basin.

For a detailed study of fishery pollutants, see the paper by Ellis (1937). The list below, by no means complete, summarizes the indirect causes for the declining yields of fresh-water and tide-water species in the Salmon Area.

1. Agriculture: erosion silt and blockage of streams by irrigation and drainage canals.

2. Livestock raising: erosion silt from over-grazing, organic wastes from dairies, and wool washings.

3. Mining: erosion silt from open pits and quarries, blockage or diversion of streams by dams and flumes, tailings and dredge-wastes, chemical pollutants from smelting.

4. Lumber industry: erosion silt from cleared areas, logging debris, flush-dams and mill-dams, sawdust and paper-mill wastes.

5. Transportation: stream blockage by culverts in highway and railway embankments, silt from erosion of cuts and fills, silt from harbor and channel dredging, fuel oil and bilge wastes.

6. Miscellaneous: organic, mineral, and chemical wastes from various manufacturing plants; municipal sewage; stream blockage by water supply and power dams; hot water discharged from chain-reaction piles (as at Hanford on the Columbia River).

In contrast to these destructive processes, there have been stream-improvement projects and the operations of fish hatcheries, to say nothing of laws and regulations to protect fishery resources by limiting the kinds or times of use of various types of gear. An incidental benefit to the salmon and trout populations of the area may also have come about with the virtual extinction over enormous areas of their range of beavers, during the early decades of the 19th century. The hunting of beavers soon resulted in the natural removal (through lack of constant repair) of hundreds of thousands of beaver dams, which have been recognized as disadvantageous to migrating salmon as well as to resident trout (Cook 1940).

Attempted Projection of a Curve of Abundance for Salmon Resources, 1780-1940

Table 3 referred to above is an attempt to project an estimated curve (shown by dotted line) of abundance of the various Pacific salmon species, as a whole, during the three economic periods: native subsistence, transition, and commercial; with this curve are curves representing the estimated aboriginal catch or consumption (dashed line) as it declined from 1780 to 1880, and the commercial catch (solid line) as it rose from 1864 to 1940. The portion of the dotted line near the top of the table, at χ, represents the hypothetical pre-human abundance of salmon, possibly several thousand years ago. When the dotted line is resumed after the break at χ', it represents the lowered stock of fish which is assumed to have existed because of the native consumption. As the aboriginal population decrease accelerated, especially after about 1830, the total salmon stock rose gradually as shown by the rising dotted line. We assume that the highest point after its recovery was around 1890, as the net result of several decades of lowered fishing intensity on most if not all streams of the Pacific Slope. The rapid expansion of the commercial salmon fishery, combined with the cumulative destructive effects of the occupation of the adjacent lands by mining, lumbering, and agricultural enterprises may be assumed to have produced the drastic decline in the total salmon stock which is shown on the upper right-hand side of the table. This line has been drawn so as to approach the rising solid line of the commercial catch, which now takes all but 1/5 or 1/6 of the annual natural production of the various salmon species. The vertical scale (in millions of pounds) has been broken purposely above the 800 mark, however, to indicate that the actual size of the total salmon population is unknown. Only where systematic weir counts of migrating salmon have been made have there been reliable indications of the size of the stock available in a given river system.

The theory on which the curves in Table 3 rest has been carefully developed by Craig and Hacker (1940:150) to explain changes in the salmon productivity of the Columbia River system. We quote their paper:

> *Therefore* [since the salmon used by whites between 1820 and 1865 by no means equalled the falling off of the Indian catch occasioned by the great decline in the native population] *it is not improbable that there was less fishing strain on the salmon populations of the Columbia during the period from about 1835 to 1865 than at any other time in their history. If this were the case, the salmon of the Columbia may have been more abundant during the few years immediately before the advent of the canning industry in 1866 than at any other time within our knowledge.*

Further on, they state:

> *However, discontinuance of the primitive Indian catch because of the great decrease in the number of Indians may be one of the factors which helps to explain the ability of the Columbia River salmon to produce as large a catch as they have, even under increasingly unfavorable conditions.*

The high initial productivity experienced on nearly every salmon stream in the commercial era may therefore be explained in part by the "resting period" which set in with the sharp drop in the rate of the native subsistence fishing. The subsequent declines in the commercial salmon fisheries may represent a partial return to fish-population levels which had prevailed during the many centuries of aboriginal fishing, whatever additional decrease there might have been from the effects of over-fishing and the indirect destruction of resources from mining, farming, and the lumber industry.

There is no question as the importance of a "resting period" or hiatus in the exploitation of a fishery in restoring a stock to a condition which may approach its former abundance. This was clearly demonstrated in the case of the fisheries of the North Sea which were afforded a four-year respite from trawling between 1914 and 1918. The productivity of these banks had long been declining as the careful statistics of several nations showed. Yet, when the fishing fleets returned to the banks in 1919 and 1920, with no greater output of labor than in pre-war years, hauls of phenomenal size were recorded. The surplus was short-lived, to be sure, and by the 1930's the danger of depletion on the North Sea banks again became a matter of international concern (Heincke and Buckmann 1926, Thursby-Pelham 1926).

Within the Salmon Area, a less dramatic instance of fishery recuperation is reported from Bristol Bay, where fishing was greatly restricted in the 1935 season to prevent depletion in the 1940 run of sockeye, which there happen to exhibit a five-year cycle of abundance. The 1940 run was of noticeably increased size because of the larger percentage of spawning fish which had been allowed to escape the gill nets and to proceed upstream in 1935.

We are simply suggesting that a similar, though nondeliberate, conservational effect occurred in the northwestern North American area during the period of pioneer white settlement and the shattering of native cultures in the middle of the last century.

Conclusions

In addition to the main conclusion just presented, some minor conclusions can be drawn. We have stressed the relatively high efficiency of primitive fishing methods in the Salmon Area, and of primitive fishing in general. In this connection we have discussed the technological dilemma confronting those who would exploit a fishery, but at the same time seek to preserve its future productivity. It has been noted that the improvements which have been made in fishing technology belong mostly to the category of accessory processes—such as transport to and from fishing places; or of fishery products, or means of preserving fish—rather than to the category of basic catching techniques. So far as river and other inland fishing is concerned, the technological differences between native cultures of North America and our own civilization are almost immaterial.

In considering the fishery resources of any region, if it is or has been inhabited by man, even in cases where the aquatic fauna has not been utilized for food, one should deal with them as features of the cultural landscape, unless it can be shown that human occupance has had no effect whatsoever on such resources. Thus, in an extreme instance, where the native cultures have express prohibitions against fish as food, there are local cultural modifications of aquatic environments, as from irrigation. Much more drastic effects on the aquatic fauna of streams in parts of the American

Southwest (an area with fish tabus) have followed the introduction of sheep, with intensified erosion which the close grazing of these animals initiates.

Finally, we see that for a fisheries biologist to disregard the aboriginal fishing in an area, and to assume that the aquatic resources of that area were in a condition identical to the "natural environment" prior to the establishment of commercial or recreational fishing is to commit a serious error. The literature of ecology in America still contains statements implying that the habitat of wildlife species on this continent before the arrival of white men was a pre-cultural, primordial wilderness. The point of view is exemplified in a pamphlet of the Ecological Society of America (1921) dealing with a plan for wilderness parks to preserve something of the conditions "that existed before the coming of man."

It has been one of the purposes of this study of the relation between the aboriginal and the commercial uses of the fishery resources of Northwestern North America to show that before the epoch of European discovery, the aquatic life of the rivers, streams, lakes, bays, and coastal waters formed a genuine component of the cultural landscapes. We have also tried to show how these same faunal resources have persisted as integral features in the present cultural mosaic of fields, pastures, orchards, roads, wood lots, and towns and how their present and future productiveness is linked with past usage.

Notes

[1]This work formed Parts 3 and 4 of my 1947 doctoral dissertation in Anthropology at the University of California, Berkeley, "Aboriginal Use of Fishery Resources in Northwestern North America." Since the estimates of aboriginal fisheries productivity in various parts of the Plateau, Northwest Coast, and western Alaska have been utilized in several later studies bearing on Indian utilization of resources, it has seemed worthwhile to reissue this material. No significant changes have been made in the text. However, a bibliography has been added to provide some guidance to the literature on fisheries production in the area, between 1946 and 1972.

[2]The average North Chinese male peasant consumes 2.2 pounds per day, on a diet consisting chiefly of grains, which have higher fuel values per pound than most of the foods eaten aboriginally in northwestern North America (Buck 1937:427).

[3]This applies to nearly all the vegetable items in the native dietary aside from the acorn and the pine nut, both consumed in significant quantities only in the southern and southeastern portions of the Salmon Area. One pound of acorn meal contains 2180 calories. The farinaceous bulbs and tubers such as wapato, bitterroot, camas, clover root, etc., are low in calories, while berries and miscellaneous greens, so necessary for vitamins and trace elements, are negligible sources of fuel.

[4]Some proteins are indispensable; others may be omitted.

[5]Carrothers (1941) quotes a source which states that in 1879 the natives of British Columbia consumed about 17,500,000 pounds of salmon, said to have been the average over a period of several years. Using Mooney's (1928) population data, the Indians in that Province in 1879 numbered about 30,000, which by division gives a per capita figure of 583 pounds.

[6]The average weights of fresh salmon and equivalent values of dried salmon are given in a letter of Ward T. Bower, U.S. Fish and Wildlife Service, dated 25 March 1946. The lightest salmon at the time of spawning are humpback (*O. gorbuscha*), which weigh four pounds.

[7]The statistics on which this and the following statements are based are to be found in Cobb 1930.

References Cited

BABCOCK, J. P., AND OTHERS
1930 Report of the International Fisheries Commission Appointed under the Northern Pacific Halibut Treaty. *Report of U. S. Commissioner of Fisheries, for 1930*, Appendix 1.

BANCROFT, H. H.
1888 History of Oregon. *Bancroft's Works*, Vol. 30, Part 2.

BEAN, TARLETON H.
1887 The Fishery Resources of Alaska. *The Fisheries and Fishery Industries of the United States*, G. B. Goode, editor, Sec. 3C.

BOWER, WARD T.
1944 Alaska Fishery and Fur-Seal Industries: 1943. *U. S. Fish and Wildlife Service Statistical Digest*, 10.

BUCK, JOHN LOSSING
1937 *Land Utilization in China*, 3 vols. Chicago: University of Chicago Press.

CARROTHERS, W. A.
1941 The British Columbia Fisheries. *Political Economy Series* 10. Toronto: University of Toronto Press.

COBB, JOHN N.
1930 Pacific Salmon Fisheries. *Report of U. S. Commissioner of Fisheries for 1930*, pp. 409-704.

COOK, DAVID B.
1940 Beaver-Trout Relations. *Journal of Mammalogy* 21:395-401.

COOK, S. F.
1943 The Conflict between the California Indian and White Civilization, Part 3, The American Invasion, 1848-1870. *Ibero-Americana*, 23.

CRAIG, JOSEPH A., AND R. L. HACKER
1940 The History and Development of the Fisheries of the Columbia River. *U. S. Bureau of Fisheries, Bulletin* 32.

DALL, WILLIAM K.
1870 *Alaska and Its Resources*, Boston: Lee & Shepard.

ECOLOGICAL SOCIETY OF AMERICA
1921 Preservation of Natural Conditions. *National Research Council Reprint*.

ELLIS, M. M.
1937 Detection and Measurement of Stream Pollution. *U. S. Bureau of Fisheries, Bulletin* 22.

ELVEHJEM, C. A.

1942 The Nutritional Requirements of Man. *Smithsonian Institution, Annual Report for 1942*, pp. 289-298.

FREEMAN, OTIS W., AND HOWARD H. MARTIN, EDITORS

1942 *The Pacific Northwest; A Regional, Human and Economic Survey of Resources and Development.* New York: Wiley.

GOODE, GEORGE BROWN, EDITOR

1887 *The Fisheries and Fisheries Industries of the United States*, 5 vols. U. S. Commission of Fish and Fisheries.

HEINCKE, F., AND A. BÜCKMANN

1926 Die Überfischung der Nordsee und die Wirkung der Kriegschonzeit auf ihren Schollenbestand. *Der Fischerbote: Norddeutsche Fischerei Zeitung*, 18:3.

HEWES, GORDON W.

1947 Aboriginal Use of Fishery Resources in Northwestern North America. Unpublished doctoral dissertation, University of California, Berkeley.

KROEBER, A. L.

1939 Cultural and Natural Areas of Native North America. *University of California Publications in American Archaeology and Ethnology*, Vol. 38.

MARSH, GEORGE P.

1885 *The Earth as Modified by Human Action; A Last Revision of "Man and Nature."* New York: C. Scribner's Sons.

MOONEY, JAMES

1928 The Aboriginal Population of America North of Mexico. *Smithsonian Institution, Miscellaneous Collections* 80, Publication 2955.

NEEDHAM, PAUL R.

1938 *Trout Streams. Conditions that Determine Their Productivity and Suggestions for Stream and Lake Management.* Ithaca: Comstock Publishing Co. Revised by Carl F. Bond, 1969. San Francisco: Holden-Day

OSGOOD, CORNELIUS

1940 Ingalik Material Culture. *Yale University Publications in Anthropology*, No. 22.

PACIFIC FISHERMAN

Monthly and Yearbook publications. Seattle.

PETROFF, IVAN

1881 Report on the Population, Industries and Resources of Alaska, *U. S. Department of the Interior, 10th Census*, Vol. 8.

SULLIVAN, ROBERT J.

1942 The Ten'a Food Quest. *Catholic University of America, Anthropological Series*, No. 11.

THURSBY-PELHAM, D. E.
1926 Review of Heincke and Bückmann, Die Überfischung der Nordsee. *Journal du Conseil*, 1:173-74.

TRESSLER, DONALD K.
1923 *Marine Products of Commerce*. New York: Chemical Catalog Co.

VAN CLEVE, RICHARD
1945 Program of the Bureau of Marine Fisheries. *California Fish and Game*, 31:80-138.

Bibliography

ANDREWARTHA, H. G.
1963 *Introduction to the Study of Animal Populations*. Chicago: University of Chicago Press.

ARO, K. V., AND M. P. SHEPARD
1967 Salmon of the North Pacific Ocean, Part 4. Spawning Populations of North Pacific Salmon. Pacific Salmon in Canada. *International North Pacific Fisheries Commission, Bulletin* 23:225-327.

ATKINSON, C. B., J. H. ROSE, AND T. O. DUNCAN
1967 Pacific Salmon in the United States, *in* "Salmon of the North Pacific Ocean, Part 4." Spawning Populations of North Pacific Salmon. *International North Pacific Fisheries Commission, Bulletin* 23:43-223.

CRUTCHFIELD, J. A., AND GIULIO PONTECORVO
1969 *Pacific Salmon Fisheries. A Study of Irrational Conservation.* Baltimore: John Hopkins Press.

GREGORY, HOMER E., AND KATHLEEN BARNES
1939 *North Pacific Fisheries with Special Reference to Alaska Salmon*. New York: American Council, Institute of Pacific Relations.

KASAHARA, HIROSHI
1963 Salmon of the North Pacific Ocean, Part 1, Catch Statistics for North Pacific Salmon. *International North Pacific Fisheries Commission,Bulletin* 12:7-82.

KROEBER, A. L., AND S. A. BARRETT
1960 Fishing among the Indians of Northwestern California, with special data from E. W. Gifford and G. W. Hewes. *Anthropological Records*, 21:1.

LACK, DAVID
1967 *The Natural Regulation of Animal Numbers*. Oxford: University Press.

MARGOLIS, L., F. C. CLEAVER, Y. FUKUDA, AND H. GODFREY
1966 Salmon of the North Pacific Ocean, Part 6, Sockeye Salmon in Offshore Waters. *International North Pacific Fisheries Canadian Bulletin*, 20:1-70.

MATHEWS, STEPHEN B., AND HENRY O. WENDLER
1968 Economic Criteria for Division of Catch between Sport and Commercial Fisheries with Special Reference to Columbia River Chinook Salmon. *Washington Department of Fish and Fish Resources*, 3(1):93-105.

MURDOCH, W. W.
1966 Population Stability and Life History Phenomena. *American Naturalist*, 100:5-11.

SALO, ERNEST O.
1967 Study of the Effects of Logging on Pink Salmon in Alaska. *Proceedings of the Society of American Foresters Meeting: Resources, Foresters, and Policies for Progress*. 1966:59-62.

WALKER, DEWARD E., JR.
1967 Mutual Cross-Utilization of Economic Resources in the Plateau: An Example from Aboriginal Nez Perce Fishing Practices. *Washington State University, Laboratory of Anthropology, Report of Investigations*, No. 41.