SALMON OF THE NORTH PACIFIC OCEAN—PART IX COHO, CHINOOK AND MASU SALMON IN OFFSHORE WATERS

2. CHINOOK SALMON IN OFFSHORE WATERS

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INTRODUCTION

The International North Pacific Fisheries Commission has requested the preparation of a joint comprehensive report on the salmon of the North Pacific Ocean and the Bering Sea. Part IX of this comprehensive report deals with coho, chinook and masu salmon in offshore waters. The material to follow comprises the chinook salmon section of Part IX. The objective will be to assess the status of our knowledge concerning the qualitative and quantitative aspects of chinook salmon in offshore waters. Such assessment requires (1) a knowledge of the life history of the young in fresh water and in coastal areas and the distribution of chinook in inshore areas; (2) knowledge of the stocks in North America and in Asia and the distribution and abundance of chinook in offshore waters; and (3) appraisal of these various data to draw conclusions regarding the qualitative and quantitative aspects of the distribution of chinook salmon in offshore waters.

Chinook salmon (*Oncorhynchus tschawytscha*) have been found along the North American coast from the Ventura River in California (Cobb, 1931) north to the Chukchi Sea (Smith, 1960). In Asia, they occur in some large rivers in Hokkaido (Hikita, 1956), in Sakhalin (Shmidt, 1950) and northward at least to the Anadyr River (Kaganovski, 1933). The principal areas of production in Asia are located on the Kamchatka Peninsula. Except for Smith's report (1960), the occurrence of chinook salmon in North American and Asian arctic areas is neither established nor defined in available literature.

Chinook salmon spawn principally in the larger rivers and their tributaries. Although the major North American populations return to the Sacramento, Columbia, Fraser, Skeena, Nushagak and Yukon Rivers, important runs occur in many other rivers.

Along the North American coast, chinook are taken principally in commercial troll and gillnet fisheries, while important numbers are taken in various sport fisheries. Significant numbers are caught in the Japanese mothership and landbased fisheries and in the coastal and river fisheries of Kamchatka and the Okhotsk Sea. In the period 1954 through 1961, the combined commercial catches of Japan and Russia varied from 96,000 to 250,000 chinook salmon, as compared with 2,456,300 to 3,664,200 for the United States and Canada combined. With the exception of masu salmon, the combined commercial catch of chinook salmon is below that of all other species of Pacific salmon. For example, in 1956, 3,777,000 chinook were caught commercially by Japan, Canada and the United States, as compared to 10,442,000 coho, 29,267,000 sockeye, 34,695,000 chum and 84,949,000 pink salmon. In the same year, an additional 110,000 chinook salmon were taken in the Soviet coastal fisheries and 731,000 in the sport fisheries of Canada and the United States.

LIFE HISTORY

Identification of Runs and Races

Before describing the life history of chinook salmon, definitions of a " run " and a " race ", as used in this paper, should be established, since inherent biological differences are implied which have a direct bearing on time of migration to salt water, perhaps on the extent of marine migration, on time of return to coastal and river areas and on time of spawning.

For purposes here, a " run " is defined as a seasonal appearance of chinook salmon in a coastal or river area, first in small numbers which usually increase rather rapidly to a peak and then decline, with small numbers sometimes continuing to appear for extended periods of time. A " race " is defined as a population of chinook salmon which will spawn in a particular river or tributary at a particular time of the year. A single race may make up all or only part of a run.

Many river systems have more than one run or more than one race of chinook salmon. Each run may include more than one race, each apparently a separate biological entity. Fry (1961), for example, described three runs to the California central valley—a fall run, a spring run and a winter run. Gharrett and Hodges (1950) reported that in coastal Oregon streams a spring run of chinook entered and passed through the fishery, followed by a later fall run. The Columbia River has spring, summer and fall runs of chinook salmon. All spawn in the summer and early fall and winter months, in contrast to the Sacramento River chinook, where the fall run spawns in October to March, the winter run from May to July and the spring run in September and October. The three Columbia River runs of chinook are identifiable in the commercial fisheries of the lower river and estuary (Figure 1, using 1960 for illustration purposes), as well as at the counting stations at Bonneville Dam. These runs also maintain their identity at The Dalles, McNary and Rock Island Dams farther upstream. The chinook counts from The Dalles and McNary Dam are not included in Figure 1, but they may be found in U.S. Army Corps of Engineers (1960).

Many coastal and Puget Sound streams of Washington, and the smaller British Columbia coastal rivers, may have a spring and a fall run similar to those of Oregon (Smoker, 1954). In the Fraser River, chinook may first appear in the commercial

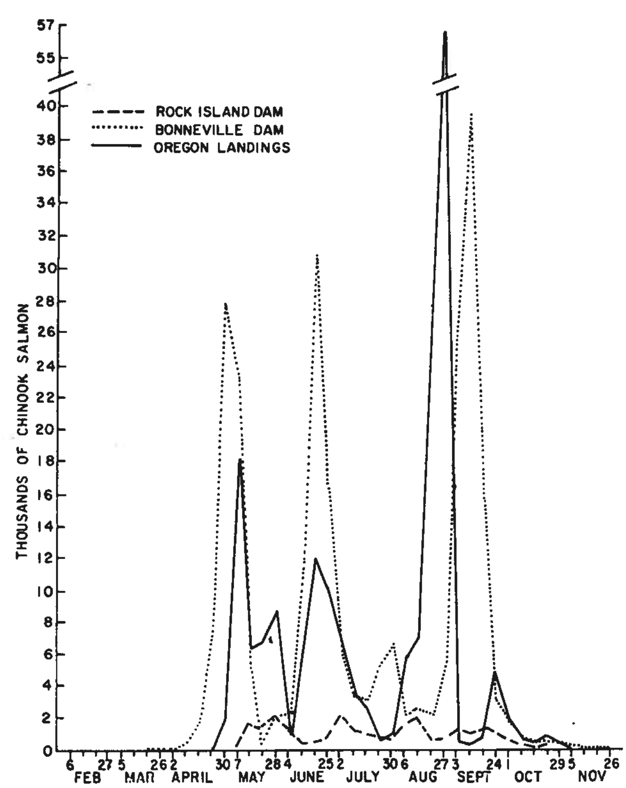

Figure 1. Number of chinook salmon caught by Oregon in the Columbia River and counts of chinook salmon at various dams on the Columbia River, 1960. Data from U.S. Army Corps of Engineers (1960), Zimmer and Davidson (1962) and INPFC Statistical Yearbook 1960.

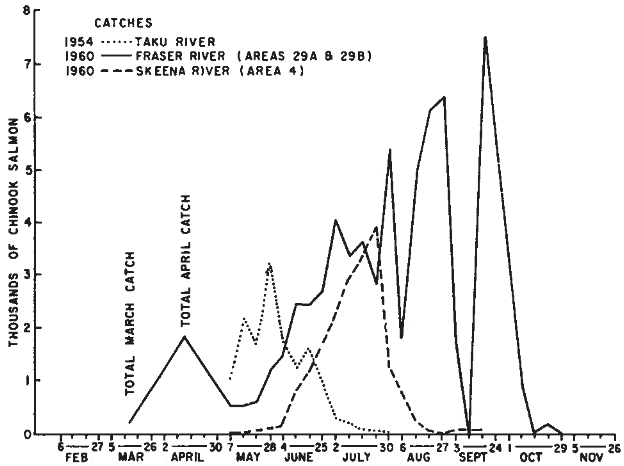

FIGURE 2. Gillnet catches of chinook salmon in the Taku, Skeena and Fraser Rivers. Data from Canada Department of Fisheries (1960) and Weberg and Garceau (1956).

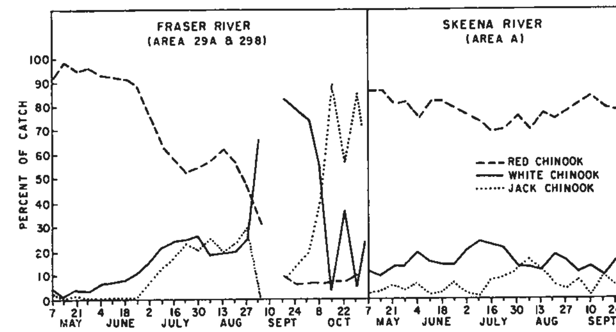

FIGURE 3. Composition (in percent) of weekly catches of chinook salmon in the Fraser and Skeena Rivers in 1960, based on their commercial classification as red, white, or jack chinook (see footnote, page 43). Data from Canada Department of Fisheries (1960).

fishery near its mouth as early as January, rising to maximum numbers in August and September and are present into October and even December in some years. Figure 2 shows the gillnet catches near the mouth of the Fraser River for British Columbia statistical areas 29A and 29B for 1960, selected for illustration purposes. The major intra-season declines are attributable to changes in regulations and there is no gross evidence of more than one run. Babcock (1931), on the other hand, stated that the early Fraser River chinook were destined for the headwaters, which implies existence of separate races. Passage of these races through the commercial fishery may overlap to the extent that they are not identified by the gillnet catches alone.

The chinook landings listed in the British Columbia catch statistics are also tabulated in terms of numbers classified as red, white and jacks[1]. The percentages of these three commercial categories in each week's total chinook catch are shown for the Fraser River (statistical areas 29A and 29B) for 1960 in Figure 3. It may be seen that early in the season the catches were almost exclusively of red chinook with only small percentages of white chinook and jacks. The numbers of red chinook declined through the season and rose only slightly near the end of September. The numbers of white chinook rose steadily until July, remained relatively constant through July and August and reached a peak in September. Jack chinook comprised only a very small proportion of the catch through May and June, with the percentage rising in July and peaking in October. This change in catch composition, when compared to the Fraser River catch curve in Figure 2, is substantial evidence of the existence of different races of chinook within the Fraser River watershed and that the classifications of red, white and jacks may be indices of some possible use in race identification.

The commercial catches of the Skeena and Taku Rivers (Figure 2) were also examined for evidences of more than one run of chinook salmon. For this purpose, the 1960 gillnet catches of statistical area 4 were used for the Skeena River. The Taku River data were taken from Weberg and Garceau (1956) for the year 1954, which was selected as being typical of the published catch data for the years 1945 through 1954. For both the Skeena and Taku Rivers, the commercial catches offer no evidences of more than one chinook salmon run. Also, Parker and Kirkness (1951) recognized only one chinook run in the Taku commercial fishery. It might be noted in Figure 2 that the Taku run reaches a peak earlier than either the Skeena or Fraser run. The Skeena River run is apparently of shorter duration than the Fraser River run and it reaches a peak earlier in the season.

The Skeena River data for percent composition of red, white and jack chinook were plotted in Figure 3 for evidences of changes in racial composition, as were the data for the Fraser River already presented (similar statistics are not available for the Taku). A comparison with Figure 2 again suggests the existence of different races, but not to the degree apparent for the Fraser River.

The rather meager data on weir counts for a number of western Alaskan streams (U.S. Department of

[1] Separation of red and white chinook is made on the basis of flesh color, red chinook commanding a higher price than white chinook. Jacks are chinook salmon of either flesh color weighing less than six pounds.

Commerce, 1931–1940), indicate single chinook salmon runs that arrive in late June, July, or August, depending on the particular stream.

Gilbert (1922) stated that the Yukon River run starts around the first of June and is over in about three weeks, the time factor again indicating the presence of only a single run.

The trend indicated in the above examples, ranging from the Sacramento River to the Yukon River, is for a greater number of chinook salmon runs to be found in the rivers to the south, with the number of runs dropping to one to two at mid-latitudes and then to only one in more northern waters. The data also show differences in the time of arrival of chinook salmon runs to various rivers and that the peaks of spring or fall or other runs may vary from river to river. It is also apparent that catch statistics do not always provide enough information to separate races of chinook salmon in the absence of other biological data.

Within a single watershed, a particular run in the commercial fishery may be composed of a number of different races, each bound for a separate tributary. This is particularly true of the major watersheds, such as those of the Sacramento, Columbia and Fraser Rivers. Within their broad geographical boundaries, these watersheds include high altitude streams that depend on melting snows for water, vast arid areas which become extremely hot in the summer and sometimes extremely cold in the winter, and coastal drainages that depend upon seasonal rains for water. The various tributaries originating and flowing through these different climates offer, at one time or another during the course of the year, conditions suitable for migration and spawning of adults, hatching and rearing of young and their feeding and transport to the sea. It is more than coincidence that chinook salmon occur and spawn in particular tributaries at a particular time. It is also reasonable that such things as climate, geography and relationships with other aquatic life have at least some influence on the life history of the species.

The runs described by Fry (1961) in the Sacramento River may also be identified as races, since the fall run usually spawns in the period October to March, the spring run in the following September and October, and the winter run from May to July.

The spring chinook run in the Columbia River commercial fishery includes races destined for such diverse places as some of the tributaries of the Willamette, Snake and Wenatchee Rivers. In the Fraser River, there are spring run races to the Nechako, Bowron, Quesnel and other tributary rivers. In the summer and fall there are late run races in Harrison River and elsewhere. On the Sacramento River, there are spring run races destined for the Keswick Dam area, Battle Creek, Mill Creek and tributaries. A similar list could be made to illustrate summer, fall and winter runs where they occur.

Even in the rivers to the north where a single run is apparent, the racial identities are not lost in the tributaries. The Taku River, for example, has separate races that spawn concurrently in the Nahlin, Nakina and other tributaries. It is unfortunate that,

TABLE 1. Kilograms of chinook salmon landed at Ozuchi, Iwate Prefecture, Honshu, Japan, by 10-day period in 1960 through 1962[1].

10-day period		1960	1961	1962
January		*13.7*	*6.6*	—
	Early	9.8	3.9	—
	Middle	3.9	2.7	—
	Late	—	—	—
February		—	—	—
March		*6.4*	—	*31.9*
	Early	—	—	—
	Middle	5.0	—	10.3
	Late	1.4	—	21.6
April		—	*68.0*	*
	Early	—	—	34.9
	Middle	—	—	*
	Late	—	68.0	*
May		*144.1*	*706.1*	—
	Early	15.8	83.8	—
	Middle	128.3	413.7	—
	Late	—	208.6	—
June		*7.5*	*29.2*	—
	Early	—	13.0	—
	Middle	7.5	8.5	—
	Late	—	7.7	—
July		—	—	—
August		—	—	—
September		—	—	—
October		—	—	—
November		—	*1.7*	—
	Early	—	—	—
	Middle	—	—	—
	Late	—	1.7	—
December		—	*6.3*	—
	Early	—	4.6	—
	Middle	—	—	—
	Late	—	1.7	—

[1] Data provided by Dr. S. Tanaka of the Japanese Fisheries Agency.

* No data available.

at present, there is no method of identifying the various races of chinook salmon until such time as the adults arrive on a particular spawning ground.

There are few data describing the arrival of chinook salmon in Asian waters. Data supplied by Tanaka (Table 1) show that chinook are landed in Ozuchi, in northeastern Honshu, in small quantities from November through January; however, most are landed in the April–May–June period. The chinook caught in the November–January period are apparently immature, as indicated by a 10-day catch of 1.7 kg, which is a small weight even if it consisted of only one fish. An ocean migration and not a spawning migration is indicated for these fish. In describing Okhotsk Sea fisheries, Shmidt (1950) noted that chinook runs to the Soviet coast start in early May and continue to the end of August with no pronounced peak. The 1960 catch statistics of the Kamchatka Peninsula (Research Institute of Marine Fisheries and Oceanography of the U.S.S.R., 1961), show only 30 metric tons of chinook for West Kamchatka and 670 tons for East Kamchatka. The latter catches started in May and peaked in June with only one metric ton landed in August. Data are not available in sufficient detail to comment on the number of runs and races which may exist in the various Asian streams.

Life History in Fresh Water

The individual races found in various rivers and tributaries may have unique freshwater life histories and total life histories. While the literature establishes the existence of these differences, it does not broadly document them, nor describe them in detail.

It is apparent, for example, that the runs or races described by Fry (1961) spawn at different times. Some of the eggs, therefore, incubate in a falling temperature regime, while others incubate during rising temperatures. The time of hatching of eggs from these different races therefore differs, as well as the environmental and ecological conditions with which the resulting young must endure and cope. What effects, if any, the differences in season of emergence of fry from the gravel would have on later migration and distribution in marine waters are conjectural and substantially unknown.

Differences of the type found in the Sacramento River system are also found elsewhere. Mains and Smith (1955) reported on concurrent sampling for downstream migrants on (1) the Snake River, (2) the Columbia River above the mouth of the Snake and (3) the Yakima River, which joins the Columbia above the mouth of the Snake but below the Columbia River sampling point. The Snake and Columbia Rivers in this area are migation routes for both spring and fall migrating races of chinook adults. Table 2 illustrates some of the differences found in the resulting downstream migrants. (Hereinafter, the word " fingerlings " will apply to chinook lacking a freshwater annulus, while " yearlings " will include those that show one freshwater annulus.) These three areas show a dominant downstream migration in the spring, although a few chinook are found occasionally in other months in the Snake and Yakima Rivers. These data from Mains and Smith (1955) show differences in size, time and age of migration at three concurrent sampling locations on the Columbia River and its tributaries.

The reports of the U.S Army Corps of Engineers (i.e., 1950) show that chinook salmon fingerlings and yearlings are present every month of the year in the Bonneville Dam area. In the Taku River in Alaska, however, most chinook salmon migrate to sea in the April-June period, with the peak occurring in May (Meehan and Siniff, 1962). Smoker (1954) reported that fall run chinook salmon in Puget Sound normally migrate to salt water after about 90 days in fresh water while the spring run progeny may remain in fresh water for more than one year.

Rutter (1903) reported catching seaward migrants in the Sacramento River at Walnut Grove from January into May. His trap caught at least some downstream migrants daily with maximum numbers

Table 2. Results of concurrent sampling for downstream migrating chinook salmon at three locations in the Columbia River watershed (from Mains and Smith, 1955).

	Time of migration		Peak of migration		Age composition		Length in mm	
River	Fingerling	Yearling	Fingerling	Yearling	Fingerling (%)	Yearling (%)	Fingerling (range)	Yearling (modal)
Snake	March–April	April–June	April	June	7–20	80–93	30–55	95–100
Columbia	March–April	June–July	April	June	76	24	20–55	85–90
Yakima		April–August		May	100			125

occurring in March. While some yolk-sac fry were taken, sizes generally ranged from about $1\frac{1}{2}$ inches (3.8 cm) at the start of the season to about three inches (7.6 cm) at the end. Gilbert (1913) reported that in Alaska as well as in the Sacramento River some chinook salmon pass to salt water in the spring and early summer while others remain in fresh water and go to sea as yearlings during their second spring. Hanson *et al.* (1940) found that a fall downstream migration occurred in some of the Sacramento River tributaries.

These examples have demonstrated that differences in growth and time of migration do occur among the juvenile chinook salmon from different races in a given river system and between races in different rivers. There are two additional features which may be characteristic of a watershed—(1) length of time in fresh water and (2) total age.

Age at Migration

Clark (1929) stated that 80 to 90 percent of the Sacramento chinook salmon have scales of the ocean nucleus type (as defined by Gilbert, 1913) and that chinook returned to the Sacramento primarily (50 percent) as four-year-olds. They also returned as five-year-olds, three-year-olds, six-year-olds and two-year-olds, in that descending order of abundance. Fry[2] reports that this age composition is no longer true; the four-year-olds predominate in some years, three-year-olds in some years; two-year-olds are common, five-year-olds less so, and six-year-olds quite scarce.

Rich (1920) seined at various places in the lower Columbia (excluding hatcheries) and found 97 chinook salmon which he classified as yearlings and 473 as fingerlings. Hence, about 80 percent of his samples had ocean type scales. He stated that his data suggested that the fastest growing individuals left for salt water first. It should be noted that Mains and Smith (1955) found yearling migrants into August and peak migrations in June, while Rich (1920) discontinued sampling after May 25. Rich (1920) also concluded that males and females migrated out of the Columbia River in equal numbers throughout the seasons of migration.

Rich and Holmes (1929) reported that spring chinook returned to the Columbia River in their third to sixth years, with the greatest number maturing in their fifth year; the six-year-olds exceeded the four-year-olds, with the three-year-olds being least common. For the fall chinook, the four-year-olds were apparently most abundant, with the five-year-olds second most abundant. Some two-year-old males and three-year-old females also occurred, but no six-year-olds were recorded. Van Hyning[3] reports that, at present, four- and five-year-olds are most abundant in the Columbia River spring chinook with very few six-year-olds; three- and four-year-olds are most abundant in the fall chinook.

Samples of Taku River seaward migrant chinook salmon were all of the stream type, with 94 percent being in their second year and six percent in their third year at time of migration, according to Meehan and Siniff (1962). However, Parker *et al.* (1954) presented contrary data from reading adult scales showing that most had ocean type scales. Although the matter is under study[4], it seems probable that the more recent work of Meehan and Siniff more accurately describes the true age composition, since it was done when scale reading methods were more advanced and on scales taken from small fish, not adults. Returning adults (Edson *et al.*, 1955) varied in age from two- to six-year-olds. Different levels of abundance for each yearclass of returning adults were indicated, depending on the sampling method—troll and gillnet catches being different from each other and both being different from catches of a fish wheel. In an estimated compilation by Edson *et al.* (1955), the five-year-olds were usually more abundant, followed by four-, three-, two- and six-year-olds, in that descending order.

In the Yukon River samples reported by Gilbert (1922), all were of the stream type. Two-year-old adults were absent and only one three-year-old was taken. All fish less than five years old were males. Six-year-olds of both sexes were more abundant than five-year-olds, seven-year-olds being the least common in the mixed-sex groups.

Throughout their North American range, then, chinook salmon may be expected to migrate to the sea over a rather wide range of time after hatching. At the southernmost point of their distribution, some may migrate as yolk-sac fry, although some may remain in fresh water for from a few months to a year. In the rivers farthest north, all may stay at least a

[2] Personal communication from D. H. Fry, Jr., to J. E. Mason, dated August 2, 1963.

[3] Personal communication from Jack M. Van Hyning to J. E. Mason, dated Nov. 26, 1963.

[4] Personal communication from Dr. William R. Meehan, Alaska Department of Fish and Game, to J. E. Mason, dated February 14, 1963.

year in fresh water. The age at maturity varied from one to six years in more southern areas, with four- and five-year-olds being more abundant. Farther to the north, the five- and six-year-olds were more abundant.

Migrations in Coastal Waters

The preceding material has established that most downstream migrants enter salt water in the spring, as fingerlings and yearlings, at least in streams south of Alaska. Rich (1920) noted a tendency for the larger downstream migrants of a particular tributary to migrate earlier than the smaller. Rich and Holmes (1929) presented data to show that there were many gradations between typical stream and ocean types of scales, which are apparently related to the time and method of entry into brackish water and the duration of stay therein. Clark (1929) reached the same conclusions for the Sacramento River chinook salmon and Snyder (1922 and 1923) showed that departures from the typical scale types also occurred in Klamath River fish.

In the brackish and marine environment, almost nothing is known of growth, distribution and migration until the fish are of sufficient size to be taken in commercial troll or sport fisheries. Pressey (1953) shows that the size of first entry into the sport fishery of Puget Sound is at about 11 inches (27.9 cm) and about 15 inches (38.1 cm) in the Strait of Juan de Fuca area. Fraser (1917) reported immatures from the Departure Bay area of British Columbia a little in excess of 10 inches (25.4 cm) long. The Columbia River troll fishery takes chinook as small as 17 to 18 inches (43.2 to 45.7 cm) in length (Van Hyning, 1951), although smaller chinook are caught but not landed. Neave (1951) reported on tagging in the troll fishery of the west coast of Vancouver Island. The age composition included chinook of the 2_1 age group and individuals below 24.5 inches (62.2 cm) in length and less than five pounds (2.3 kg) in weight. Immature chinook salmon were thus included, although the minimum size caught is not a matter of record.

All the Puget Sound-British Columbia and Columbia River samples were obtained from areas where chinook salmon populations from more than one river may be found. The only available data on the origin of these mixed populations is from marking experiments, as follows. The most northerly recoveries recorded by Rich and Holmes (1929), reporting on results of liberating marked chinook salmon at Columbia River hatcheries, were one spring run chinook from Dixon Entrance, southeastern Alaska, and two fall run chinook, one each from near Barkley Sound and near Ucluelet (west coast of Vancouver Island). The Cowichan River chinook marked in the years 1937 to 1944 resulted in over 65 recoveries in the Georgia Strait area and along the west coast of Vancouver Island (Neave, 1941a, 1941b, 1949; Neave and Pritchard, 1942).

More recent Columbia River marking experiments, as reported in Pacific Marine Fisheries Commission (1959), have resulted in recoveries in Washington, Oregon, British Columbia and in southeastern Alaskan commercial fisheries. These experiments were not specifically designed for studies of ocean distribution and do not materially aid in the understanding of this distribution.

Distribution Indicated by Tagging in Southeastern Alaska

On the basis of scale type, age composition and growth, Parker and Kirkness (1951) indicated that southeastern Alaskan chinook salmon are of two types, those found in inside waters and those found in outside coastal waters. Parker and Kirkness (1956) divided the latter into three groups by the characteristics of the chinook salmon found there. Those in the Cross Sound to Cape Fairweather area averaged about 27.5 inches (69.9 cm) in fork length. Most (probably in excess of 80 percent) were immature, with 4_1's being most abundant, followed by 3_1's. Chinook salmon found on the west coast of Chichagof Island were mostly (probably in excess of 80 percent) mature. Their modal fork length was between 30.0 inches (76.2 cm) and 32.5 inches (82.6 cm). Age group 4_1 was most abundant, followed by 5_1.

Since most recoveries (86.5 percent) of tags applied in outside waters were made outside of Alaska, Parker and Kirkness (1951, 1956) were of the opinion that the chinook salmon in outside waters were primarily from streams to the south of Alaska. Chinook salmon on the west coast of Prince of Wales Island were the largest of the three areas, with the principal modal fork length lying between 35.0 inches (88.9 cm) and 37.5 inches (95.3 cm). Again, probably in excess of 80 percent were mature, with the dominant age groups being 4_1 and 5_1, in that order. Rich and Ball (1933) reported that about 60 percent of the tags recovered from tagging off Baranof Island in 1926 and 1927 came from the Columbia River. Thus, two tagging experiments separated by many years resulted in substantial numbers of recoveries in fisheries to the south. In inside passage areas, all adult chinook tagged were of the ocean scale type as compared to 10-20 percent in outside waters. The 1951 tagging reported by Parker *et al.* (1952) resulted in no recoveries from tags applied north of Cross Sound, while those recovered from tagging south of Cross Sound supported the opinion of Parker and Kirkness (1951)—that chinook salmon in that area were primarily from streams to the south of Alaska.

The spring season tagging in inside passage waters such as Stephens Passage and Clarence Strait resulted in substantial numbers being recovered in Alaskan rivers when tagging was in close proximity to the rivers. When tagging was removed from such rivers or carried out later in the season, numbers were recovered in areas to the south and in British Columbia with only rare recoveries to the north and west of the tagging locations.

Kirkness *et al.* (1953) reported on tagging chinook salmon north of Cape Spencer in 1952. The returns followed the pattern for previous tagging in the area and also resulted in the first returns in an Alaskan river (the Taku) from Alaskan tagging. They concluded that the stocks of chinook salmon north of Cape Spencer were composed largely of immatures and that their origins were primarily from rivers to the south. Tagging in southeastern Alaska in 1951 and 1952 resulted in northern British Columbia recoveries, but none from the Fraser or Columbia Rivers.

Distribution Indicated by Tagging in British Columbia

Milne (1957) summarized chinook salmon tagging in British Columbia in the years 1925–1930 and compared the results to tagging in 1949–1952. He reported very little difference in total percentage of tags recovered between the two time periods. In both periods, the majority of the chinook salmon tagged in outside coastal waters travelled in a southeasterly direction toward the Fraser and Columbia Rivers. In recent years, more were recovered in British Columbia waters than in earlier years. He states that " Off the southwestern part of Vancouver Island many small immature fish are also captured while they are foraging in the ocean a year or two prior to the spawning migration."

Distribution Indicated by Tagging in Washington

Kauffman (1951) reported on tagging of chinook salmon in 1948 and 1949 at Swiftsure Bank and at Umatilla, recoveries from tagging in other areas being too few for conclusions. The Swiftsure tagging resulted in a rather high rate of recovery (55–62 percent of those recovered) in the general tagging area, and a substantial number of recoveries (26 out of a total of 58 recoveries from 1949 tagging) one or more years after tagging. A high abundance of immatures in the tagging area was thus indicated. Recoveries also came from areas northwest of the tagging site to near the northern tip of Vancouver Island and from the Fraser and Columbia Rivers. The Umatilla tagging showed a movement of chinook to the Sacramento and Columbia River areas, Puget Sound and along the coast of Vancouver Island.

Distribution Indicated by Tagging in Oregon

Van Hyning (1951) reported on tagging undersized chinook (less than the legal 27 inches, 68.6 cm) in 1948 and both undersized and larger chinook in 1949 on the coast of Oregon. Very few tags were applied at the three sites, the Columbia River, Newport and Coos Bay. Only five tags were recovered from the Columbia River tagging, none from Newport and six from Coos Bay. The recoveries indicated a northward movement from the Columbia River along the coast of Washington to the coast of British Columbia. Two of the five tags applied near the Columbia were recovered in the Columbia River and one in San Francisco Bay. Some of the tags from the Coos Bay tagging were recovered north and one was recovered south of the tagging location. In scale samples from Astoria and Newport taken in 1947, Van Hyning found that about 72 percent were of the ocean nucleus type compared to about 78 percent reported by Rich (1920) for this general area.

Distribution Indicated by Tagging in California

Fry and Hughes (1951) reported on California tagging of chinook in the years 1939 to 1942 and 1948 to 1949. The results showed that the Sacramento-San Joaquin River systems were the primary suppliers of chinook salmon to the California coastal troll fishery, although a few recoveries came from California streams north of the Sacramento. Point Arena seemed to be a dividing point. Most of those tagged south of this point were recovered to the south, while most of those tagged to the north were recovered to the north.

Summary of Tagging

These various tagging experiments indicate that most chinook salmon yearling and fingerling migrants must move to the northward on entering marine waters. For the Columbia River chinook, this migration is most pronounced. However, a few chinook from many areas may travel to the south. Evidence from tagging has demonstrated that large numbers of chinook from the Columbia River and southern British Columbia river systems migrate into the troll fishery areas of British Columbia and Alaska. Along the inside shores of southeastern Alaska, British Columbia and Puget Sound, there are apparently chinook salmon which do not migrate to any great extent in a northward direction. Present evidence indicates that some of the chinook in inside waters may not intermingle to any great extent with those of the outside coastal areas of Washington, British Columbia and some Alaskan waters.

CHINOOK SALMON STOCKS IN NORTH AMERICA AND ASIA

The numbers of chinook salmon caught in North America for the years 1920 through 1961 are summarized in Table 3. Similar statistics for Asia for the years 1909 through 1961 are presented in Table 4. These commercial fisheries data have generally been more complete and accurate in more recent years. While California, for example, adopted its basic " fish ticket " or multiple sales slip system in 1918, for many years all species of salmon were combined so that single species data are unavailable for the years 1920 through 1946. Oregon adopted a fish ticket system in 1923, and adoption of and improvements in this system followed in Washington in 1935 and in both British Columbia and Alaska in 1951.

Soviet and Japanese commercial catch statistics were unavailable for some years, even into the 1930's (Table 4). In general, however, the data were more detailed since World War II, and were later improved by the release of Japanese mothership data for $2° \times 5°$ statistical areas and ten-day periods. Tables 3 and 4 both show omissions in knowledge of commercial catch statistics. The figures which most accurately represent the catches of both continents are probably those following the close of World War II.

While the accuracy and detail of North American, Japanese and Soviet commercial catch data increased in recent years, a similar improvement in the recording of North American sport fisheries and other personal use catches was not apparent. The sport fisheries in ocean waters have grown tremendously in post World War II years and fishing effort in inshore and freshwater areas has also increased. However, none of the fishery agencies has developed a means of completely censusing the numbers of chinook landed in diverse fishing areas over protracted seasons by various types of non-commercial fishing gear. As a result, the sport catches shown in Table 3 are believed to be minimum figures in most cases.

In spite of these deficiencies, when the total chinook landings of the two continents are compared, North American catches greatly exceed the combined catches by the U.S.S.R. and Japan (Figure 4). It is also apparent that in spite of substantial fluctuations in the North American catches since World War II, there has been an increasing trend in numbers of chinook caught. The combined Soviet and Japanese catches since 1952 have shown a general increase which is probably attributable to expansion of both the Soviet coastal and Japanese mothership fisheries. Figure 4 shows that since World War II the North American catch has tended to increase. Figure 5 shows that in this period the United States catches have tended to fall, while those for Canada have tended to rise. It should be noted that the sport catches are missing for some states for 1959, 1960 and 1961, which could influence the trends of the catches. However, the trends remain the same if Figure 5 is replotted with sport catches assumed to be the highest of record in each state for the missing years.

In recent years, the Japanese commercial catch has been taken primarily in offshore waters by gillnets and to some extent longlines. In coastal waters of both Japan and the U.S.S.R., both traps and nets are used. The North American catch is primarily taken by trollers operating in both open coastal and inside waters. A major exception is commercial fishing in Bristol Bay and its tributaries, which is exclusively by gillnet. In inside waters, gillnets take substantial numbers, particularly in river estuaries such as those of the Columbia and Fraser Rivers and places such as Cook Inlet in Alaska. In some areas, traps, dip nets and fish wheels still operate, most commonly for personal use fisheries.

The troll fisheries make appreciable catches starting in May, with catches substantially reduced after August. To illustrate the seasonal variation in catch between different North American areas, the percentiles of representative troll catches for the year 1960 were calculated (Table 5). It should be noted that these data were subject to the effects of variations in regulations, fishing effort, weather and market conditions.

DISTRIBUTION AND ABUNDANCE OF CHINOOK SALMON IN OFFSHORE WATERS

The offshore distribution and abundance of chinook salmon will be described from catches of research vessels using purse seines, gillnets and longlines, and from catches of the Japanese mothership fishery. The data to be used for these purposes were taken from

TABLE 3. North American catches of chinook salmon, in thousands of fish, with available data on sport catches given in parentheses.

Year	Alaska[1]	British Columbia[2]	Washington[3]	Oregon[4]	California[5]	Total
1920	775.5	641.8	771.4	—		2,188.7
1921	826.4	406.8	598.7	—		1,831.9
1922	770.3	373.2	562.9	843.3		2,549.7
1923	681.4	343.0	678.2	1,157.4		2,860.0
1924	794.3	305.8	1,267.5	1,307.0		3,674.6
1925	816.6	666.5	1,219.2	1,428.0		4,130.3
1926	588.6	489.9	980.7	1,093.2		3,152.4
1927	967.3	614.3	1,090.0	1,142.1		3,813.7
1928	656.6	415.0	894.7	800.3		2,766.6
1929	768.1	344.8	972.9	729.6		2,815.4
1930	892.9	539.4	1,025.1	791.0		3,248.4
1931	680.3	424.7	1,042.6	926.5		3,074.1
1932	882.3	645.6	910.2	710.6		3,148.7
1933	608.7	448.2	894.0	874.9		2,825.8
1934	559.7	1,737.3	872.5	807.3		3,976.8
1935	800.5	1,341.4	563.1	821.0		3,526.0
1936	894.1	1,634.4	610.3	968.1		4,106.9
1937	1,071.8	813.8	652.4	1,070.5		3,608.5
1938	927.7	330.7	434.7(27.5)	735.9		2,456.5
1939	817.6	361.0	468.5(34.8)	754.0		2,435.9
1940	574.2	326.3	588.1(34.1)	807.6		2,330.3
1941	1,126.2	713.3	656.8(29.8)	1,026.6		3,552.7
1942	739.8	415.7	607.7(8.3)	940.2		2,711.7
1943	629.6	1,076.4	487.0	623.2		2,816.2
1944	506.2	276.4	497.2	751.5		2,031.3
1945	608.2	502.1	546.1	779.2		2,435.6
1946	739.9	780.5	643.4(23.4)	866.3		3,053.5
1947	717.8	874.3	637.2(12.8)	1,004.6	759(5)	4,010.7
1948	677.9	513.9	572.8(12.0)	927.4	517(11)	3,232.0
1949	703.8	*	507.8(105.2)	632.9(8.0)	438(23)	2,418.7**
1950	609.9	*	480.4(114.6)	567.9(11.0)	487(57)	2,327.8**
1951	789.5	794.0	594.8(139.2)	620.7(10.0)	476(103)	3,527.2
1952	735.3	905.4	662.1(213.0)	519.0(11.0)	512(123)	3,680.8
1953	713.0	1,013.9(75)	630.4(152.2)	445.0(15.0)	533(141)	3,718.5
1954	610.4	876.8(76)	570.1(219.1)	428.7(17.0)	828(171)	3,797.1
1955	582.1	872.0(90)	651.2(228.9)	627.7(59.0)	868(184)	4,162.9
1956	458.0	983.1(106)	519.3(318.6)	677.8(51.0)	1,026(163)	4,302.8
1957	513.8	938.1(135)	586.2(331.9)	461.5(79.0)	491(64)	3,600.5
1958	550.2	1,068.7(144)	481.6(235.1)	398.8(74.0)	375(65)	3,392.4
1959	601.2	948.3(117)	375.0(197.0)	247.2	514	2,999.7
1960	547.2	742.5(93)	288.3(195.2)	338.3	540	2,744.5
1961	503.6	685.3(67)	371.1(205.6)	297.5	792	2,922.1

* No data available in number of fish for B.C. catches in 1949 and 1950.

** Incomplete total.

1) From Kasahara (1963), Table 47.

2) From Kasahara (1963), Table 60 (commercial) and Table 80 (sport). Sport catches include 25% of "grilse" catches as given by Kasahara.

3) From 1920 to 1934, from Kasahara (1963), using 19.48 lbs per fish. From 1935 to 1961, from 1962 Annual Report, Washington State Department of Fisheries, except that sport catches given for 1938 to 1942 are from Annual Bulletins 38, 39, 40, 41 and 42 of the Washington State Department of Fisheries.

4) For 1922 to 1955, Oregon commercial catches in Table 69 of Kasahara (1963) were converted from metric tons to pounds (2,204.59 lbs per metric ton) and then to number of fish (15 lbs per fish—see Kasahara's note 7, Table 75); for 1956 to 1961, data were taken from INPFC Statistical Yearbooks. Sport catches from 1949 to 1958 are from Kasahara (1963), Table 82.

5) For the years prior 1947, there are no data available on catches of chinook salmon, since catches of coho and chinook were not separated. Commercial catches shown here are from D. H. Fry, Jr., California Department of Fish and Game, as given in a letter to J. E. Mason dated August 2, 1963. Sport catches for 1947 to 1958 are from Kasahara (1963), Table 82.

TABLE 4. Commercial catch of chinook salmon, in thousands of fish, by Japanese and U.S.S.R. fisheries.

Year	Catch by Japan from U.S.S.R. coast[1]	U.S.S.R. coastal catch[2]	Japanese mothership and North Kuril fisheries[3]	Total
1909		2.6		2.6
1910		0.4		0.4
1911	6.0	8.2		14.2
1912	5.1	25.4		30.5
1913	28.2	7.3		35.5
1914	11.8	8.7		20.5
1915	17.6	10.1		27.7
1916	15.0	8.8		23.8
1917	14.9	24.4		39.3
1918	12.0	79.4		91.4
1919	50.6	0.8		51.4
1920	70.3	6.5		76.8
1921	64.6			64.6**
1922	35.8	39.0		74.8
1923	24.8			24.8**
1924	23.7			23.7**
1925	39.6			39.6**
1926	77.0			77.0**
1927	98.2	7.8		106.0
1928	68.6	18.4		87.0
1929	82.5	26.5		109.0
1930	111.6	67.4	3.3	182.3
1931	74.8	40.2	4.7	119.7
1932	74.8	53.2	2.8	130.8
1933	35.5	15.5	1.1	52.1
1934	68.7	23.3	3.2	95.2
1935	103.2	40.8	20.3	164.3
1936	77.0	65.0	41.4	183.4
1937	123.4		32.6	156.0**
1938	91.4		28.8	120.2**
1939	57.6		9.1	66.7**
1940	67.3	22.0	12.0	101.3
1941	66.3	57.0	13.4	136.7
1942	31.4	36.0	16.0	73.4
1943	*	48.0	4.5	52.8
1944	*	17.0	*	17.2
1945		38.0	*	38.0
1946		81.0		81.0
1947		81.0		81.0
1948		130.0		130.0
1949		75.0		75.0
1950		62.0		62.0
1951		72.0		72.0
1952		66.0	1.0	67.0
1953		88.0	8.0	96.0
1954		65.0	74.0	139.0
1955		134.0	76.0	210.0
1956		110.0	137.0	247.0

Continued.

TABLE 4. (Continued)

Year	Catch by Japan from U.S.S.R. coast[1]	U.S.S.R. coastal catch[2]	Japanese mothership and North Kuril fisheries[3]	Total
1957		90.0	31.0	121.0
1958		70.0	46.0	116.0
1959		98.3	68.0	166.3
1960		70.0	180.0	250.0
1961		65.0	31.0	96.0

* Less than 500 fish.

** Incomplete total.

1) From Kasahara (1963), Table 15.

2) For 1909 and 1910, from Baievsky (1926). For 1911 to 1922, by subtraction of Kasahara's Japanese catch from total U.S.S.R. coastal catches given by Baievsky (1926); for 1927 to 1936, by subtraction of Japanese catch from total U.S.S.R. coastal catch, both as given in Kasahara (1963); for 1940 to 1961, from metric ton figures given by Kasahara (1963) in Table 29, converted to number of fish using a conversion factor of 22 lbs per fish approximated from 1958 through 1961 averages given in Table 32 of Kasahara (1963).

3) For 1930 to 1945, from Kasahara (1963), Tables 34 and 35; for 1952 to 1961, from Kasahara's Table 37 (mothership catches only).

the annual reports of the International North Pacific Fisheries Commission (1955-1961), INPFC Statistical Yearbooks for 1952 through 1961, Neave *et al.* (1962), French (1964), Powell and Peterson (1957) and Fisheries Agency of Japan (1962). Before proceeding, some of the limitations and possible sources of error in the data should be recognized.

LIMITATIONS OF THE DATA

The research vessels of Canada, Japan and the United States have used a variety of gear in the period 1955 through 1962, including troll lines, purse seines, longlines and gillnets. Data from trolling were too few to be of any help in describing distribution and abundance, but appreciable numbers of chinook salmon have been taken in purse seines. However, since purse seines were usually operated in the more coastal waters and principally for the purpose of obtaining salmon for tagging, the resulting data are of limited use in describing offshore distribution of chinook. The same criticism can be made of some of the longline experimental fishing, although Canadian and Japanese longline fishing in 1962 was carried out in a manner which adds to knowledge of distribution and abundance.

The most consistent data are those procured from the use of gillnets fished in surface waters. Those fished

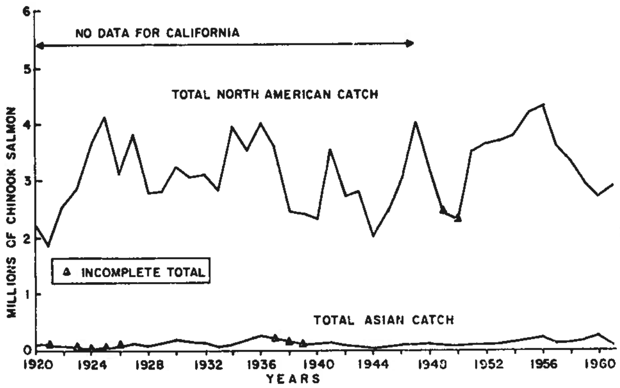

FIGURE 4. Chinook salmon catches (in millions of fish) from North America and Asia (U.S.S.R. and Japan), 1920–1960. Data from Tables 3 and 4.

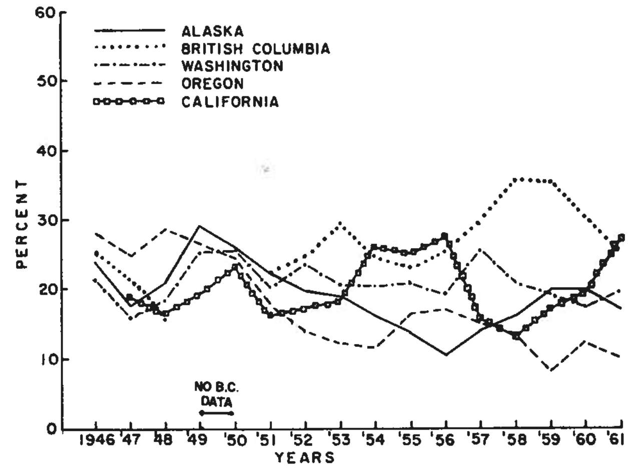

FIGURE 5. Chinook salmon catches in North America, by area, as percentages of total North American catch. Data from Table 3.

TABLE 5. Percentiles of chinook salmon troll catches by areas in 1960[1].

Area	10%	25%	50%	75%	90%
Alaska					
Icy Strait and Western	May 21	June 4	June 18	July 16	Aug. 20
British Columbia					
Areas 1 and 2	May 28	June 18	July 9	July 23	July 30
Areas 22–27 and C	May 14	June 11	July 30	Aug. 13	Sept. 10
Columbia River					
Oregon Coastal	May 28	July 2	Aug. 6	Aug. 20	Sept. 17
California					
San Francisco	Early May	Early June	June	July	Mid-August

1) Data taken from INPFC Statistical Yearbook for 1960.

at depths in studies of vertical distribution, again, are of no material value in describing offshore distribution and have been omitted. The gillnets were typically of the INPFC standard meshes, that is, $5\frac{1}{4}''$, $4\frac{1}{2}''$, $3\frac{1}{4}''$, and $2\frac{1}{2}''$ stretched mesh (13.3, 11.4, 8.3, 6.4 cm), although many other mesh sizes and both monofilament and multifilament synthetic web materials have been used, all in various amounts and in various combinations.

Since gillnets were used by all three nations for extended periods of time over broad ocean areas, it would appear desirable to describe distribution and abundance in terms of catch per unit of effort. Examination of the data revealed that the combined chinook catches by research vessels of Canada, Japan and the United States in the years 1955 through 1962 totalled less than 2,000 chinook for both surface fishing gillnets and the longline data which could be used to describe offshore distribution. The number of chinook salmon caught was almost insignificant in terms of catch in numbers and in catch per unit of gear. The maximum figures given by Manzer *et al.* (MS 1963) for the Japanese landbased fishery by 10-day periods in the years 1956 through 1960 are 1.17, 0.22 and 0.16 chinook per tan (about 180 feet). All other catches amounted to only a few hundredths of a chinook per tan. In the Japanese mothership fishery, the maximum recorded catches per tan by months and areas were 0.23 and 0.09 chinook per tan, with most figures falling below 0.03 chinook per tan (INPFC Statistical Yearbooks 1954 through 1960). If the data for research vessels, the landbased fishery, or the mothership fishery were to be further divided to express catch per unit by mesh size, they would have even less significance. Since the total number of chinook caught was so small and since such a variety of gillnets was used, it was decided to avoid expressing results in terms of catch per unit of fishing gear. The data are expressed in terms of fishing position, numbers of occasions fishing was carried out at that position and the number of chinook caught. This approximates catch per unit in terms of catch per set.

The approximate total of 2,000 chinook caught over eight years of fishing is a number of such small magnitude that it makes it impossible to compare abundance on a monthly basis or to compare catches by years. As a result, the seasonal changes discussed below for research vessel catches are based on combined data by months for 1955 through 1962. This totally obscures differences in abundance by years or seasonal variation which may be related to differences in ocean environment.

While research vessel fishing is intended to give unbiased estimates of salmon populations at each fishing location, the sampling gear is known to be selective. These vessels have usually fished surface waters and while the gillnet mesh sizes have generally ranged from 2½ to 5¼ inches (6.4 to 13.3 cm), the most efficient sizes for retaining larger and smaller chinook were not used. The bias due to this factor cannot be evaluated. Biases are also introduced from the use of longline gear, hook sizes and bait type both being recognized as introducing size and species selection. Here again the degree of bias is unknown.

The species identification of catches by research vessels are subject to correction after laboratory examination of specimens, such correction occurring on some occasions after the annual reports of the International North Pacific Fisheries Commission had been published. While there are occasions of misidentification of species or errors in recording data, they are relatively few, and this type of error should not significantly affect the analyses to follow.

Another factor limiting the analyses is the relative lack of any numbers of chinook, not only in research vessel catches as was pointed out, but in the mothership fisheries, as shown in Table 6 for operations in 1957, which year was selected at random for demonstration purposes. The number of chinook is virtually insignificant in terms of catch in numbers and catch per unit of gear as compared to other species.

Other sources of bias in the commercial fishing data are selective fishing by area, by gear and by time for other species which may be more abundant or otherwise preferred. Therefore, catch, or catch per unit of effort, data of commercial gear cannot be used as unbiased indices of the distribution and abundance of chinook salmon. Unfortunately, it is not possible to estimate the degree of bias introduced by selective fishing.

There are other sources of error which may act in combination with the above. Table 7 compares catches by Japanese research vessels and motherships for specific times and areas. The table includes sockeye, chum, pink and coho salmon for illustration purposes, since so few chinook were taken. It can be seen that in 1957 the catches per tan by species for two research vessels were of the same general order of magnitude. However, the catch per tan of the 1957 mothership fishery was higher than that of the research vessels for some species (sockeye and pink) and lower for others (chum and coho). In 1958 and 1959, the mothership catches per tan were usually higher than those of the research vessels for all species (approximately two to four times). In 1960, however, mothership catches were lower than research vessel catches for all species except sockeye. These variations may be partly explained on the basis of (1) grossly dissimilar amounts of effort by the two fisheries, (2) the few occasions when both fisheries were operated concur-

Table 6. Catch and catch per unit of effort in 1957 for salmon caught in gillnets by Japanese and Canadian research vessels and the Japanese mothership fishery[1].

Operation	Species				
	Sockeye	Chum	Pink	Coho	Chinook
Japanese research vessels (2,203 tans)					
Number of fish	4,297	3,004	5,516	516	7
Mean catch per tan	1.9	1.4	2.5	0.2	0.003
Canadian research vessels (2,096 shackles)					
Number of fish	998	1,797	519	355	5
Mean catch per shackle	0.5	0.9	0.2	0.2	0.002
Japanese motherships (6,619,089 tans)					
Number of fish	19,822,540	9,246,132	21,045,585	339,623	31,104
Mean catch per tan	3.0	1.4	0.32	0.05	0.005

[1] Data from INPFC Annual Report 1957.

TABLE 7. Catch and catch per unit of effort by species of salmon for Japanese research and mothership vessels using the same types of gear in the same areas in the same time periods in the years 1957 through 1960[1].

Year	Vessel	Date	Area[2]	Sockeye	Chum	Pink	Coho	Chinook	Tans
1957	*Kano-maru*	July 19–30	E6050, E6052	450	665	272	57	2	274
			Catch per tan	1.6	2.43	1.06	0.21	0.007	
1957	*Etsuzan-maru*	July 15–30	E6050, E6052	570	542	733	229	1	392
			Catch per tan	1.45	1.38	1.87	0.58	0.003	
		July 19–30	E6050, E6052	374	427	417	227	—	280
			Catch per tan	1.34	1.53	1.49	0.81		
1957	Mothership	July	E6050, E6052	2,301,830	665,063	5,382,496	111,628	4,766	959,152
			Catch per tan	2.4	0.69	5.6	0.12	0.005	
1958	*Kano-maru*	June 1–30	E6052, E6054	98	90	13	—	—	144
			Catch per tan	0.68	0.62	0.09			
1958	Mothership	June	E6052, E6054	224,811	262,557	234,710	68	1,423	182,879
			Catch per tan	1.23	1.44	1.28	0.0003	0.008	
1959	*Wakashio-maru*	June 10–20	E6048, E6052	215	230	193	1	—	260
			Catch per tan	0.83	0.89	0.74	0.004		
1959	Mothership	June	E6048, E6052	345,255	985,062	1,179,532	1,171	725	378,600
			Catch per tan	0.91	2.6	3.1	0.003	0.002	
1960	*Etsuzan-maru*	Aug. 10	E6552	55	36	1	34	—	60
			Catch per tan	0.92	0.6	0.02	0.57		
1960	Mothership	Aug. 1–10	E6552	26,703	2,036	41	171	—	8,448
			Catch per tan	3.16	0.24	0.005	0.02		

[1] Data from INPFC Annual Reports, 1957, 1958, 1959 and 1960.
[2] See Figure 6.

rently, (3) commercial fishery statistics (except 1960) being tabulated by months whereas the research vessel catches were by specific days, and (4) the fact that the mothership fishing areas had boundaries as large as two degrees of latitude and five degrees of longitude. These various possible sources of error for sockeye, chum and pink salmon are assumed to apply as well to chinook salmon.

It is thus apparent that neither the research vessel nor mothership data for chinook salmon can be accepted as being superior. In most cases, the differences in data from the two sources may be viewed as being due, perhaps, more to sampling differences than to biological phenomena. As a result, trends or conclusions can be indicated only very generally.

The following material concerning distribution and abundance is based on chinook salmon catches in surface waters. If these fish occur in surface waters only occasionally or only seasonally, then the actual distribution of most of the chinook may be grossly different from any conclusions reached here.

Distribution and Abundance Described from Research Vessels Using Purse Seines

The purse seine catch data given by Hartt (1962) are summarized in Table 8 by INPFC statistical area (Figure 6), month, catch per set, number of sets and for sets open to the east and west. While Hartt did not give specific information on maturity, he stated the opinion that most of the chinook salmon caught were immature, hence the following material is thought to apply primarily to immature chinook. The totals in Table 8 show a slightly higher average catch per set for sets open to the east than to the west, suggesting a possible westerly migration. A change in abundance in relation to time is also suggested for sets open to the east, as well as a substantial increase in abundance after the month of May. Such changes are not apparent in sets open to the west, due, at least in part, to the small number of sets and small catches of chinook in May, July and August.

Data for the areas in which chinook were caught in three or more consecutive months are summarized in greater detail in Table 9. Only areas E7052, E7550, 8050 and W7052, involving sets open to the east, met the three month criterion. While areas E7052 and E7550 in Table 8 show an increasing abundance of chinook in succeeding months, Table 9 shows that the changes were the result of combining data and were not actually time related. In Table 8, area W7052 shows an increased abundance in July as compared to June, but in Table 9 it is apparent only for 1957 and includes a total of only nine sets. The 1958 data

TABLE 8. Chinook catch per purse seine set for the combined years 1956 through 1958. Numbers in parentheses are total numbers of sets[1].

Area code number	Open to East					Open to West				
	May	June	July	Aug.	Sept.	May	June	July	Aug.	Sept.
E6554			0 (1)							
E7050	0.3 (3)	0 (1)	0.8 (14)			0 (0)		0.5 (2)		
E7052	0 (3)	0.07 (14)	0.3 (35)	0.5 (21)		0 (2)	0 (24)	0 (1)	0 (4)	
E7054		1.3 (3)	0 (2)			0 (1)	0.7 (3)	0 (1)		
E7548			0.5 (2)					0 (1)		
E7550	0 (1)	0.6 (5)	0.25 (4)	0.45 (13)			0 (3)	0 (3)	0 (6)	
E7552	0 (1)	0 (1)	1 (1)	0 (2)		2.5 (2)	0 (1)	0 (1)	1 (1)	
E7554			0 (1)					0 (1)		
8048			2 (1)					0 (1)		
8050	0 (2)	0.17 (23)	1 (60)	0.70 (44)		0 (4)	0 (1)	0 (3)	0 (1)	
8052	0 (1)	0 (1)	0.17 (6)			0.2 (5)	1 (3)	0 (2)		
8054		2 (2)	1 (1)				2.7 (3)	0 (1)		
8056		1 (1)					0 (1)			
W7550	0 (1)	0 (3)	0.6 (5)	2.3 (3)			0 (3)	0 (1)		
W7552		0.3 (1)	0 (2)				0 (1)			
W7556		4 (2)					0.3 (10)			
W7558							0 (1)			
W7560							0 (1)			
W7052		0.2 (35)	12 (8)	1.5 (4)			0.3 (6)	0.5 (4)		
W7054		0.25 (4)					0.4 (10)			
W7056							0.14 (14)			
W6552	0 (6)					0.3 (3)				
W6554		0.07 (15)	0 (2)							
W6050				0 (1)					0 (1)	
W6052				0 (4)						
W6054			0 (2)	1 (7)	1.5 (2)			0 (1)	2 (2)	
W5554		0 (6)		1.5 (8)	0 (2)		0 (1)	0 (2)	0 (1)	

Continued

TABLE 8. (Continued)

Area code number	Open to East May	June	July	Aug.	Sept.	Open to West May	June	July	Aug.	Sept.
W5556				0.2 (5)	1 (2)				5 (1)	
W5558										4 (1)
W5054		0 (1)								
W5056				0 (1)	0 (3)					0.5 (2)
W4554						0 (1)				
W4556					0 (1)					0 (3)
W4054										0 (1)
W4056					2 (2)					4.3 (3)
W4058										0 (1)
W3554					0 (2)					0 (2)
W3048										2.2 (13)
W3050					2.3 (3)					
Total chinook caught	1	37	188	80	16	7	24	3	10	46
Total sets	18	118	147	113	17	18	86	25	17	26
Catch per set	0.05	0.31	1.28	0.71	0.94	0.39	0.28	0.12	0.59	1.8
	Total chinook caught: 322					Total chinook caught: 90				
	Total sets: 413					Total sets: 172				
	Catch per set: 0.77					Catch per set: 0.52				

[1] Data from Hartt (1962).

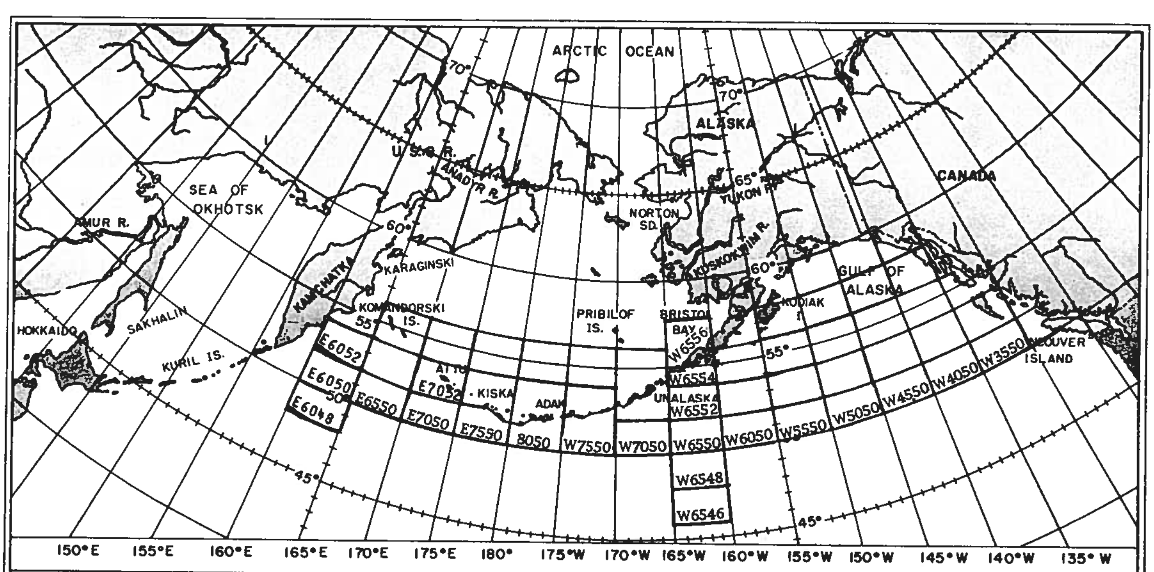

FIGURE 6. Reference map with key to area coding.

TABLE 9. Chinook catch per purse seine set for sets open to the east. Numbers in parentheses are numbers of sets[1].

Year and area		May	June	July	August
1956	E7052	(0)	(0)	(0)	(0)
	E7550	(0)	(0)	(0)	(0)
	8050	(0)	0.11 (9)	0.06(17)	0.78(18)
	W7052	(0)	0.19(31)	(0)	5.0 (1)
1957	E7052	(0)	0 (4)	0.06(17)	0.65(17)
	E7550	(0)	1.00 (3)	0.25 (4)	0.50(12)
	8050	0(1)	0.20 (5)	1.55(29)	0.69(13)
	W7052	(0)	0.25 (4)	1.60 (5)	0 (1)
1958	E7052	0(3)	0.10(10)	0.56(18)	0 (4)
	E7550	0(1)	0 (2)	(0)	0 (1)
	8050	(0)	0.22 (9)	1.00(14)	0.62(13)
	W7052	(0)	(0)	29.33 (3)	0.5 (2)

[1] Data from Hartt (1962).

were unusual in that the three sets made on July 2, 3 and 4 resulted in individual catches of 47, 27 and 14 chinook salmon on successive days. In Table 8, area 8050 shows increases in abundance of chinook in June and July, with a decline in August. Table 9 shows this same trend for area 8050 in 1957 and 1958; however, in 1956, the catch per set was lowest in July and highest in August.

The suggested westerly migration of chinook salmon indicates a possibility that they would become more abundant in the more western areas later in the season. This seems apparent in Table 9 for the 1957 data, which are more extensive than for 1956 or 1958.

The generally higher catches per purse seine set for sets open to the east as compared to the west suggest a westerly movement of chinook in areas W7550, 8050, E7550 and E7052, adjacent to and south of the Aleutian Islands. While a total of only five sets was made in May in these four areas in 1956 through 1958, the data indicate that chinook were more abundant in June than in May. Catches in area 8050 for 1957 and 1958 indicate peak abundance in July and a decline in August, changes not clearly apparent in 1956 or in other areas. The 1957 data suggest that chinook become more abundant in the more western areas in August, possibly as a result of a migration to the west suggested by the differences between catches of purse seines set open to the east and open to the west. The successive catches of 47, 27 and 14 chinook per set in area W7052 in 1958 show that chinook may be found in concentrations in some areas and times.

DISTRIBUTION AND ABUNDANCE DESCRIBED FROM RESEARCH VESSELS USING GILLNETS

Figures 7 through 13 show summaries by months of positions and catches of chinook salmon by research vessels using surface fishing gillnets in the years 1955 through 1962. Each open circle shows a set location with no chinook catch. If more than one set was made, the number is shown in the upper part of or at the left of each circle. If one or more chinook was caught, the number is given below or to the right in each circle.

In offshore Pacific Ocean waters, the Okhotsk Sea and the Bering Sea, chinook were taken over nineteen degrees of latitude, from 41°N latitude (Figure 7) to 60°N (Figures 8 and 10) and across the entire Pacific from North America into the Okhotsk Sea close to the eastern shore of Sakhalin Island. It is apparent, however, that the distribution was not uniform and that

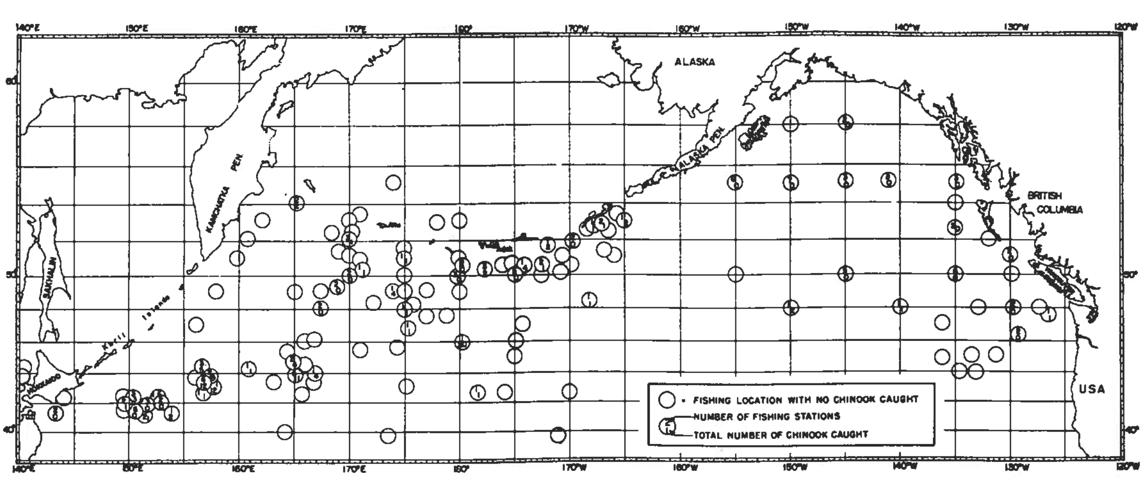

FIGURE 7. Gillnet fishing locations by research vessels of Canada, Japan and the United States in *May*, 1955 through 1962 combined.

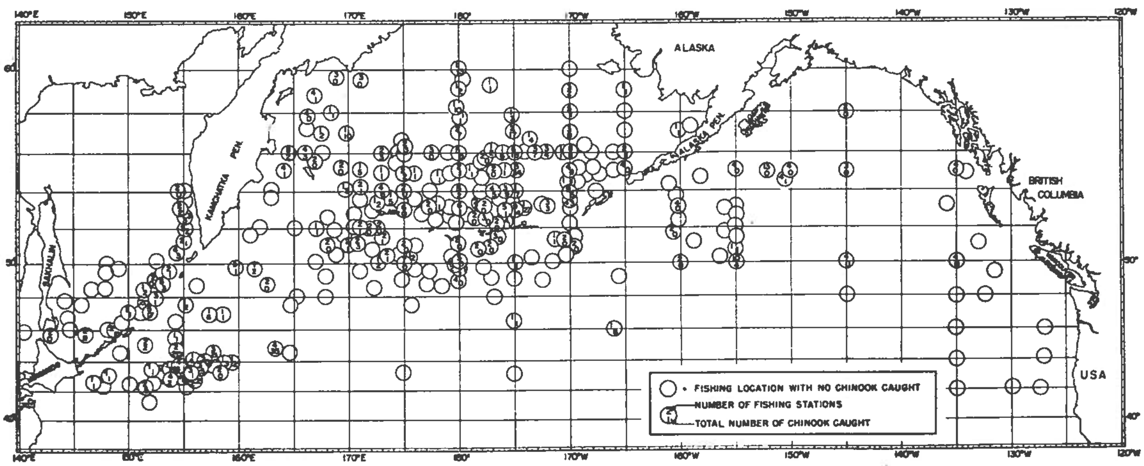

FIGURE 8. Gillnet fishing locations by research vessels of Canada, Japan and the United States in *June*, 1955 through 1962 combined.

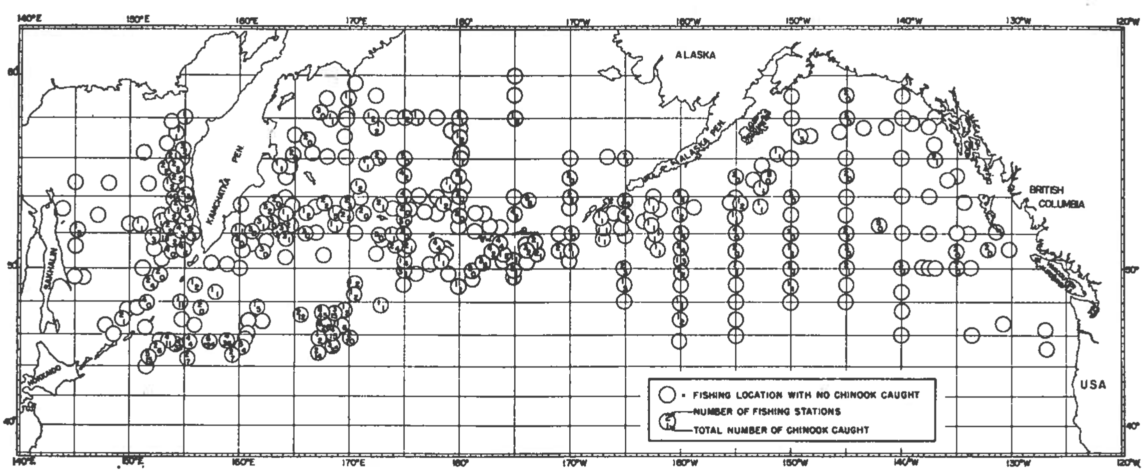

FIGURE 9. Gillnet fishing locations by research vessels of Canada, Japan and the United States in *July*, 1955 through 1962 combined.

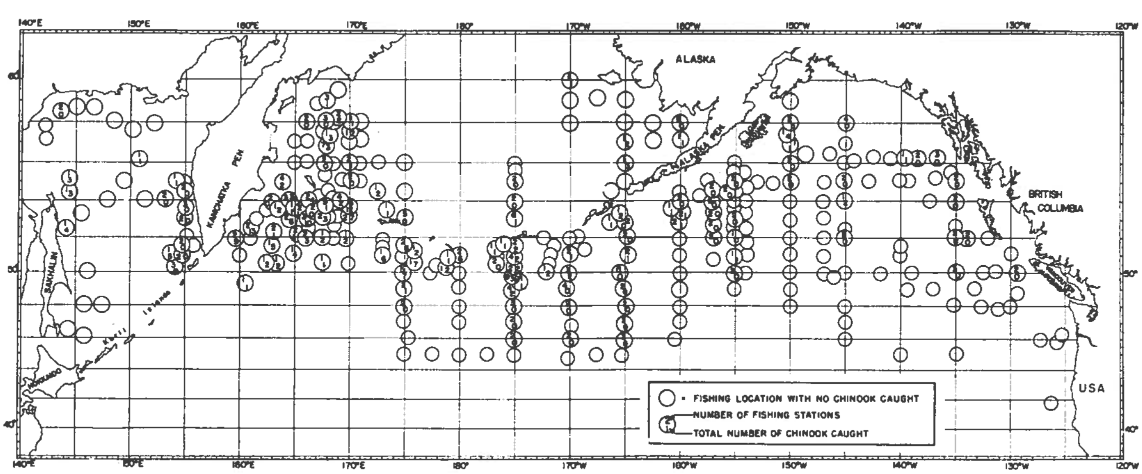

FIGURE 10. Gillnet fishing locations by research vessels of Canada, Japan and the United States in *August*, 1955 through 1962 combined.

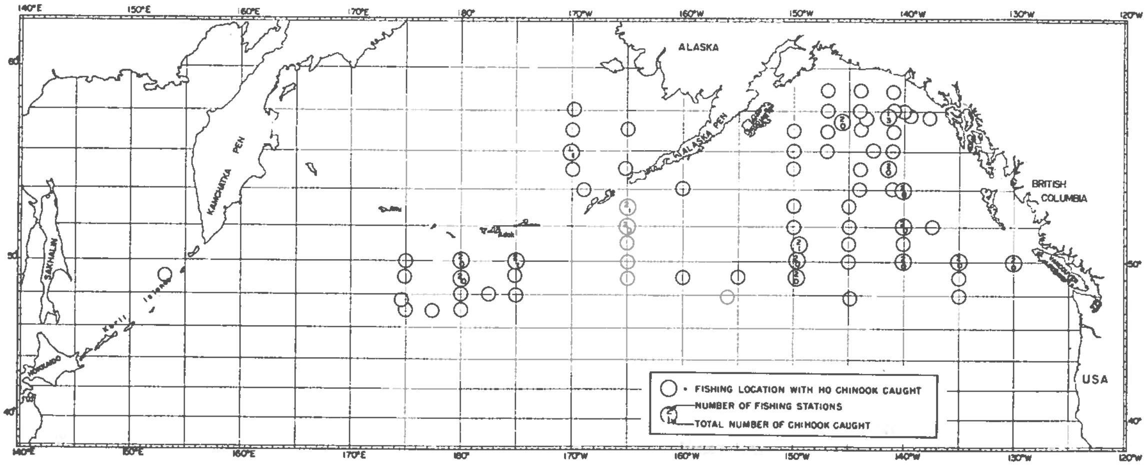

FIGURE 11. Gillnet fishing locations by research vessels of Canada, Japan and the United States in *September*, 1955 through 1962 combined.

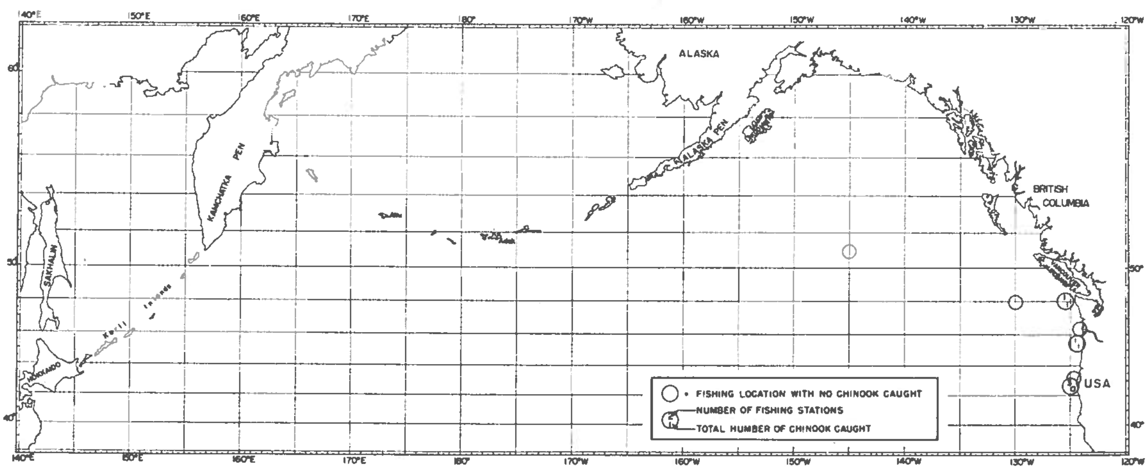

FIGURE 12. Gillnet fishing locations by research vessels of Canada, Japan and the United States in *October*, 1955 through 1962 combined.

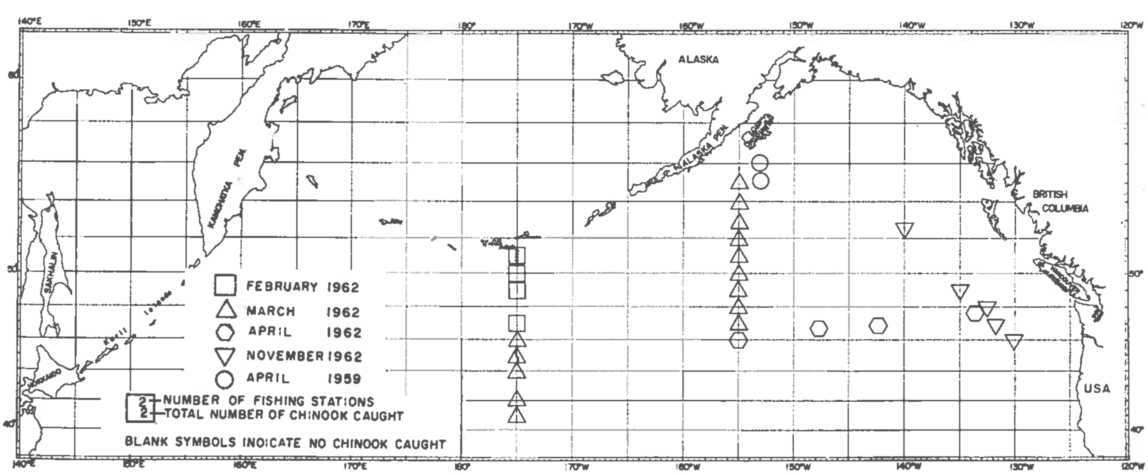

FIGURE 13. Gillnet fishing locations by research vessels of Canada, Japan and the United States in *February*, *March*, *April* and *November*, 1955 through 1962 combined.

the abundance of chinook varied during the spring and summer months at least.

Figure 13 summarizes gillnet fishing positions in the years 1955 through 1962 in all months other than May through October. All that can be said is that chinook may be found south of Adak in February and March.

Bering Sea

In the Bering Sea, data are too few for comment for periods earlier than the month of June (Figure 8). In June, chinook salmon were found from Bristol Bay to the Kamchatka Peninsula, northward from the Aleutian Islands to 60°N. They were apparently more abundant to the east of the 180° meridian than in waters to the west of 180°. Chinook were less abundant in July and August (Figures 9 and 10) in the central Bering Sea with the center of abundance located to the west of 180°. There may have been a similar movement east of 180°, but the data are too few for comment.

North Pacific Ocean

Gulf of Alaska to Unimak Island. No chinook salmon were caught in the area from the Gulf of Alaska to Unimak Island in May (Figure 7) except near the southern limit of fishing. They were caught in the southwest section of the area in June (Figure 8) and more to the north and northeast into the center of the Gulf in July (Figure 9). In both August and September, they were virtually absent from the center of the Gulf.

In July and August, chinook were relatively abundant west of Kodiak compared to east of Kodiak. This suggests that the Kodiak to Unimak area might be an area of transition between the Gulf of Alaska area and western areas. It is also apparent that chinook were virtually absent in a band or corridor running southeast from the Kenai Peninsula to the State of Oregon coast.

Unimak Island to Attu Island. In May, chinook were rather widely and sparsely scattered throughout the Unimak to Attu Island area south of the Aleutians. The few that were taken were generally rather close to the Aleutian Chain and in the westerly section of the area. In June (Figure 8), chinook were still rather widely scattered throughout the area and seemingly most abundant in the northwestern section. In July (Figure 9), chinook were apparently more abundant than in May and June and were found throughout nearly the whole of the area fished and as far south as fishing was carried out. While fishing was more extensive in August (Figure 10), most chinook salmon were taken in a band near the Aleutian Chain about four degrees of latitude wide. The only chinook caught in September (Figure 11) were in the same band.

Attu to Kuril Islands. In May (Figure 7), chinook were most abundant in the south and southeast parts of the general area, while none was caught near Kamchatka and only a few in the north near the Aleutian Chain. In June (Figure 8), chinook were apparently more abundant over a larger section in the southern part of the area than in May. The concentrations found in May near 165°E and 44°N were less apparent, perhaps due to the paucity of fishing in this section. A few were still taken close to the Aleutian Chain and a few were taken closer to Kamchatka. In July (Figure 9), the sections of principal abundance were in the southern part of the area. The greatest concentrations of chinook for all areas and all time periods were to the southeast. In August (Figure 10), limited fishing in the northwest section of the area resulted in catches throughout the section.

Okhotsk Sea

After fishing started in June (Figure 8), chinook salmon were found close to the western shores of the more northern Kuril Islands and the southwest Kamchatka Peninsula. None was caught in the few fishing positions in the southern central Okhotsk Sea area. In July (Figure 9), the area of principal abundance was along the west coast of the Kamchatka Peninsula over the whole north to south range that was fished. Abundance along the Kuril Islands appeared to be reduced from that in June. In August, chinook were apparently less abundant than in June and July along the west coast of the Kamchatka Peninsula. They were generally absent from the northern central and southern sections of the Okhotsk Sea, although they were caught to the northeast of Sakhalin Island. Fishing was discontinued after August.

Sea of Japan

In 1962, Japan undertook a limited amount of exploratory fishing in the Sea of Japan in April and May. One chinook was caught close to the western shore of Hokkaido Island.

Distribution and Abundance Described from Research Vessels Using Longlines

Research vessels using longlines were operated by Canada in 1962 in the Gulf of Alaska area and westward approximating the longitude of Unimak Island as shown in Figures 14 through 17. While Japan also operated research vessels using longline gear, only that area between the longitudes of Attu and the Kuril Islands was fished enough to add to knowledge of

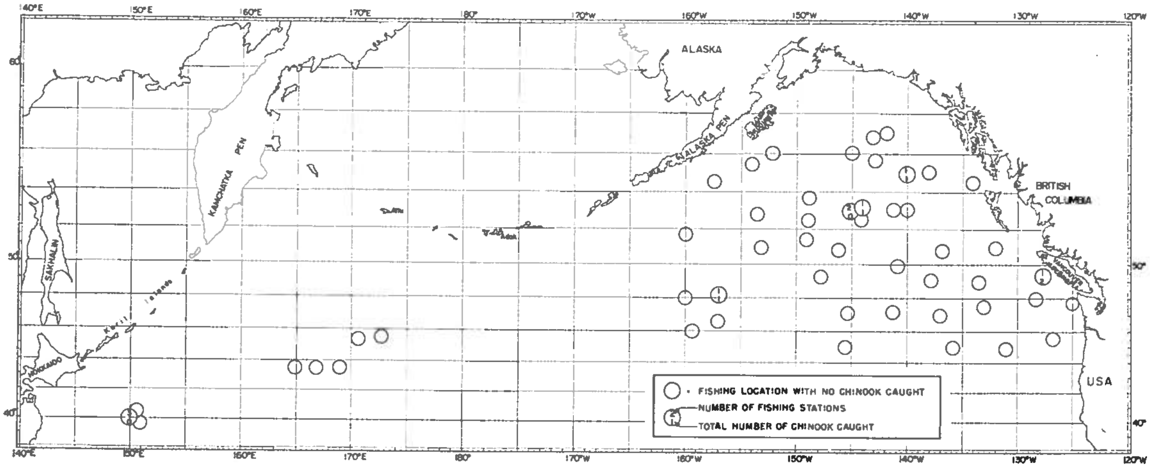

FIGURE 14. Longline fishing locations in *April* 1962 by research vessels of Canada and Japan.

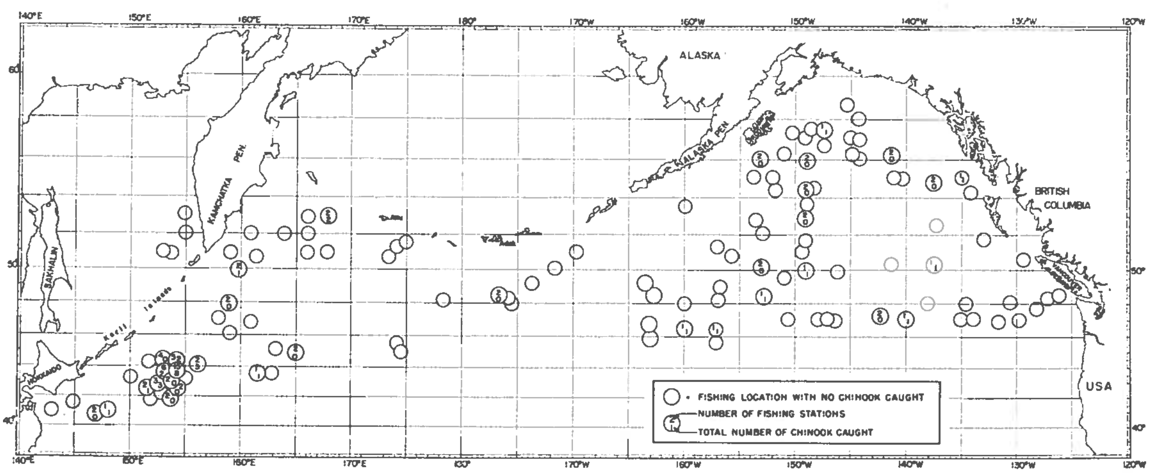

FIGURE 15. Longline fishing locations in *May* 1962 by research vessels of Canada and Japan.

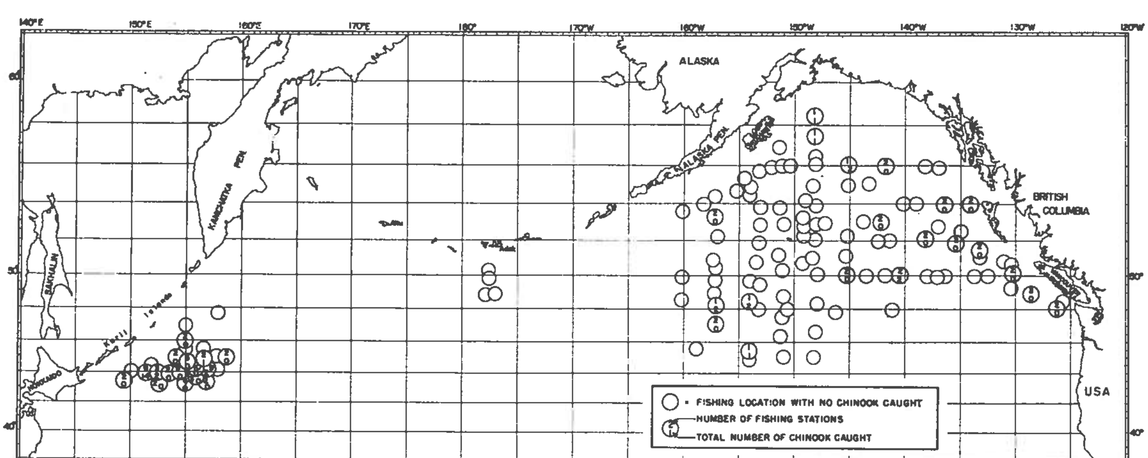

FIGURE 16. Longline fishing locations in *June* 1962 by research vessels of Canada and Japan.

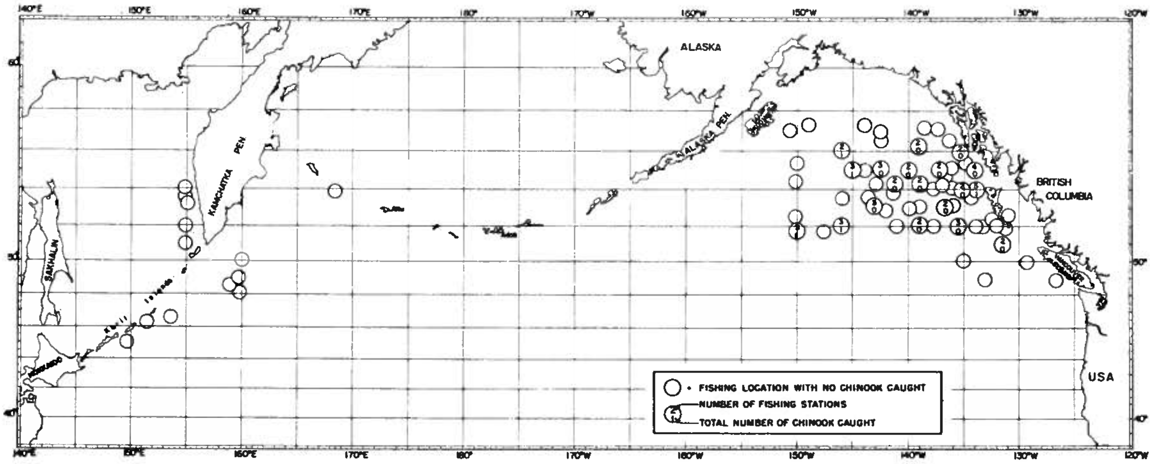

FIGURE 17. Longline fishing locations in *July* 1962 by research vessels of Canada and Japan.

distribution and abundance of chinook. The data in Figures 14 through 17 were taken from Neave *et al.* (1962) and Fisheries Agency of Japan (1962).

Gulf of Alaska

In April (Figure 14), a single chinook was taken southwest of Kodiak near the periphery of the area of fishing. Two others were taken to the northeast near the center of the Gulf. Figure 15, for May, shows that, aside from two chinook taken in the more northern periphery of the fishing area, no chinook were caught from the Gulf of Alaska and westward to about Unimak Island north of 51°N latitude. The six caught were taken west of 137°W longitude and south of 51°N latitude. In June (Figure 16), catches of chinook were similar in location to those in May, although the area fished was larger and fishing more intense. In July (Figure 17), the chinook taken in offshore waters were in the western and southern sections of the area fished.

Attu to Kuril Islands

Figure 15, for May, shows the principal area of chinook abundance to be eastward of Hokkaido Island near 155°E longitude. This was still the principal area of abundance in June. Longline fishing effort for earlier and later months was too scattered to add to the knowledge of distribution and abundance.

Comparison of Distribution and Abundance Based on Gillnet and Longline Catches of Research Vessels

Comparisons of the distribution of chinook salmon as described from longline and gillnet catches can be made only for the Gulf of Alaska area and the area eastward of Hokkaido. While the longline data are for 1962 only, it is assumed that they will serve as an index of chinook distribution for all years.

Gulf of Alaska

The chinook caught by longlines in April (Figure 14) established their presence in the Gulf of Alaska in that month where none had been taken by gillnets. Longline catches as shown in Figure 15 extended the May range further to the south and west and slightly eastward from that shown by gillnets (Figure 7). In June (Figure 16), longlines took chinook south and southwest of Kodiak and extended the range to the south of the areas fished by gillnets (Figure 8).

Attu to Kuril Islands

The area of highest abundance indicated by longline fishing and that indicated by gillnet fishing in the same season is generally the same in the region east of Hokkaido Island. Data for other parts of this general ocean area are not comparable due to the scattered longline fishing operations.

Distribution Described from Japanese Mothership Operations

Summaries of the number of chinook caught and catch per 100 tans by month and by areas for the combined years 1954 through 1961 by the Japanese mothership fisheries are given in Figures 18 through 21 as compiled from INPFC Statistical Yearbooks 1955 through 1961. These figures show chinook occurring from at least 46°N to 62°N latitude and from 175°W longitude (the eastern fishing boundary) to the Kamchatka Peninsula. No differences in distribution by months can be noted, since chinook were to be found in all the areas where the fleet operated in one or more of the years.

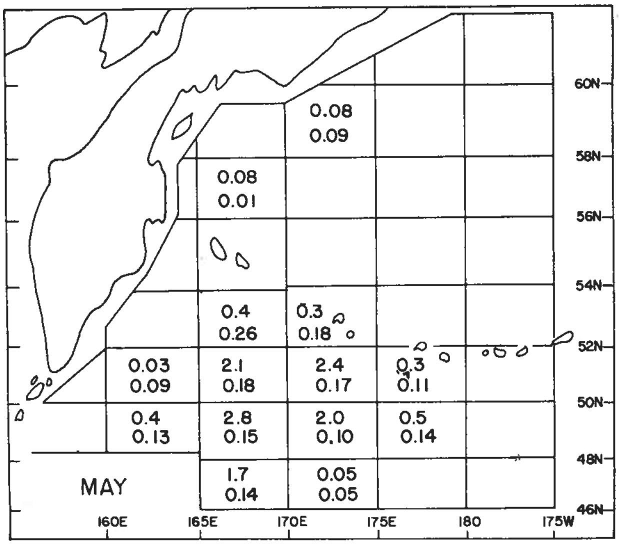

FIGURE 18. Thousands of chinook salmon caught (upper numerals) and catch per 100 tans (lower numeral) in the Japanese mothership fishery, *May*, 1954 through 1961. Data from INPFC Statistical Yearbooks 1954–1961.

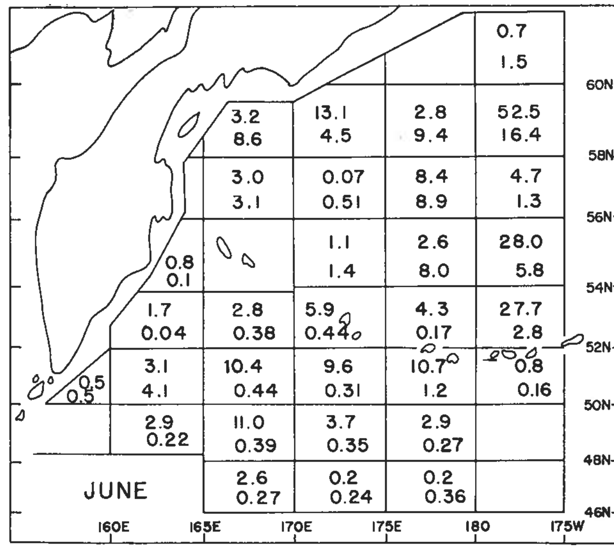

FIGURE 19. Thousands of chinook salmon caught (upper numerals) and catch per 100 tans (lower numeral) in the Japanese mothership fishery, *June*, 1954 through 1961. Data from INPFC Statistical Yearbooks 1954–1961.

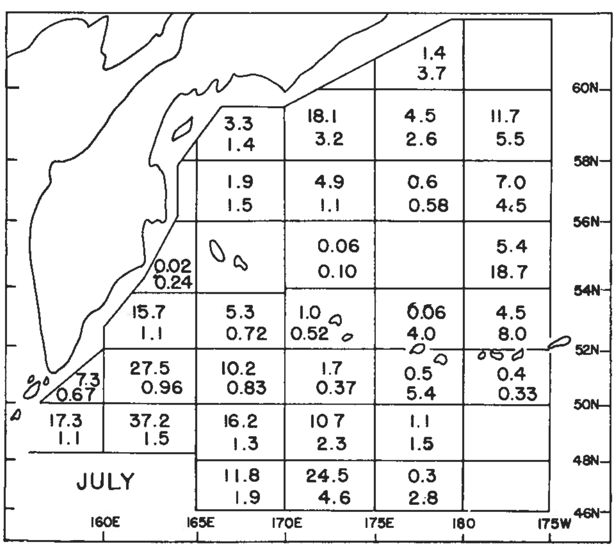

FIGURE 20. Thousands of chinook salmon caught (upper numerals) and catch per 100 tans (lower numeral) in the Japanese mothership fishery, *July*, 1954 through 1961. Data from INPFC Statistical Yearbooks 1954–1961.

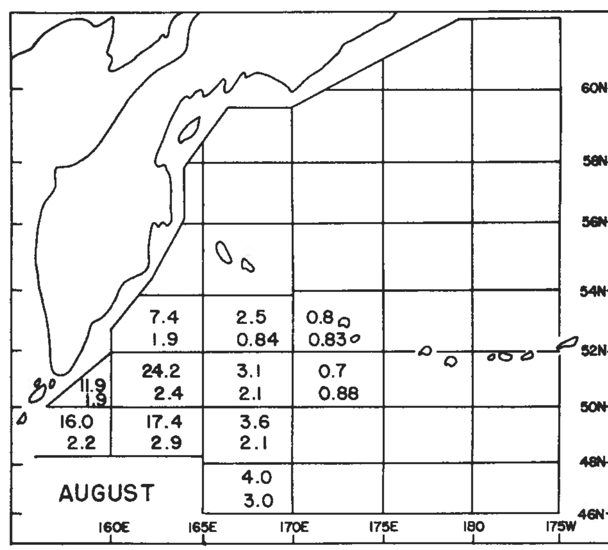

FIGURE 21. Thousands of chinook salmon caught (upper numerals) and catch per 100 tans (lower numeral) in the Japanese mothership fishery, *August*, 1954 through 1961. Data from INPFC Statistical Yearbooks 1954–1961.

The mothership data for the years 1952 and 1953 were also examined for indications that would broaden the knowledge of distribution. No information that would add to the conclusions for the combined years 1954 through 1961 was found.

Bering Sea data for interpretation of abundance in May and August are too few for evaluation, except to note that the area of principal catch was southeast of Kamchatka. The areas of largest catches in June centered around the Aleutian Islands between 175°E and 175°W longitude in the Bering Sea and southeast of Kamchatka (Figure 19). In July (Figure 20), the largest catches were made to the northwest toward

Oliutorski in the Bering Sea. Thus, a shift to the west is indicated in July followed by a further shift in August. In July, the chinook catches southeast of Kamchatka were higher than in all the other months and closer to coastal waters.

Chinook salmon were landed in the Okhotsk Sea in those years when a Japanese mothership fishery existed there. Fishing started in June south and west of the Kamchatka Peninsula, reached a peak in the same area in July, and ended in August.

The principal areas of abundance as shown by the catch per 100 tans were somewhat different from those shown by the catch in each area. In May, they were the same—southeast of Kamchatka (Figure 18). In June (Figure 19), the catch per 100 tans showed a greater abundance near 58°N latitude in the Bering Sea, as compared to the latitude of the Aleutian Islands shown by catches. Both catches and catches per unit of effort showed the center of abundance south of the Aleutians to be southeast of Kamchatka. While July catches in the Bering Sea were highest near Oliutorski, the catches per unit of effort showed that chinook were relatively abundant not only in that area, but also along the eastern fishing boundary. Catches and catches per unit of effort coincide reasonably southeast of Kamchatka.

Age, Sex and Maturity in Offshore Waters

The only data available for age and sex composition studies of chinook salmon are from Manzer *et al.* (MS1963) from samples taken in the Japanese mothership and landbased fisheries in 1960 (Table 10). (Research vessel data had not been tabulated nor collated at the time this manuscript went to press.) It should be recognized that these data are limited. They represent only one year and they concern only the fish caught, since no data are available as to either the effects of gear selectivity or the areas of sampling as related to the distribution of chinook salmon populations.

Ages and Sex Ratios

The age composition changed in all areas during the course of the fishing season (Table 10). Chinook salmon in their fourth year which had gone to sea in their second year (4_2's) were most abundant in the samples, followed by fish in their fifth year which also had left fresh water in their second year (5_2's). The data also indicate that as the season progressed the abundance of 5_2 chinook declined and that of 4_2's increased, 4_2's becoming predominant in the samples. By July and August, the abundance of 5_2's had decreased appreciably from the levels indicated in May and June except in the area west of 170°E where the decrease was not as great and interpretation limited by small samples in August.

In sex identification, 911 chinook salmon were identified as females and 948 as males, an approximately 50–50 ratio. The sex ratio was different, however, by (1) age groups, (2) by time of season within areas and (3) between areas. Excluding the landbased region data because of lack of sex-classified samples in the 5_2 age group, in the 4_2 age group, females comprised about 40 percent of the samples, compared to about 63 percent in the 5_2 age group.

In the east of 170°E-south of 52°N and west of 170°E areas, the percentage of females generally increased as the season progressed, while it decreased slightly in samples in the area east of 170°E-north of 52°N. The several small samples in the landbased fishery do not permit any interpretations of changes in sex ratio within the season. In the landbased fishery, 4_2 age group females were almost 51 percent of the samples, compared with 42 percent for all areas combined.

Average Length

The published research vessel data include length measurements from 33 chinook salmon reported by Powell and Peterson (1957) and a statement by Hartt (1962) to the effect that chinook caught for tagging purposes varied in size from 21 to 84 cm. These data are obviously inadequate for length analysis.

Dr. Hanamura of the Japanese Fisheries Agency supplied the data for Table 11 from the mothership fishery. These data show that females were almost always larger than males in all samples collected during May through August in the four years in which samples were taken. It is also apparent that for both males and females the average length per sample decreased in the period May through August in all years in all areas. The few exceptions were the 1958 samples from the Okhotsk Sea in June through July.

It should be noted in relation to the apparent greater sizes of females and their declining average length in relation to time, that males outnumbered females in May and June (combined year data) in all areas where significant sample sizes were obtained, except in the Bering Sea, where there were a few more females than males. In July and August, males again outnumbered females except in the Aleutian and Bering Sea samples. These data show that while males were generally more abundant in the samples, females were generally larger at any time during the fishing season in most areas. The reasons for these

TABLE 10. Age composition of samples of chinook salmon caught by mothership and landbased fisheries in 1960, with the sex ratio of age 4_2 and age 5_2 fish[1)].

Area	Month	Age								Sample size	No. of 4_2's and 5_2's identified by sex
		3_2	4_2	4_3	5_2	5_3	6_2	6_3	7_3		
East of 170°E, South of 52°N	MAY										
	Percent		15		76		3		6		
	Number		5		26		1		2	34	
	% Male		80		27						11
	% Female		20		73						20
	JUNE										
	Percent		35		54		5	3	3		
	Number		32		49		4	3	3	91	
	% Male		72		49						47
	% Female		28		51						34
	JULY										
	Percent	1	85		9	5		1			
	Number	1	140		14	8		1		164	
	% Male		53		43						80
	% Female		47		57						74
	AUGUST										
	Percent		90		10						
	Number		7							8	
	% Male		57								4
	% Female		43								3
	Total males		105		37						142
	Total females		79		52						131
	% males		57.1		41.6						
	% females		42.9		58.4						
East of 170°E, North of 52°N	JUNE										
	Percent		51		38	6	1	4			
	Number		236		177	28	5	19		465	
	% Male		53		33						183
	% Female		47		67						230
	JULY										
	Percent	4	52		23	16		5			
	Number	2	29		13	9		3		56	
	% Male		55		31						20
	% Female		45		69						22
	AUGUST										
	Percent		74		26						
	Number		14		5					19	
	% Male		57		40						10
	% Female		43		60						9
	Total males		149		64						213
	Total females		130		131						261
	% males		53.4		33.8						
	% females		46.6		67.2						

Continued

TABLE 10. (Continued)

Area	Month	Age 3_2	4_2	4_3	5_2	5_3	6_2	6_3	7_3	Sample size	No. of 4_2's and 5_2's identified by sex
West of 170°E	MAY										
	Percent		23		45	2	13	13	4		
	Number		16		33	1	9	9	3	71	
	% Male		81		49						29
	% Female		19		51						20
	JUNE										
	Percent		38		43	4	6	7	2		
	Number		121		136	13	19	22	6	317	
	% Male		81		41						154
	% Female		19		59						103
	JULY										
	Percent	1	59	1	31	4		4			
	Number	7	398	7	209	27		27		675	
	% Male		59		36						310
	% Female		41		64						297
	AUGUST										
	Percent		89		11						
	Number		8		1					9	
	% Male		38								3
	% Female		62		100						6
	Total males		349		147						496
	Total females		194		231						425
	% males		64.3		38.8						
	% females		35.7		61.2						
Landbased, North of 45°N	JULY										
	Percent		84		11	1		4			
	Number		58		8	1		3		70	
	% Male		45								26
	% Female		55								32
	AUGUST										
	Percent	4	59		30	4		4			
	Number	1	16		8	1		1		27	
	% Male		44								7
	% Female		56								9
	Total males		33								33
	Total females		41								41
	% males		44.6								
	% females		55.4								

Continued

differences cannot be ascertained.

MIGRATION AND VERTICAL MOVEMENT IN OFFSHORE WATERS

While the material presented in Figures 7 through 13 suggests seasonal changes in horizontal distribution of chinook salmon, the deficiencies inherent in these data prevent any quantitative inferences concerning migration of chinook salmon on the high seas.

Powell and Peterson (1957) presented data which indicated that a greater percentage of chinook were caught in the lower two-thirds of a gillnet hanging approximately 20 feet into the water. No other data have been found concerning vertical migrations or distribution on the high seas. There is some information from North American commercial coastal trolling operations that chinook salmon may be further below the surface than coho salmon caught in the same area, but this information does not necessarily

TABLE 10. (Continued)

Area	Month	Age 3_2	4_2	4_3	5_2	5_3	6_2	6_3	7_3	Sample size	No. of 4_2's and 5_2's identified by sex
Landbased, South of 45°N	MAY										
	Percent		50		50						
	Number		6		6					12	
	% Male		33								2
	% Female		67								4
	JUNE										
	Percent		50			41	9				
	Number		11			9	2			22	
	% Male		64								7
	% Female		36								4
	JULY										
	Percent		84		12	3		1			
	Number		100		14	4		1		119	
	% Male		55								55
	% Female		45								45
	Total males		64								64
	Total females		53								53
	% males		54.7								
	% females		45.3								
All areas	Total males		700		248						948
	Total females		497		414						911
			1,197		662						1,859
	Percent males		58.5		37.5						
	Percent females		41.5		62.5						

[1] Data from Manzer *et al.* (MS 1963), Tables 40 and 42, and calculations based thereon.

apply to the offshore waters (Milne, 1955).

No data have been found that would allow any comment on distribution and abundance of chinook as affected by oceanographic conditions.

IDENTIFICATION AND SEPARATION OF STOCKS OR RACES

Only limited effort has been directed toward methods of identifying the continental origin of oceanic chinook salmon. Tagging for this purpose has indicated the probability of some intermingling of immature chinook from both continents (Figure 22). There were seven returns from over 900 chinook tagged west of 155°W longitude by Japanese and United States research vessels in the years 1956 through 1960 (INPFC, 1957–1961). With the exception of one chinook tagged and recovered by Japanese scientists, all were recaptured either one or two years after tagging. An examination of tagging data given in the INPFC Annual Reports (1956 through 1960) showed that about 94 percent of the chinook tagged by United States vessels was estimated to consist of immatures at time of tagging. Data on maturity were not available from the Japanese experiments.

The estimated 94 percent composition of immatures, the delay of one to two years in time of recapture, the apparent direction of migrations from a nearly common tagging point south of Adak and the apparent crossing of migration paths in the Bering Sea are interpreted as being evidences of the intermingling of immature chinook stocks from the two continents. The lack of data for chinook salmon tagged and recovered in the same year prevents any such statement for mature fish.

It is also apparent that the data are too few to allow any comments as to origin within continents. However, the two recoveries from the Yukon and the Columbia River systems indicate that a wide geographical range is quite possible.

DISCUSSION

The data used in this report were collected over nearly a century. They represent programs varying from small isolated pieces of research to coordinated

TABLE 11. Mean lengths of chinook salmon taken in areas fished by the Japanese mothership fishery[1].

			May		June		July		August		
Area	Year	Sex	Cm	No	Cm	No	Cm	No	Cm	No	Total
Aleutian	1957	F	78.3	58	61.7	205	55.2	93	—	—	
		M	70.7	100	59.1	227	54.1	87	—	—	
	1958	F	74.9	78	66.6	133	—	—	61.9	62	
		M	64.9	86	62.7	223	—	—	62.4	39	
	1959	F	82.5	5	67.1	113	60.1	198	—	—	
		M	59.8	13	61.7	186	58.7	167	—	—	
	1960	F	72.5	26	72.3	55	60.3	123	64.5	4	
		M	72.4	18	63.8	72	60.8	130	59.8	6	
	Total	F		167		506		414			1063
		M		217		708		384			1254
Bering Sea	1959	F	—	—	64.4	49	60.6	403	—	—	
		M	—	—	62.8	64	59.4	360	—	—	
	1960	F	—	—	61.5	420	59.9	49	66.1	11	
		M	—	—	59.8	392	58.8	48	62.8	19	
	Total	F				469		452			932
		M				456		408			883
Kamchatka-Kuril	1957	F	71.3	3	65.0	21	62.0	87	—	—	
		M	71.3	18	63	40	61.7	103	—	—	
	1958	F	72.1	168	68.6	848	62.0	1167	61.1	435	
		M	66.7	212	62.7	1200	61.2	1287	60.9	351	
	1959	F	78.1	50	65.8	115	62.6	143	—	—	
		M	64.1	93	61.2	228	61.2	170	—	—	
	1960	F	77.3	54	70.2	197	64.0	609	64.2	13	
		M	69.4	55	65.4	234	62.0	685	64.0	20	
	Total	F		275		1181		2006			3462
		M		378		1702		2245			4325
Okhotsk	1957	F	—	—	99.	1	64.4	14	—	—	
		M	—	—	68.1	27	60.5	46	—	—	
	1958	F	—	—	57.3	23	63.0	21	60.0	2	
		M	—	—	60.7	51	61.2	42	60.0	2	
	Total	F				24		35			59
		M				78		88			166
Landbased, North of J-S Treaty line	1960	F	—	—	—	—	60.1	42	59.9	21	
		M	—	—	—	—	61.8	36	60.7	22	
Landbased, South of J-S Treaty line	1960	F	56.0	5	71.9	13	58.5	61	—	—	
		M	69.1	8	63.5	11	59.9	80	—	—	
	Total	F									142
		M									157
	Total	F									5658
		M									6785

[1] Data supplied by N. Hanamura of the Japanese Fisheries Agency.

programs concurrently pursued by several fishery agencies. In spite of the elapsed time and the discontinuity in certain research efforts, some features are apparent that are pertinent to knowledge of the offshore distribution of chinook salmon.

Coastal tagging has shown that chinook salmon migrate in substantial numbers from the Columbia River, and even from as far south as the Sacramento River, to Alaskan and British Columbian waters. Consistent with this is the fact that the most northerly

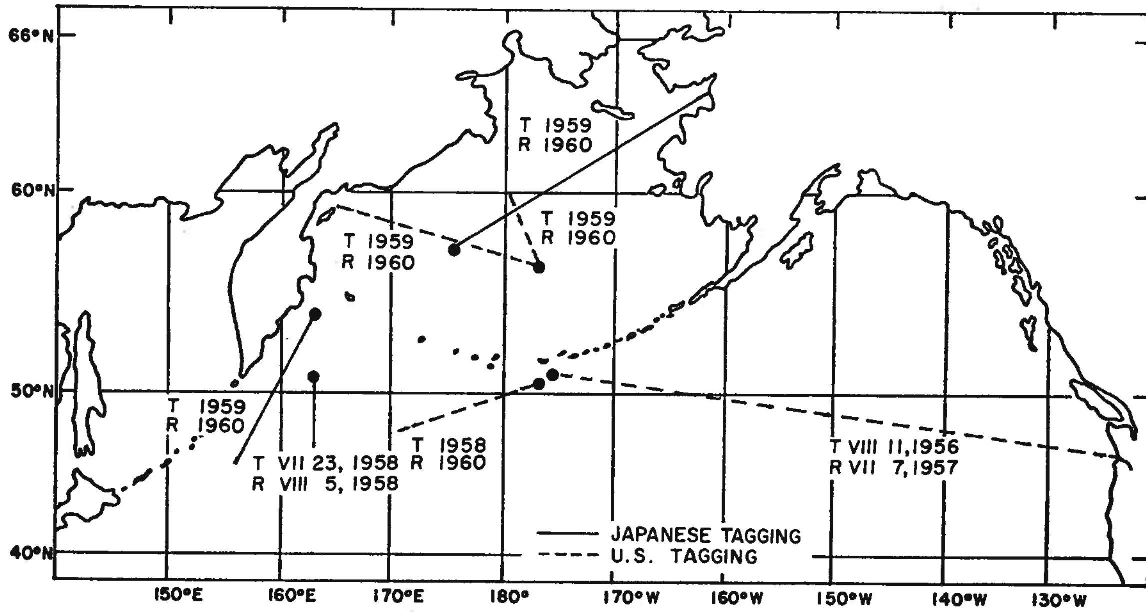

FIGURE 22. Recoveries of chinook salmon from tagging by Japanese and United States research vessels. Data from Godfrey (1961) and Hartt (1962).

recovery of a chinook salmon marked by fin excision was a fish from an early run Columbia River race. A difference in proportion of ocean type scales for chinook salmon leaving fresh water is indicated between southern and northern latitudes as shown from samples from the Taku and Yukon Rivers which were almost exclusively stream type scales, while in the area between the Taku and Sacramento Rivers some 70 to 90 percent were ocean type scales. (No samples were available to show where this change in composition occurred in relation to the geographical distribution of chinook salmon.) These factors suggest the possibility that the early run chinook of the Columbia River and elsewhere, which have a predominance of stream type scales, may mature in waters north (and west) of Cape Spencer. The fact that early run races of Columbia River chinook do reach Aleutian waters was established by the recovery in the Salmon River (an upper Columbia River tributary) of a fish tagged south of Adak as an immature. A possible migration route along the Aleutians for immature chinook salmon was noted from differences in catches between purse seine sets open to the east as compared with sets open to the west as well as an increase in abundance in June and July.

A limited number of scale samples from chinook taken by the Japanese mothership fishery failed to reveal a single instance of an ocean type scale. This may be due to the method of sampling, or even the possibility of a difference in method of interpreting scales. Until such time as additional data are found, present information indicates that any chinook that might be of North American origin and that might be taken in the Japanese mothership fishery would be from the more northern rivers or from early races of the more southern rivers.

It was noted that research vessels caught very few chinook salmon in a band running southeast from the Kenai Peninsula to the Oregon coast. Chinook have been caught both east and west of this band suggesting the possibility of a zone of delineation between populations. This apparent zone might be an artifact resulting from selectivity of the gear, a different vertical distribution of fish in this area, or even from the oceanographic conditions that existed. Still another possibility is that fishing in this band at other times of the year might have resulted in chinook catches. Whatever the reasons for the apparent existence of this band, they are not apparent in the data available.

SUMMARY AND CONCLUSIONS

This report has been based almost entirely on published information which was used without critical review or comment although some of the deficiencies and limitations were noted. The data were comparatively few, collected in widely scattered places and times, and usually collected for other purposes than the objectives of this report. Therefore, the following conclusions are considered as tentative.

(1) Chinook salmon are found in North America from the Monterey Bay area to the Chukchi Sea. On the Asian coast, they occur from the Anadyr River area southward to Hokkaido. The larger populations are usually associated with the larger river systems.

(2) Total North American chinook catches greatly exceed those of Asia. In the period 1954 through 1961, the combined catches by U.S.S.R. and Japan have ranged from 96,000 chinook to 250,000 as compared with 2,456,300 to 3,664,200 chinook for the United States and Canada. Additional numbers were taken in North American sport fisheries.

The overall trend since World War II has been toward increased catches in both North America and Asia. Increased catches in Asia are attributable to additional fishing effort in the Japanese high seas fishery, starting in 1952, and increased Soviet coastal catches. The North American trend since 1946 toward increased catches is the resultant of declining catches in United States fisheries and increasing catches in British Columbia fisheries.

North American chinook catches, mostly from troll fisheries, start early in the spring and are much reduced after August. The specific dates are determined by regulations and characteristics of the populations in particular fishing areas.

Chinook salmon are occasionally taken in the Japanese coastal fisheries in November through January, although most are taken in April, May and June. In the Japanese mothership fishery, they are taken in the months of May through August with the peak usually occurring in July. Chinook catches on the East Kamchatkan coast are higher than those on the west coast and peak in June, although catches occur from May through August.

Since few escapement figures are available on either continent, it cannot be maintained with certainty that the population magnitudes are directly proportional to the catch.

(3) In North America, different river systems may characteristically have from one to several commercially fished runs of chinook, with southern rivers having more runs than northern rivers. Each such run may be composed of one or more races each destined for a particular spawning area. At the present time there are no demonstrated methods of identifying a particular race of chinook salmon prior to its arrival on its spawning grounds.

(4) In North America, chinook salmon migrate to the sea as yolk-sac fry, as fingerlings or yearlings, and sometimes at greater ages. They may pass through brackish water immediately or remain there for an indefinite period of time. Most apparently migrate towards the north, although some may migrate to the south and some may remain in the general area of the stream of their origin.

(5) North American scale samples showed that the age at maturity varies from two to seven years. In more southern waters, chinook salmon mature more commonly in their fourth and fifth years of life and in their fifth to sixth year of life in more northern waters. South of the Taku River, most scale samples were of the ocean type. In the Taku River and the Yukon River, all were of the stream type. Present data do not establish precise geographical areas of transition.

(6) For maturing chinook salmon, various tagging experiments show a positive southward migration in coastal waters off southeastern Alaska and British Columbia.

(7) Data from the Asian coast are either not presented in sufficient detail or are not available to establish the existence of various runs and races or describe variations in size of downstream migrants or the time of their migration. Coastal migrations, marine life history and age at maturity also are not adequately defined for Asian fish.

(8) The data from research vessels of Canada, Japan and the United States, and from the Japanese mothership fishery indicate that chinook may generally be found across the Pacific Ocean from at least 41°N latitude to the Aleutian Chain in the months of June through August. No chinook were caught in this period in a rather broad band running from the Kenai Peninsula southeast to the Oregon coast.

In June, chinook salmon were found in the Bering Sea westward from Bristol Bay to Kamchatka and northward from the Aleutian Islands to 60°N latitude. Greatest concentrations appeared to be in the central Bering Sea area. In July, the concentration apparently shifted to the westward of 180°, followed by a further westward shift in August. There was no September fishing in the area.

In May, chinook were found south of the Aleutians to 42°N latitude in the central North Pacific and to 40°N latitude close to Japan. The area of greatest abundance appeared to be south of the Komandorski Islands and east to 175°E longitude. The apparent abundance in this area increased in June, reached a peak in July and declined in August. At the same time, the zone of greatest abundance apparently moved westward toward the coast of Kamchatka.

The pattern of a westerly movement of immature chinook with increased abundance in June and peak abundance in July was also observed south of and in close proximity to the Aleutian Islands at and west of Adak. This suggests a possible route by which chinook of North American origin might enter areas fished by the Japanese mothership fishery in some years.

(9) Since surface fishing gillnets, selective as to size of chinook caught, were used in both research and commercial operations, any conclusions reached on offshore distribution and abundance may apply only to the sizes of chinook caught in these surface waters and not to the total population which may have been present.

(10) Limited samples taken from the Japanese mothership fisheries in 1960 indicated that 4_2 chinook salmon were most abundant, followed by the 5_2's. All scale samples were of the stream type. The age composition changed with the season, older fish being more common earlier in the season.

While the sexes were evenly divided in the combined samples from the mothership and landbased fisheries, the sex ratio differed by ages, by time within areas and between areas. Males generally outnumbered females and the females were generally larger than the males in samples from the mothership fishery.

(11) No quantitative statements can be made on vertical or horizontal migrations, or on identification and separation of continental stocks, or on the degree of intermingling of mature and immature chinook salmon in offshore waters. However, the data show that migrations and intermingling do occur.

(12) There is an indication from one tag recovery that early run chinook races from the more southern North American rivers occur in waters of the central North Pacific Ocean as immatures.

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