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FOREWORD

These short reports are intended to inform the public, industry, and other interested parties of the current studies of the Commission's staff and the basis for conservation measures. Reports will be published from time to time when studies are sufficiently complete to provide reliable biological evidence for conclusions upon which regulations are based. Research Briefs are free and may be obtained upon request from the Fish Commission office.

Arnie J. Suomela,
Master Fish Warden

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A PRELIMINARY REPORT ON THE COLUMBIA RIVER STURGEON

Introduction

Very little work has been done in the past on the biology of the two species of Columbia River sturgeon. Although these species (white sturgeon *Acipenser transmontanus* and green sturgeon *Acipenser medirostris)* were described many years ago and considered as highly prized food fishes, practically nothing more than their geographic distribution and the maximum size which they attain has been known up to the present time.

Sturgeons represent one of the oldest groups of fishes which were one time dominant on our planet. At the present time less than two dozen species of these "living fossils" are found in the Northern Hemisphere. Some of them are anadromous, others entirely freshwater. All sturgeons spawn in fresh water as far as is known.

Only a comparatively few years ago the sturgeons were very common in North American waters, and they were at that time of little commercial value. However, when caviar and smoked sturgeon became popular, the prices of these products rose rapidly, and about 30 or 40 years ago fishermen found that sturgeon fishing was profitable. As a result they were overfished and in many places almost exterminated. Certain species, as for example *Acipenser sturio,* formerly very abundant and widely distributed in Europe and along the Atlantic Coast of North America, are almost extinct now; and there is little hope that the populations of these valuable species can ever be restored.

The decrease in the sturgeon industry, while general throughout the world, is particularly marked in Central Europe and North America. This decrease is due largely to the extensive fishing coupled with the slow growth of the fish, which does not permit replacement rapid enough to keep pace with the annual catch. The American freshwater sturgeon *(Acipenser fulvescens)* which only 50 years ago was extremely common in the Great Lakes and in Lake Winnipeg is considered now a rare fish. Its annual catches in Lake Michigan dropped from nearly 4,000,000 pounds in 1880 to almost nil in 1920. The following graph (Fig. 1) shows the tremendous declines in the catch of three species of American sturgeon during the last few decades. This decline is indeed more rapid than in any other species of commercial fish. The data for Atlantic sturgeon were compiled from Hildebrand and Schroeder (1928), and for lake sturgeon from Bajkov and Neave (1930). Considerable catches of sturgeon are still made in the Caspian Sea and in Siberian rivers. With the exception of one species of small sturgeon found in Russia, all female representatives of this group reach maturity at an age of between 15 and 20 years. The males become ripe somewhat younger than females. The females as a rule grow more rapidly and attain larger size than males. This is more apparent in older fish.

Breeding in some sturgeons does not take place every year, as indicated by the fact that large females often show very small, unripe eggs during the regular spawning season. According to studies made elsewhere, the intervals between the spawnings in a large fish can be three, four, or even more years; and the fecundity (number of eggs) increases tremendously with the age of the fish. The following data obtained from studies of the

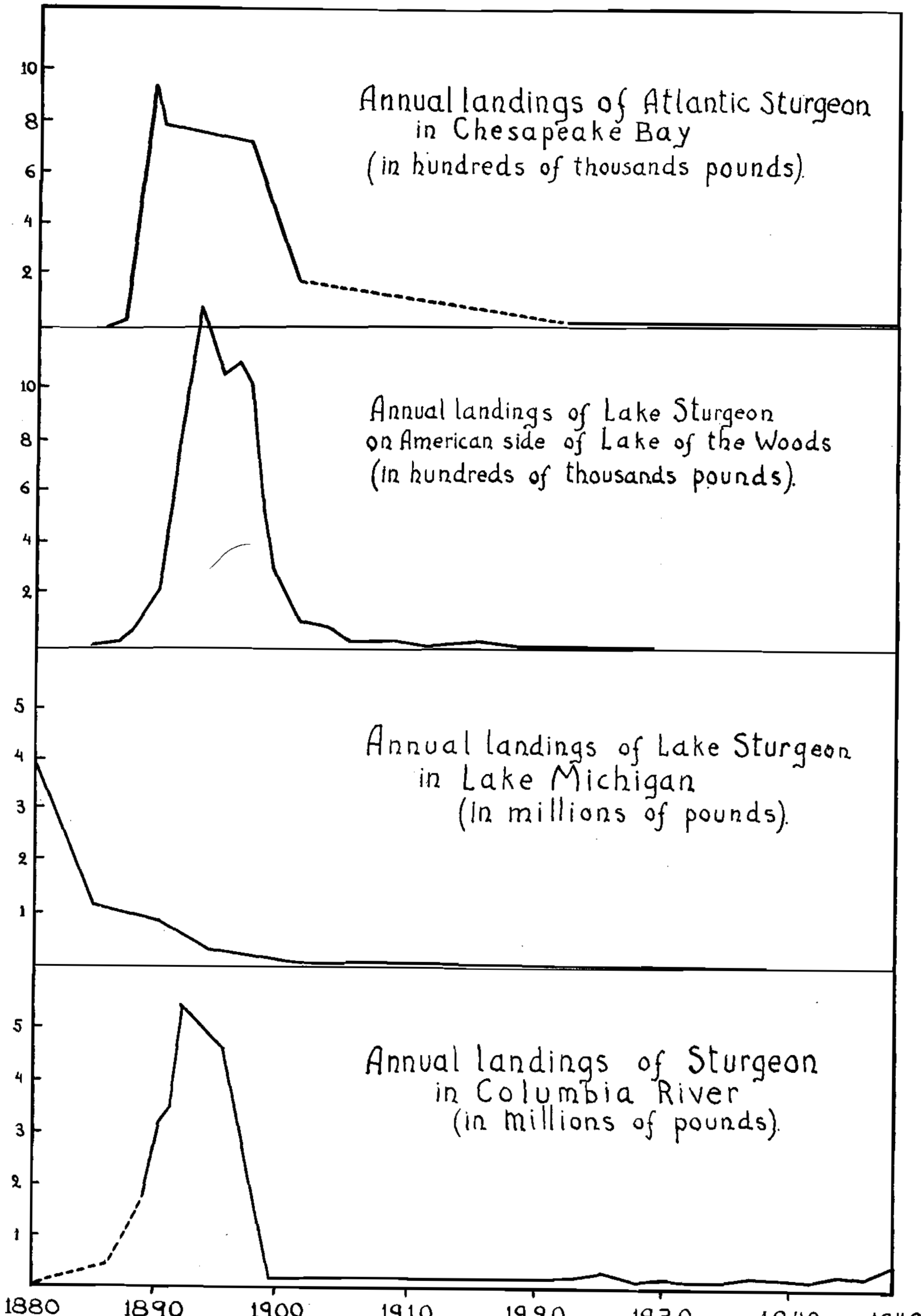


Figure 1. THE ANNUAL CATCH OF THREE SPECIES OF STURGEON IN SEVERAL PARTS OF THE UNITED STATES DURING THE LAST FEW DECADES.

large Amur River sturgeon of Siberia—the rates of growth of which are somewhat comparable with the Columbia River white sturgeon—can be used as an illustration of fecundity of this fish:

Age	*Number of Eggs*
25	665,000
40	1,978,000
50	4,100,000

The spawning time of most sturgeons has been found to occur during the spring and the beginning of summer (May-June). The ripe sturgeon eggs are dark gray in color and slightly larger than one-tenth of an inch in diameter. They are heavier than water and immediately after fertilization become adhesive and attach to gravel, stones, submerged logs, and vegetation. The eggs hatch in about one or two weeks depending on the temperature of water and the fry frequent shallow bays where the current is not too swift. They grow rapidly during the first month to the average size of about 1.5 inches, feeding mostly on small insect larvae, minute crustaceans, and mollusks. The adult sturgeon also feed on mollusks, insect larvae, crustaceans, and fishes.

Slow growing and seldom spawning before the age of 15 years, according to studies elsewhere, the sturgeon have to be rigidly protected if extinction is to be prevented. It is obvious, therefore, that the means of maintaining the industry in a healthy condition lies not only in the protection of the young fish but also in the preservation of the remaining large individuals. Judging from the data that have been obtained to date, it seems that one effective method of preserving the breeding stock, depending upon the extent of migrations, is to create special reserves in suitable localities in which sturgeon fishing is permanently prohibited in order that the fish may have the opportunity of producing the maximum number of eggs. Such reserves should include not only spawning grounds in the rivers but also areas where the fish spend the greater part of their lives. Fortunately enough some closed areas are already established in the upper Columbia and Snake Rivers and also in the vicinity of Bonneville Dam.

The artificial propagation of sturgeon, which has proven feasible in other countries, may also give satisfactory results in the Columbia River.

The releasing of large mature individuals by both commercial and sport fishermen is highly desirable, and in a long run would be beneficial to all parties concerned. In that particular case, a full grown female sturgeon can be well compared with the hen which laid golden eggs.

The white sturgeon of the Columbia River is the largest representative of the genus *Acipenser*, and only two other sturgeons belonging to another genus (the Amur River *Huso daricus* and Caspian *Huso huso*, which attain the weight of 2,500 lb. and 3,500 lb. respectively) are larger. Individuals of white sturgeon weighing up to 1,800 lb. have been reported in the Fraser River. As a matter of fact, the species in question are the largest freshwater fishes found in the Northern Hemisphere. Fortunately the rate of growth of white sturgeon in general seems to be more rapid than some other species of *Acipenser*.

As far as the potential supply, population, and the annual catch of white sturgeon in the Northwest are concerned, it would be no exaggeration to say that they exceed that of the three other American sturgeons combined.

But at the same time, as in Lake Winnipeg and in the Great Lakes, the commercial catch of sturgeon in the Columbia River consists mostly of immature fish. The ripe females are caught only on rare occasions which indicates their absence from the fishing grounds. Of course the fact that the adult fish may not spawn every year must be also taken into consideration. Nevertheless, Mr. Ed Sibasky, who has fished sturgeon at Cooks, Washington for the last 20 years, reports that he has seen only one fish with ripe eggs in all this time. Another sturgeon fisherman at The Dalles, Oregon, who recently caught a 434-pound sturgeon, stated he had caught only one other fish of that size, and that one ten years ago. This specimen was a female with newly forming eggs in which a few ripe unspawned eggs from the previous spawning were still present. According to the information obtained at Seufert's Cannery near Celilo Falls, large female sturgeon with ripe eggs were not rare in that part of Columbia River 30 years ago. Now they are extremely rare. Such a statement is good evidence that the large part of the breeding stock of sturgeon is fished out from that portion of the Columbia River.

In 1880, when the sturgeon fishery was in its infancy, this fish was extremely abundant in the Columbia River (Craig & Hacker, 1940). The prices were between one and two cents per pound for dressed fish and five cents per pound for caviar. At that time and shortly thereafter, tremendous numbers of large and small sturgeon were destroyed by the fishermen because the fish had no commercial value and were detrimental to the fishermen's salmon nets. When frozen sturgeon was introduced in the eastern markets in 1889, there were neither size limits nor other fishing regulations for that species. The peak of production was reached in 1892 when about six million pounds of sturgeon were landed by the fishermen. About ten years after the intensive fishery started, the annual catch declined rapidly and was for a few years in the vicinity of 100,000 pounds. During those years sturgeon were fished throughout the Columbia and Snake Rivers. The fish ranged from 100 to 500 pounds, and the average weight was 150 pounds. However, the large individuals were soon fished out and the average weight dropped to 50 pounds. At the present time the average weight of sturgeon caught in Columbia River is much smaller.

For a number of years the general opinion has been that the white sturgeon is an anadromous fish to the extent that it migrates to and from the ocean. Evidently this may be false because it seems that many large sturgeons stay in the upper Columbia and Snake Rivers during their entire life and never go to sea. However, it is very common to find white sturgeon in brackish water.

The green sturgeon on the other hand must be considered an anadromous species which occurs in brackish water and never goes far up the rivers. It is much smaller, having a maximum weight of not much more than 350 pounds. It is of smaller abundance and of lesser commercial value than the white sturgeon.

Tagging of Sturgeon

In order to find data concerning the migration and rates of growth of Columbia River sturgeon a number of specimens were tagged under the joint Columbia River program of the Washington Department of Fisheries and the Oregon Fish Commission. Some of these fish were tagged by Mr. Ivan Donaldson and other biologists at Bonneville Dam, who are cooperating with the two state agencies. The majority of the tagged fish were small, and, as only very few tagged fish were recaptured, it is premature to draw any conclusions regarding the migration of the sturgeon at the present time. It must be mentioned, however, that one 42-inch white sturgeon which was tagged in the Columbia River about 20 miles above the mouth on the 20th of April, 1949, was recaptured 12 days later near St. Helens, Oregon. The fish migrated upstream nearly 50 miles, averaging slightly more than four miles per day. A green sturgeon tagged in about the same locality was taken in the Coquille River after migrating out to sea and south along the Oregon Coast for about 200 miles.

It is planned to tag greater numbers in the near future. The tags used for sturgeon are the conventional Peterson type, consisting of two circular colored plastic discs and attached by means of a rustproof nickel pin inserted through the flesh below the dorsal fin. These tags were tried on sturgeon at a Bonneville hatchery pond and have remained on many for over two years.

The following table shows the number of sturgeon tagged in the Columbia River in the last three years.

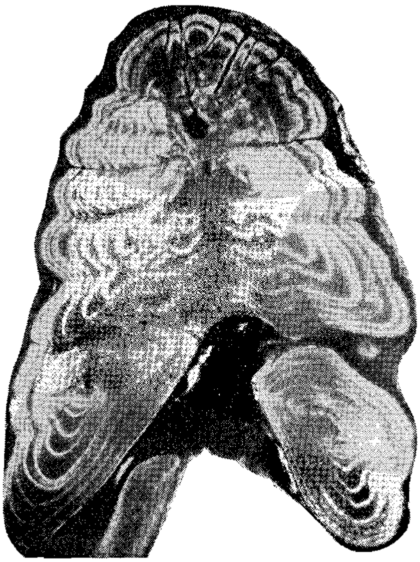
1947	143
1948	159
1949	800
Total	1,102

A number of fishermen have cooperated in the tagging program by supplying undersized fish for marking at no expense to the Fish Commission. Among them are Tracy and John Broughton, Gene Kilker, Edward Sibasky, and others.

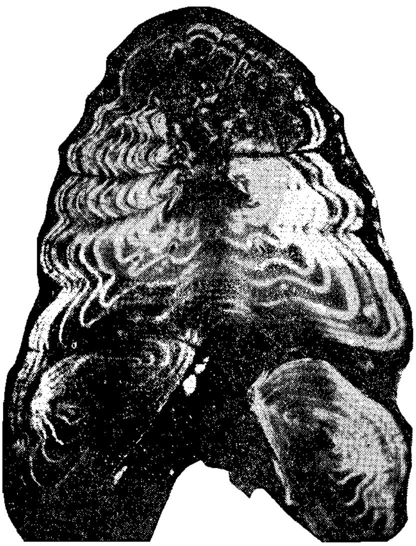
The Rates of Growth of Sturgeon

Perhaps the most important part of the scientific management study of fisheries is the determination of the age and rate of growth of fishes. The common methods applied for this purpose are reading the scales and bones. The sturgeons have no scales and the few bones which they possess are not always suitable for age determination. Even the otoliths, or earbones, which are so valuable for age reading in many species of fish, cannot in some sturgeons—especially the old ones—be used for this purpose because of their crystallized structure. However, it has been found that the bony fin rays of sturgeons, particularly those of the pectoral fins, appear to be very suitable for the determination of their age. The formation of rings of growth in some of the fin rays of sturgeon is very distinct. This has been proved in Russia on fish of known age hatched artificially and kept in captivity for at least ten years. (Chugunov, 1925). The great advantage of this method is that the very small portion of the first bony ray of the pectoral fin can be easily excised from the sturgeon when it is caught by commercial or sport fishermen. Furthermore, live specimens when tagged and released appear to withstand removal of the fin ray without any apparent damage. This makes the method very valuable because in case of recapture the growth of the same fish may be rechecked.

When a thin transverse section of the bony ray is cut out by the means of an ordinary fret-saw (jeweler's saw) and polished with sandpaper, the annual rings are usually plainly seen under the microscope. It has been recently found in this laboratory that the use of polarized light gives amazing results as far as the clearness and definition of the rings are concerned (Figure 2). It is not necessary to use an expensive polarizing microscope, for it is sufficient only to place the thin section of the fin between two ordinary polaroid filters or sheets of polaroid plastic. The preparation of permanent micro-slides to which thin fin sections (about 0.5 mm. thick) are fastened to the glass by means of transparent waterproof cement takes only a few minutes.



Photomicrograph of the section of first bony ray of sturgeon pectoral fin (20X). This specimen was 41 inches in length, (fork length), and weighed 19.5 lb. It shows 11 annual rings on the section.



The same taken with polarized light.

Several dozens of such slides were prepared by Mr. D. L. McKernan some time ago and his collection is being used as a nucleus for the expansion of this work at the present time. Approximately 2,000 samples of sturgeon fins have been collected from the fishermen during the past two years and many were provided by Mr. Ivan Donaldson, biologist at Bonneville Dam. Unfortunately more than half of these specimens were collected from fish of unknown sex. However, even these unsexed specimens represent valuable material which can be used for construction of a general growth curve, length frequency, length-weight relationship, etc.

Food of Sturgeon

The examination of a few digestive tracts of sturgeon from Columbia River proper indicates that the fish during the summer months feed chiefly on small mollusks, both clams and snails, which live on the bottom. The remains of aquatic insect larvae also have been observed in sturgeon stomachs.

It is planned to examine carefully the contents of every available sturgeon stomach and to prepare the complete list of organisms upon which the various age groups of sturgeon prey in order to help explain their presence or absence from a locality and the migration of the species. Apparently, as in the case of all fishes, sturgeon food must vary with the seasons and localities.

Sturgeon Investigation Program

A detailed program on sturgeon investigation is proposed which includes the statistical, biological, hydrological, and artificial propagation aspects. Considerable attention will be paid to the spawning migration of sturgeon, location and character of spawning grounds, duration of the spawning season, percentage of males and females, frequency of spawning, maturity and the age of spawning fish, number of eggs and fertility of sturgeon, development of eggs under natural conditions, and the mortality and predators of sturgeon eggs and fry. The rates of growth in both male and female fish will also be studied in fresh as well as in salt water. The study of food habits of all sizes of sturgeon in different seasons and localities, as well as the quantitative and qualitative determination of the potential supply of sturgeon food is also included in the program. The estimation of the sturgeon population, the present age groups, the enemies, diseases, parasites, and food competitors of the sturgeon will be also studied. Particular attention will be paid to the artificial propagation of the sturgeon and rearing and feeding of sturgeon fry. Experimental planting of sturgeon fry into waters where the species does not occur at the present is also proposed.

Hydrological conditions of sturgeon habitats, such as temperatures, dissolved oxygen, pH, chemistry of water, etc., as well as the influence of the man-made obstructions and industrial pollutions will be studied.

Maintaining and rebuilding the sturgeon fishery on the Columbia River is an exceedingly difficult and complex problem. On the one hand, every fisherman is anxious to catch the large fish, which are the potential breeding stock and—unlike salmon which move rapidly through the fishery—appear to be available for capture during the entire commercial fishing period. On the other hand, sturgeon constitute a real nuisance to hundreds of gillnetters whose major consideration is the salmon fishery. Thousands of immature sturgeon are taken annually which must be laboriously removed from the nets before release. It is quite possible that an individual young sturgeon may be taken dozens of times before it is large enough to be kept by commercial fishermen.

In recent years a significant sport fishery for sturgeon has developed. Sport anglers are not restricted as to minimum size of the fish they take, so a "double standard" exists on sturgeon. While a fish under 48 inches in total length may not be retained by a commercial fisherman, a sport angler may keep fish of any size.

The effect of dams has not yet been assessed. While sturgeon fishing may improve in an area after construction of a dam, this does not necessarily mean the stocks throughout the river have been improved as a result of such construction.

The many facets of the sturgeon question serve to complicate a problem already made difficult by the nature of the species involved.

Summary

1. During the last few decades the population of sturgeon in the Columbia River has greatly decreased and this decrease has been more rapid than in any other species of commercial fish.

2. Seldom spawning before the age of 15 years, the sturgeon have to be more rigidly protected than other commercial fishes, and this is particularly true as far as the *old* breeding females are concerned. Fecundity is known to increase markedly with age.

3. White sturgeon in the Columbia River must be considered a comparatively fast growing species, the rates of growth of which may be more rapid than in other members of the genus *Acipenser*. The largest female sturgeon examined was a 500-pound fish, which measured 9 feet 6 inches in length and appeared to be over forty years old.

4. The rates of growth of white sturgeon may be somewhat slower than that of two species belonging to another genus, which enter the Volga and Amur Rivers of Russia.

5. The female white sturgeon seems to grow slightly faster than the male; the difference between their rates of growth appears to be more significant in older fish.

6. The best method of age determination of sturgeon seems to be by means of a cross section of the first bony ray of the pectoral fin.

7. The sturgeon is a bottom feeder, and its food consists mostly of small mollusks, insect larvae, and crustaceans. The larger individuals frequently feed on fish.

8. A detailed program of sturgeon investigation has been outlined, which includes biology, migration, and the artificial propagation of the sturgeon.

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TILLAMOOK BAY SPRING CHINOOK SALMON

Introduction

Tillamook Bay is located approximately 50 miles south of the Columbia River. It is fed by five rivers which have their sources in the Coast Range (Fig. 1). The two largest rivers, the Trask and Wilson, both roughly 30 miles in length, support small runs of spring chinook salmon, *Oncorhynchus tshawytscha.* Since the spring chinook salmon spend the entire summer of their last year of life in fresh water without feeding, it is necessary for them to store considerable quantities of fats and oils in their flesh to tide them over this fasting period. Not only must enough material be stored to supply the energy needed for the normal activities of life, but also the tremendous quantity of materials needed for the development of the maturing sexual products. For this reason the spring chinook is rightfully considered by many as the finest of the salmon.

Some controversy exists as to whether these runs have been introduced or whether they occur naturally in these rivers. Some of the early settlers

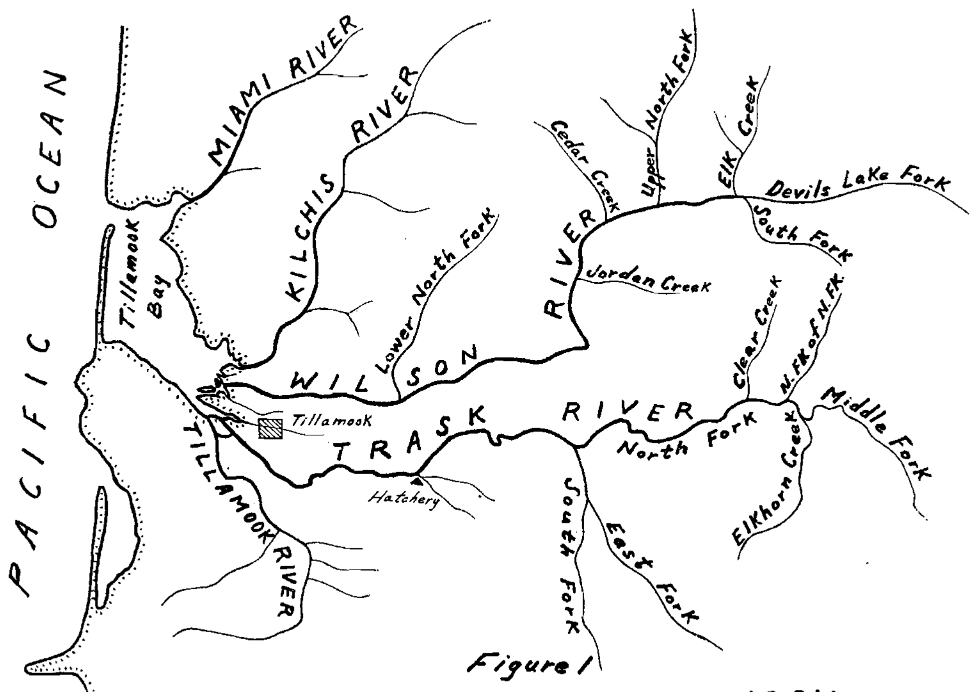

Figure 1

SKETCH MAP OF TILLAMOOK BAY TRIBUTARIES

One Inch = Approx. 4 Miles

and natives maintain that the spring chinook salmon were introduced in the early 1900's. From reports of others it appears that spring chinook were observed in these rivers at least as early as the 1890's. The general belief has been that the spring run of chinook salmon are indigenous only to the larger rivers fed by the glaciers of the Cascade Range.

Most of the Trask River run has been maintained by a hatchery located about eight miles above the bay on the Trask River. The Wilson River run is at present maintained through natural propagation, no plantings of artificially reared fish having been made since the 1940 brood year. The present studies were inaugurated in the summer of 1947.

Artificial Propagation

Two racks are placed across the Trask River annually to block the ascent of the adult spring chinook salmon in the spring of the year. The racks are placed about 250 yards apart, blocking off a section of deep slow-moving water. A small opening in the lower rack allows fish to migrate into the holding areas, while the upper rack is constructed to prevent further upstream passage of salmon. The fish ascend the river in April, May, and June, spend the summer in the deep quiet water of the holding area, and are spawned about the middle of September. The eggs hatch during the middle of November; the young fish begin to feed about the first of January, and are released in the headwaters of the Trask River in the late spring at a length of from two to four inches. Since 1945, 25,000 to 100,000 young fish have been fed at the hatchery until the second spring of their life and released at a size of four to eight inches. Prior to World War II, from 50,000 to 425,000 were planted annually in the Wilson River and small numbers in the other Tillamook Bay tributaries and nearby rivers.

Figure 2 shows the egg take and fingerling release of spring chinook salmon at the Trask Hatchery from 1923 to 1949. In earlier years additional eggs were received from other stations thus accounting for the fingerling releases being greater than the egg take in some years. The egg takes are not a reliable measure of abundance since the racks have been installed at varying dates throughout the years with unknown escapements prior to that time. Also in many years the spring freshets raise the water level above the racks, allowing fish to ascend the river.

Improved hatchery techniques are being applied under the direction of Mr. Henry Bolle, the superintendent at the Trask River station. The young fish are being held to a larger size before liberation, improvements are being made in the diet, and improved methods of distributing the young fish are being carried out. In 1949 the racks were not installed until the first of June. This allowed considerable escapement of salmon to the upper reaches of the Trask River to spawn naturally, eliminating the danger of having "all the eggs in one basket".

Sport Fishery

Angling for spring chinook salmon has been quite popular in two areas. In the spring of the year when the fish first enter the bay, they are fished in the upper end of the bay in the vicinity of the mouths of the Trask and Tillamook Rivers. The method employed here consists of trolling with

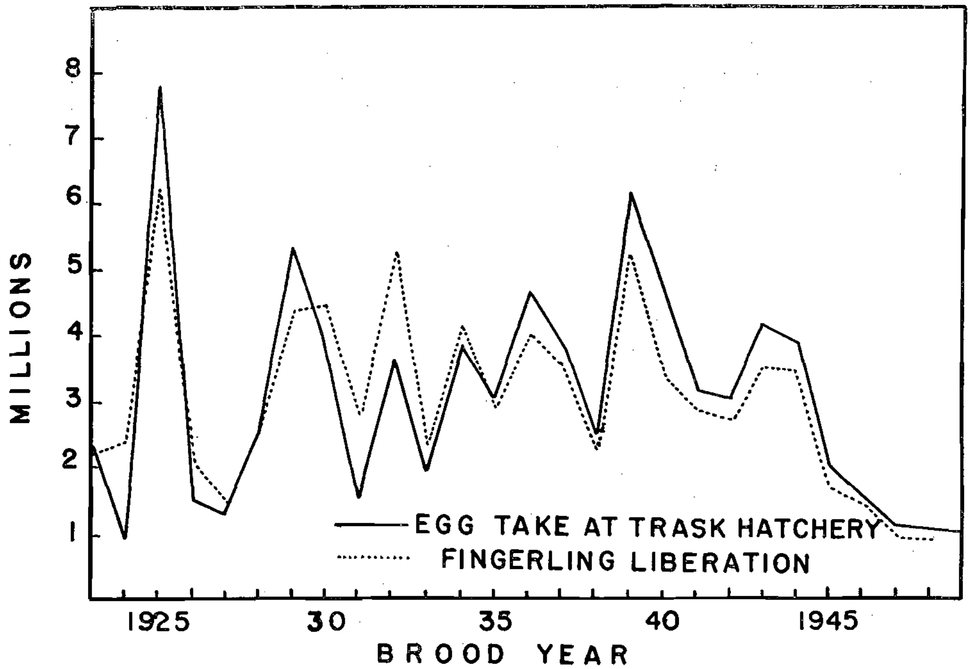

Figure 2. EGG TAKES AND FINGERLING RELEASES, PLOTTED ACCORDING TO BROOD YEAR, OF TRASK RIVER SPRING CHINOOK SALMON, 1923 TO 1949.

a skiff and outboard motor, using a spinner and red-feathered hook as a lure. This fishery takes place during the entire month of May and early June and is probably supported entirely by the Trask River run.

The other area, which is in the vicinity of Jordan Creek on the upper Wilson River, has been closed to angling for the past two years. The salmon rest in the deep pools in this area throughout the summer months. Here they were fished from the bank, using a spinner and red-feathered hook, cluster eggs (salmon eggs), or crayfish tails for bait. Stomach examinations of these fish revealed that they were not actively feeding, although they did strike at these lures, and even appeared to have certain preferences.

Table 1 gives the sport take of spring chinook salmon for 1947, 1948, and 1949. The estimates for the bay fishery are based on records kept by one of the three moorages renting boats for this fishery. The take of the bank fishermen is based on interviews with anglers, fishing camp operators, and State Police Officers assigned to fish and game law enforcement. Twenty-seven fish taken in the bay fishery in 1948 and 1949 ranged in size from 8 to 25 pounds, averaging 15.5 pounds.

TABLE 1

ESTIMATED SPORT CATCH OF SPRING CHINOOK SALMON IN TILLAMOOK BAY AND TRIBUTARIES, IN NUMBERS OF FISH

Year	Bay Fishery	Bank Fishery	Total
1947	No record	300	300+
1948	100	Closed	100
1949	120	Closed	120

Commercial Fishery

Since 1947 the commercial fishing season for spring chinook salmon has been closed. The landings for the period of 1923 to 1947 are shown in Figure 3. The totals given for each year represent the landings of chinook salmon for the months of May and June, although the fishermen consider the spring chinook run to be over about the middle of June.

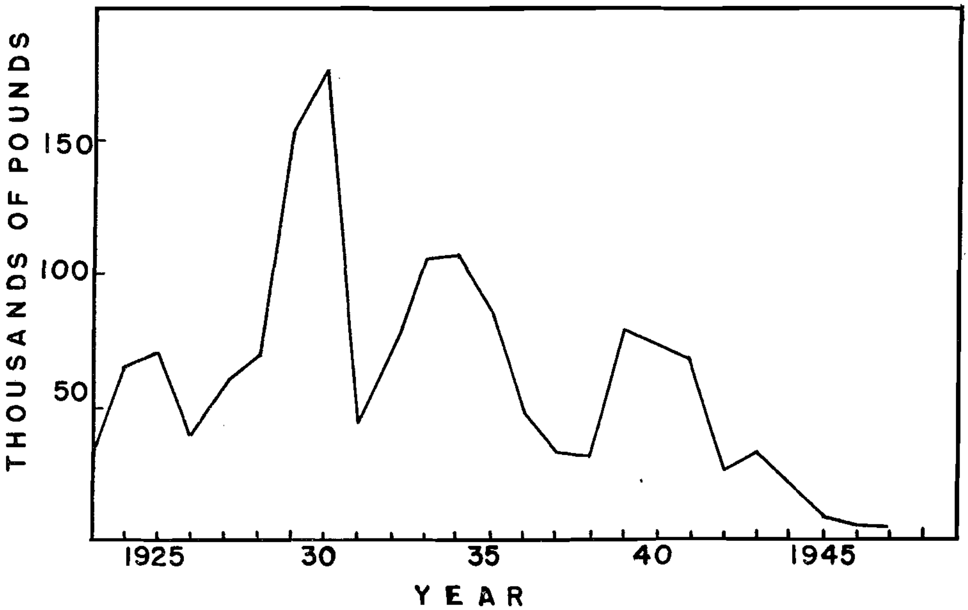

Figure 3. COMMERCIAL CATCHES OF SPRING CHINOOK SALMON IN TILLAMOOK BAY, 1923 TO 1947.

This species was fished by means of drift gill nets of 8¼ to 9 inch mesh (stretched measurement). The average weight of the fish has been determined from the records of the buyers, the numbers of fish as well as the poundage being recorded for much of the catch. Sizeable samples during the period of 1929 to 1947, give an over-all weight of 21.6 pounds, varying from 19.7 to 23.6 pounds for the individual years.

Escapement to Spawning Grounds

The Wilson River has been selected for study of natural propagation since it is most readily accessible and since a considerable portion of the Trask River run is spawned artificially. Starting in 1947 and continuing in 1948 and 1949 surveys were conducted on the Wilson River to determine the numbers of fish utilizing the spawning grounds. Some observations and counts of fish have been made in the deep pools in the vicinity of Jordan Creek where the fish lie quietly throughout the summer. However, it is felt that a more reliable count can be obtained through surveys of the shallow riffle areas where spawning takes places in the fall.

Most of the fish spawn in the Wilson River from Cedar Creek upstream to the confluence of the Devil's Lake Fork and the South Fork, the lower 1.3 miles of the Devil's Lake Fork, and the lower 2.5 miles of the Upper

North Fork (Fig. 1). The most important riffles are on the Wilson River in the vicinity of the mouth of the Upper North Fork. Table 2 gives the counts of fish found in the major spawning areas at the height of spawning activity in 1947, 1948, and 1949.

TABLE 2

COUNTS OF SPAWNING SPRING CHINOOK SALMON ON THE WILSON RIVER

Area	Distance in Miles	Numbers of Fish 1947	1948	1949
Wilson River from Cedar Creek to South Fork	6.0	11	18	31
Devil's Lake Fork	1.3	9	1	....
Upper North Fork	2.5	1	6	0
Totals	9.8	21	25	31

The fish do not move from the resting pools onto the riffles for spawning until the arrival of the fall freshets and lower water temperatures. Due to the late arrival of rains in 1949, the spawning time was considerably later than usual. Table 3 gives the dates of spawning ground surveys and water temperatures at time of spawning in 1947, 1948, and 1949. The temperature of the surface water in the resting pools reaches a maximum of about 65°F. in the summer.

TABLE 3

DATE OF SPAWNING GROUND SURVEYS FOR WILSON RIVER CHINOOK AND WATER TEMPERATURES

Year	Date of Survey	Water Temperature
1947	Sept. 12-13	54°F.
1948	Sept. 24-25	54°F.
1949	Oct. 7-8	49°F.

The total count of 31 fish on the spawning grounds in 1949 is somewhat low due to several factors. Some fish had spawned in the Upper North Fork prior to the survey date, their newly dug redds being readily observed. The water was discolored and observation limited. The fish on one of the important riffles of the main Wilson River had been disturbed just prior to the arrival of the surveyor. The 1949 count has thereby been somewhat minimized as compared with the 1947 and 1948 counts.

It was determined on the North Umpqua River (joint studies of the Oregon Fish and Game Commissions) that approximately 14 percent of the spring chinook salmon known to be in the area were observed by the spawning ground surveyors. The actual number present had been determined by counting the fish as they passed over the fish ladder at Winchester Dam. On this basis, the total escapement in the Wilson River has been determined to be approximately 150 fish in 1947, 180 fish in 1948, and 220 fish in 1949. These figures are probably high since the Wilson River is smaller than the North Umpqua River and a larger percentage of the population has probably been observed. However, in a study of this type, the important consideration is the relative numbers of fish. By following the trends of the spawning ground counts through a period of several years it will be possible to evaluate the management program now in effect.

In 1949 a survey was made of a 2.5 mile section of the North Fork of the Trask River to determine whether any fish had passed upstream before the racks were installed at the hatchery. The area surveyed extended from the mouth of Clear Creek upstream to the mouth of the North Fork of the North Fork and included the lower mile of Elkhorn Creek. In this distance a total of 12 fish were observed spawning on September 20, at which time the water temperature was 59°F. A report was received of a number of salmon on the South Fork of the Trask River on October 1. These would necessarily have been spring chinook salmon since the racks at the Trask Hatchery were still in place on this date and had been intact since early June.

Regulations for Protection

Due to the decline in the size of the runs as evidenced from the commercial fishery landings and the scarcity of fish on the spawning grounds, it was recommended to the Oregon Game Commission that both the Wilson and Trask Rivers be closed to salmon angling during the summer months. Regulations to this effect were established in 1948, closing these rivers to salmon angling above tidewater from May 1 to September 15 and in 1949 from May 1 to October 1.

The Oregon Fish Commission in 1948 delayed the opening date of the commercial gill-net fishery from May 15 to August 15, thus allowing the spring chinook salmon to pass through Tillamook Bay unmolested by the commercial fishery. This regulation was continued in effect in 1949.

Discussion

The short rivers of the Coastal Range cannot produce the large numbers of spring chinook salmon which are found in the more favorable habitat of the large rivers having their headwaters in the Cascade Range. However, it is evident from the past statistics of the commercial fishery that these rivers are capable of producing runs many times the size of those of recent years.

The present studies indicate that the escapement of fish to the spawning grounds of the Wilson River was about equal in 1947 and 1948 and somewhat greater in 1949. By following the trends of the spawning ground counts over a period of years it will be possible to evaluate the management program. Briefly, this program includes (1) improved hatchery techniques, (2) stream improvement work, and (3) restriction of both the sport and commercial fisheries, with the objective of building up the runs to the magnitude of earlier years.

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THE PILCHARD SITUATION IN OREGON

The drastic failure of pilchards, or sardines, to appear in the Northwest in great abundance in the past few years jeopardizes a new but well established industry in Oregon. The large outlay in plants and equipment, ill-suited for small scale reduction of other fish offal and scrap fish, may be lost, for these large plants can ill afford to remain idle waiting for a "big" pilchard year. Thus, it has been of importance to determine the probable causes of decline of this once abundant species in order to inform the industry as to whether a constant supply can be counted on in future years.

In 1947 the Fish Commission of Oregon, after a lapse of several years because of the war, again took part in the cooperative study of the pilchards *(Sardinops caerulea)* being conducted by the Pacific Coast fishery research agencies and the Fish and Wildlife Service. A brief review of the Oregon fishery with an analysis of the data collected during the 1947 season has been presented in the Fish Commission Research Briefs (Harry, 1948).

As in previous seasons, in 1948 the tons per landing and the area of catch were recorded for each boat. Whenever possible a random sample of 50 fish was measured and sexed from each landing. The fish were measured on a measuring board to the nearest millimeter from the tip of the snout to the end of the silvery area exposed at the base of the tail when the scales are removed. The average weight of the 50 fish was taken and scales were obtained from ten of the fish. The methods used in sampling were the same as those used by the California Division of Fish and Game and the Fish and Wildlife Service.

In order to show how the average lengths in 1948 differed from the average lengths in 1947, Table 1 has been constructed. The two seasons have been divided into roughly similar consecutive time periods and the average lengths of both males and females determined for each period. The average lengths of the pilchards for both sexes and in all time periods were greater in 1948 than in 1947. However, even in 1947 the fish were extremely large.

TABLE 1

AVERAGE LENGTH OF OREGON PILCHARD BY TIME PERIODS

1947	Avg. Length Males Millimeters	Avg. Length Females Millimeters	1948	Avg. Length Males Millimeters	Avg. Length Females Millimeters
July 14-29	246.4	248.4	July 16-30	255.7	259.4
July 30-Aug. 13	248.0	252.9	July 31-Aug. 11	258.1	259.6
Aug. 14-21	251.5	255.3	Aug. 12-Sep. 2	252.4	258.4
Aug. 22-Sep. 24	249.7	254.5			

There has been a considerable change in the length-frequency composition of the Oregon landings in the last few years. The magnitude of this change is indicated by Figure 1 which compares the length frequency curves for 1938 and 1948. The general increase in the size of the fish is striking. This increase is also shown in the following table which gives the modes of the lengths of pilchards sampled in Oregon in several previous years.

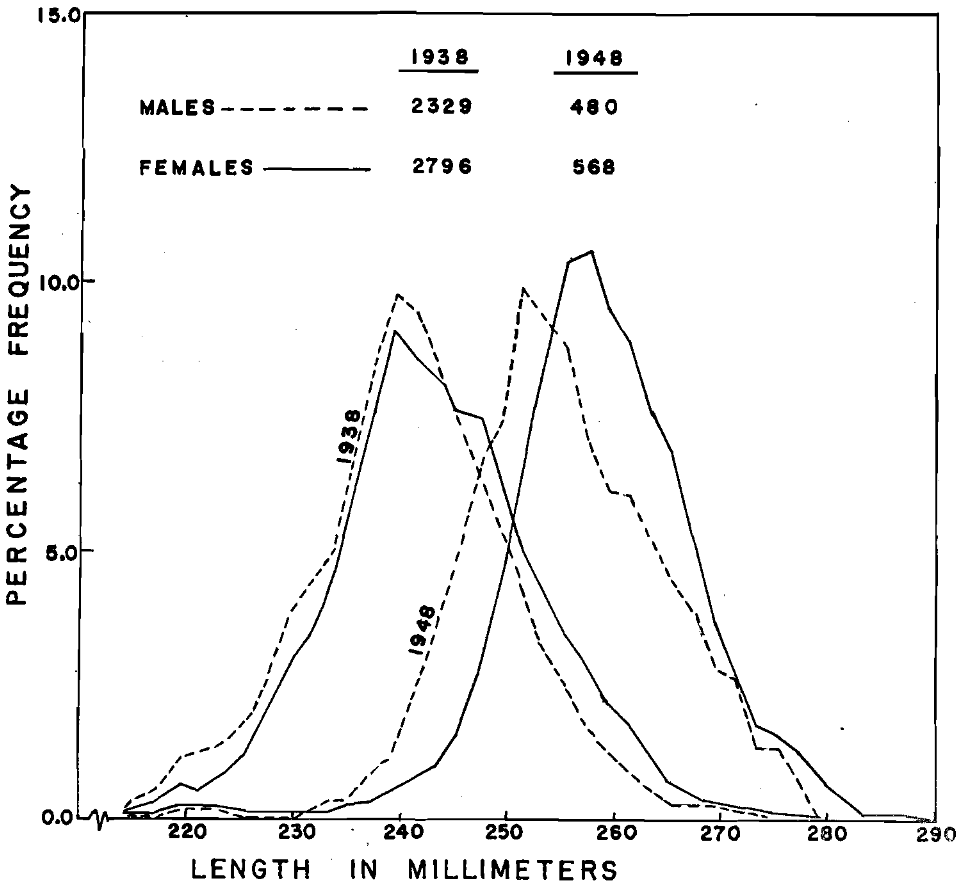

Figure 1. LENGTH FREQUENCY OF OREGON PILCHARDS IN 1938 COMPARED WITH 1948.

TABLE 2

MODAL LENGTHS IN MILLIMETERS OF PILCHARDS LANDED IN OREGON

Year	Males	Females
1938	242	242
1939	241	241
1940	229	231
1941	221	235
1947	251	255
1948	254	257

From the above table it is evident that the 1938 pilchards, although much smaller than the 1948 fish, were considerably larger than the samples taken in 1940 and 1941. From 1941 to 1948 the modal length of the males increased about 33 millimeters and that of the females about 22 millimeters. It is evident that the fishery in 1947 and 1948 was based on much larger pilchards than in former years.

The scales taken for age determination were read by biologists of the California Bureau of Marine Fisheries and the Fish and Wildlife Service (Felin and Phillips, 1948). The age composition of the Oregon pilchards for 1940, 1947, and 1948 is shown in Figure 2. In the following discussion

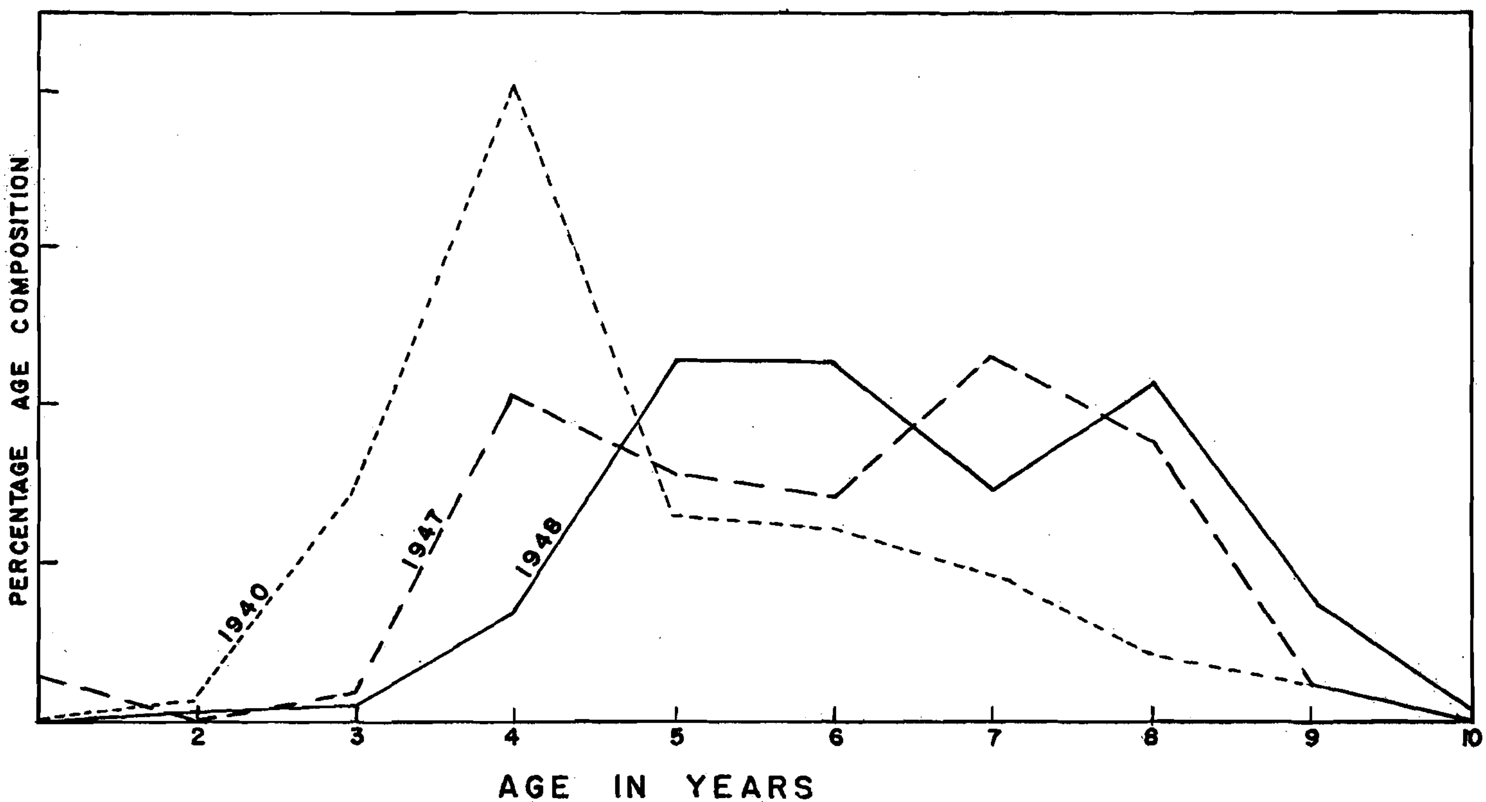

Figure 2. PERCENTAGE OF OREGON PILCHARDS IN VARIOUS AGE CLASSES, 1940, 1947, AND 1948.

the "age" of the fish actually refers to the number of annual winter rings present on the scales. For example, a one year old fish has formed one winter ring between late fall and early spring following hatching.

In 1940 the four year old fish dominated the catch; in 1948 the relative number of four year fish was quite small. In 1940, 43 percent of the pilchards sampled were five year fish or older, in 1947, 75 percent were five years or older, and in 1948, 92 percent were five years or older.

The analysis of the length-frequency samples and the age readings indicate that the Oregon pilchard fishery in 1947 and 1948 was dependent on the larger, older fish. The younger age classes are not entering the Oregon fishery in sufficient numbers to support a heavy catch.

Tagging experiments indicate that the pilchards gradually migrate farther to the north each year from the principal spawning grounds off Southern California until they reach the coast of Oregon usually at four years of age (Clark and Janssen, 1945). Because of the intense fishery for this species in California and because of poor recruitment in recent years, the younger year classes have been depleted to such a degree that few fish survive to reach the Oregon coast. As a result the Oregon fishery is now dependent on that part of the older, more abundant year classes which have escaped the California fishery and on incidental spawning which takes place in certain years in the waters of the Pacific Northwest.

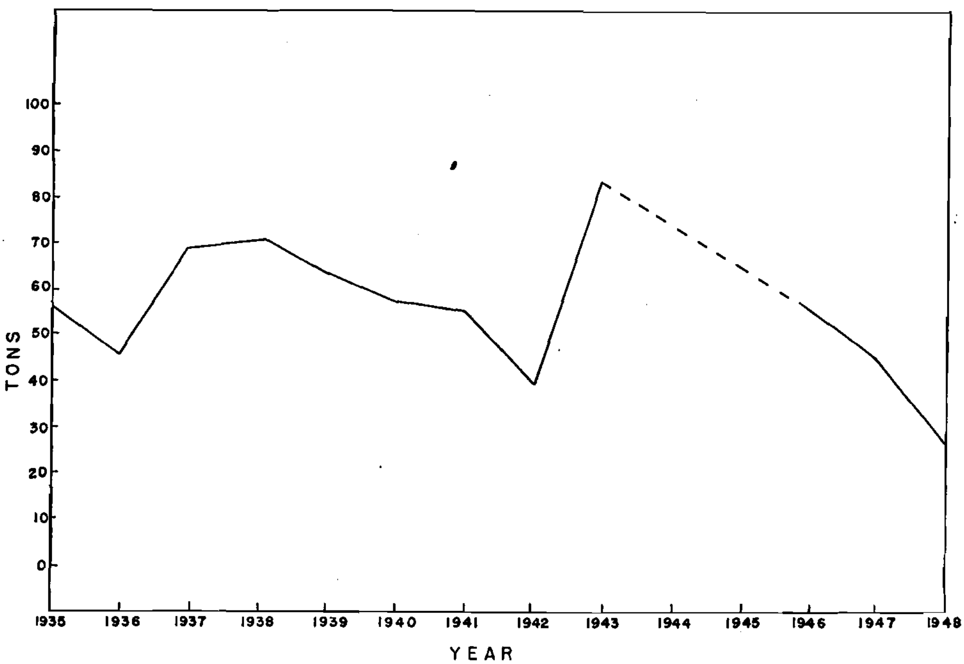

Figure 3. AVERAGE SIZE OF LANDINGS IN TONS, OREGON PILCHARD, 1935 TO 1948.

The average tons per landing is a rough measure of the abundance of pilchards. Figure 3 shows this average since the beginning of the Oregon fishery. In 1944 no fish were landed and in 1945 the total landings amounted to only 90 tons. The average landing for 1947 was below that of the 1935-

1943 period and in 1948 it declined even further. This probably indicated that there was a serious decline in the numbers of pilchards present in Northwest waters in 1948.

The total weights of the pilchards landed annually in Oregon since the beginning of the fishery in 1935 are shown in Figure 4. The annual yield has shown a downward trend although there have been fluctuations.

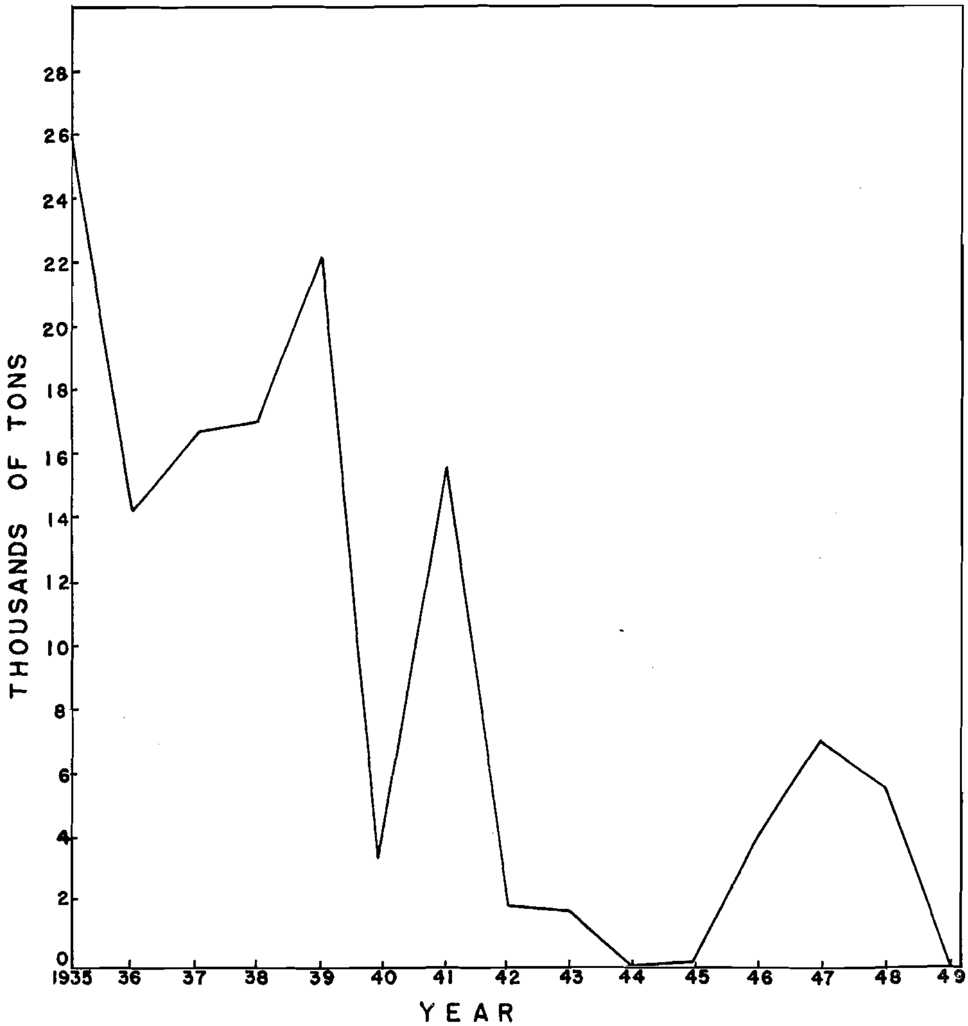

Figure 4. CATCH OF PILCHARDS IN OREGON, 1935 TO 1949.

In 1949 the Oregon pilchard fishery was a complete failure. This failure was not due to lack of effort. Pilchard boats were in Astoria for several weeks in July and August and tried repeatedly to locate the fish. Also a plane was used to scout for pilchards.

The biological data collected in previous seasons explain quite clearly the reasons for the decline in the Oregon fishery. The length-frequency data and the age determinations show that the catch in Oregon has depended on progressively larger and older fish. These older, once abundant year classes have finally been fished out or died naturally. In the last few years recruitment of young pilchards into the California fishery has been poor (i.e., the reproduction of pilchards has not been successful). This poor recruitment has been combined with a high fishing intensity. As a result, most of the pilchards have been caught in California waters before they have had an opportunity to reach the age where they might migrate to the Pacific Northwest.

The prospects for the future of the pilchard fishery in Oregon are not bright. A series of very successful brood years will probably be required before enough fish can escape the intensive California fishery to allow a successful season in Oregon. Such a situation can be expected to occur only at intervals of a few years. In the intervening years there will probably be poor fishing.

One other possible method of improving the pilchard fishing in the Pacific Northwest (and probably California also) is to decrease the intensity of the fishery in California. This could presumably be accomplished by limiting the amount of pilchards landed per season. A successful program of management of the pilchards would tend to stabilize the catch and allow a greater escapement of fish into the northern waters.

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THE LAMPREY FISHERY AT WILLAMETTE FALLS, OREGON

Out of the wide reaches of the Pacific Ocean there migrates annually into Pacific slope streams a strange eel-like creature, the three-toothed or Pacific lamprey. From southern California to the Aleutian Islands adult lampreys annually make their way up the streams in order to spawn in the freshwater tributaries.

Large migrations of lampreys occur in the Columbia River and its tributaries, but they would pass through virtually unnoticed were it not for the presence of Bonneville Dam and other barriers. They migrate during the spring, generally from April into July, and can be seen hanging in clusters by their cup-like mouths at each jump of the ladders at Bonneville. At Willamette Falls on the Willamette River, also, they inch their way over the barrier in vast clusters. Their migration coincides with the spring chinook salmon run, and few are present at the falls after the end of June.

Prior to 1941 no attempt had been made to commercially utilize the hordes of lampreys as they ascended the falls and fishway at Oregon City. During the 1941 migration the first attempt at taking these migrants on a commercial scale was made by Mr. L. T. Critchlow, a commercial fisherman from Monterey, California. The results of the first year's fishery were sufficiently successful to encourage further development, and consequently it has been continued annually.

Life History

The Pacific or three-toothed lamprey, *Entosphenus tridentatus (Entosphenus*—within wedge—referring to the shape of one tooth; *tridentatus*—three-toothed), is not an eel, which is a true fish, but a very primitive vertebrate. While the lamprey has a long, slender body, its resemblance to an eel is only superficial, and morphologically there is little similarity.

The body is long, slender, smooth, scaleless, and eel-like, and the length ranges up to 27 inches. The color of the body may vary from brown to dark grey with a light colored area around the mouth. The mouth is a circular, adhesive disc, called a buccal funnel. There are no jaws, but well developed teeth are found within the buccal funnel. The head has a single nostril on the dorsal surface, and seven paired gill openings are present behind the eyes. A caudal and two dorsal fins are present, but all paired fins, such as are found on most fish, are absent.

Adult lampreys often travel great distances and over numerous obstructions in order to reach their spawning grounds. Spawning occurs during June and July when the eggs are laid in nests prepared in fine sandy gravel on suitable riffles. After spawning the adults die and their bodies may be found disintegrating in pools and eddies below the spawning areas.

Unlike fish, whose young are similar in morphological structure to the adult form, the lamprey young pass through a larval stage of several years duration that is quite unlike the adult. Larval lampreys have neither eyes nor teeth, and instead of an adhesive disc-like mouth they have a soft fleshy structure known as an oral hood. The young larvae do not emerge from the gravel and then remain free swimming as do young salmon and trout, but burrow into the accumulated silt and sand of the stream bottom where they pass through their larval stage during the course of several years.

After the larval period young lampreys undergo a metamorphosis during which time the mouth changes into a sucking disc with functional sharp teeth and the eyes develop. At this time they emerge from their subterranean surroundings and begin migrating to the ocean.

The young adults, after reaching the ocean, become predators and subsist by feeding upon the blood and tissues of various species of hosts, probably fish, to which they attach themselves. In order to prevent the clotting of the blood during feeding, an anti-coagulate serum is injected into the victim by means of a hypodermic-type tooth within the buccal funnel. The greatest part of the life cycle is spent in the ocean. When the life cycle nears its end, the adults migrate back into fresh water to spawn and die.

The Lamprey Fishery

During the first season in 1941, Mr. Critchlow was not permitted to begin his operations until after the spring chinook salmon migration through the fishway was completed. This was done in order to prevent any interference with the spring migration of salmon enroute to their spawning grounds. The second year the fishery was allowed to commence during the latter part of the salmon movement through the ladder when it was found it could be carried out without affecting the salmon migration. In the following years the operations have begun as soon as conditions have been declared suitable by the Oregon Fish Commission.

The first two years large crews of 16 to 20 men, each furnished with small-meshed scoop nets, hand-dipped the lamprey from the fishway and adjacent pools and crevices. Then Mr. Critchlow developed a system of traps and flumes leading into a central collection basin (Figure 1). The traps were designed to take advantage of the lamprey's preference to travel over a smooth wet surface in an upward direction. Their movements are entirely limited to either underwater or exposed but smooth, water-covered surfaces; dry surfaces eliminate the adhesive action of the buccal funnel and prevent any movement by that means.

The first traps were simple in design, but eliminated much hand labor. With further development the present-day trap has evolved into a complicated structure that apparently is quite efficient. All of the traps now used are basically the same in design, but may vary slightly in construction, depending upon the location and the underlying foundations upon which the traps are placed.

Each trap consists of a smooth vertical surface—either metal, wood, rock, or concrete—down which a thin film of water flows constantly. The height of a trap may range from four to ten feet or more, and the width from three to six feet. The crest of the trap is about six inches wide and has rounded edges that permit the lamprey to continue its movement over the top. An overhead pipeline supplies the top of the trap with a constant flow of water that is directed down the side used by ascending migrants. On either side of the crest, but several feet below, wire screen collecting baskets are attached to the structure and connected to a wire

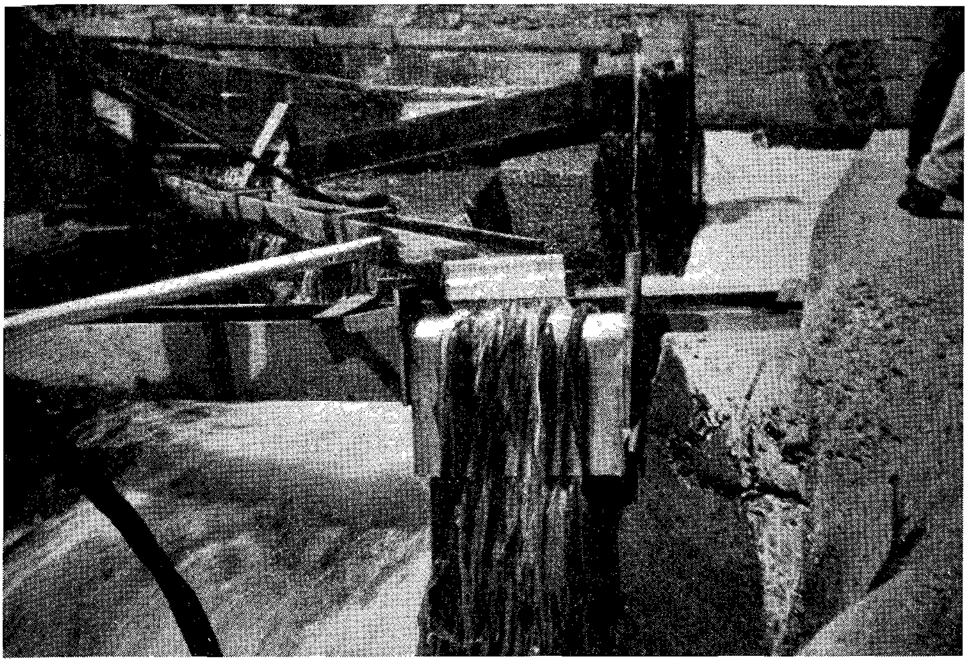

Figure 1. LAMPREY TRAPS AT WILLAMETTE FALLS, OREGON CITY. VIEW SHOWS LAMPREYS ASCENDING TRAP AND THE FLUME WHICH DELIVERS CAPTURED INDIVIDUALS TO A CENTRAL COLLECTING BOX.

screen trough that leads into a screen-lined wooden flume which has a rapid current of water flowing through it. This flume in turn leads into a central collecting basin consisting of a submerged screened livebox. The collecting basket on the ascending side of the trap has a clearance between the wire and the surface of the trap of approximately 1.5 inches that permits the lamprey to reach the crest and yet will catch the majority of those that fall on the same side of the structure.

The lamprey ascends the smooth surface of a trap by means of its adhesive mouth with which the migrant attaches itself to the vertical plane after each forward movement of the body. Upon reaching the crest of the trap the lamprey continues its forward movement until the entire body suddenly topples over the crest. Generally this sudden motion forward and downward is sufficient to break the suction of the buccal funnel and the lamprey will fall into the collection basket and begin moving down the collection system to the livebox. Occasionally the hold of the animal is not broken, and then the lamprey will reverse its movements and recross the trap crest and topple down the other side, eventually breaking its hold and falling into the downstream collecting basket. Once having reached the top of a trap, the lamprey has very little chance of escaping.

After having fallen into the collection basket, the lamprey begins moving down a wire screen trough, aided by gravity. A trough connects each trap with a screen-lined wooden flume that leads into a central collection basin or livebox. The wire screening within the wooden flume prevents the lamprey from attaching itself to the bottom of the flume.

In addition, a swift current of water aids in moving the lamprey to the livebox.

The traps, which may number from 10 to 12 at the Oregon City fishway, are placed along the sides and at the upper ends of the various pools of the ladder. When placed at the head of a pool, they are attached adjacent to the fishway slot, but not in such a manner as to diminish the size of the opening nor the flow of water through the orifice. Thus, these traps form natural paths for lamprey migration. Once erected the traps offer no obstruction to salmon migration.

During the peak lamprey migration the movement of animals from the traps into the collecting basin necessitates emptying it twice daily. At other times once a day is sufficient. The lamprey are dipped from the livebox by means of scoop nets and placed into 50-gallon oil drums that hold approximately 400 pounds of the migrants. A barge, capable of holding 14 barrels, is used for transporting the loaded drums to a landing a mile downstream, where they are transferred by a large crane to a truck and hauled to a reduction plant.

Utilization

The earliest known use of lamprey from this region was for food by the Indians, who made annual migrations to the falls in order to obtain a supply of lamprey as well as salmon. Present-day anglers use them for bait in sturgeon fishing. In addition, a limited quantity are used by fur trappers.

Lamprey taken commercially at the falls are transported to a reduction plant at Warrenton, Oregon where the vitamin oil is extracted; the residual material is manufactured into protein food for livestock and poultry or fertilizer (fish meal).

The annual catches as reported to the Oregon Fish Commission are found in Table 1. Records for the first two years could not be obtained. In addition, a catch of almost twelve tons was reported from the Rogue River fishery in 1949.

TABLE 1

ANNUAL CATCHES OF LAMPREY AT WILLAMETTE FALLS

Year	Pounds	Year	Pounds
1941	....	1946	397,260
1942	....	1947	360,165
1943	207,090	1948	231,480
1944	72,708	1949	114,685
1945	248,956		

General

Due to the difficulty in ascending the face of Willamette Falls and with fluctuating water flows over the crest of the barrier, thousands of lamprey fail each year to scale the falls and are stranded in pools and crevices as the river level drops. In early years these unsuccessful migrants perished, and their decomposing bodies released into the air the pungent odor of decaying eel flesh. Many thousands of carcasses floated downstream and were deposited upon the river banks by receding river levels, thus creating a nuisance to many residents residing on the shores of the Willamette River for some miles below the falls.

Since the fishery began operating in 1941, the annual problem of the dead and decaying lamprey below the falls has been virtually eliminated. Each year employees of the fishery have removed the stranded migrants from areas adjacent to the falls and the carcasses from the river near the fishway.

A permit to operate lamprey traps at the Savage Rapids Dam on the Rogue River was obtained in 1949, and traps were installed by Mr. Critchlow within the fishway at that barrier. Due to the small quantity which appeared the season's total catch was very light, being only twelve tons; plans have been made for continuing the development of this fishery.

The operator of the lamprey fishery has estimated that his traps catch from 10 to 20 percent of the lampreys that appear at the Willamette Falls.

This is a unique fishery and is providing, in addition to its salvage value, valuable vitamin oils and fish meal. Further, another resource of the State is being utilized. The future of the lamprey fishery and its stability will depend upon continued demand for vitamin oils and the continued productivity of the stocks of Pacific lamprey in the Willamette River and other Oregon streams.

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Spring Chinook Found in Columbia in November

In November, during sturgeon tagging operations, two female spring chinook salmon were recovered from a fish trap on Government Island in the Columbia River near Camas, Washington. The first fish was recovered on November 12, and the second November 23. The latter fish was 32 inches in length.

As both fish were extremely bright and appeared to have recently entered fresh water, they were cut open to determine whether or not they were late fall chinook salmon or unusually early spring chinooks. The flesh was a deep rich red and the body walls were thick. The immature ovaries of these two fish measured between 5 and 6 inches in length, and were filled with eggs approximately 1.5 mm. in diameter. These eggs would not have matured until next July or August, and there is no doubt that these were very early spring chinooks enroute to their spawning areas probably in some distant headwater stream of the Columbia River watershed. Examination of the scales of these two fish indicated that they would have reached the age of five years upon spawning.

THE 1949 SUMMER SPORT FISHERY FOR RAZOR CLAMS

Introduction

An investigation of the razor clam fishery of Oregon began in June, 1949 in an effort to determine the status of the present stocks of clams and the possibility of increasing the yield through a management program.

The total yield of the fishery must be learned as one criterion of productivity. Yearly trends in the fishery will determine the necessity of management and make it possible to evaluate the overall success of any imposed controls. The records from buyers and licensed commercial diggers furnish reasonably accurate information on the total commercial catch, but the size of the sport fishery must be determined before the total yield is known. The only present method of establishing the magnitude of the recreational take of razor clams is through routine counts of diggers coupled with random sampling of the catch. During the summer of 1949, from June to September, a program was carried on with this end in view.

Productive Razor Clam Beds

The razor clam populations are characterized in general by a decrease in abundance from north to south along the Oregon coast. Adequate data are not available for an accurate comparison of the beaches; estimates of productivity can only be made at the present time from a few random counts of diggers, samples of their catches, and from information volunteered by local residents familiar with the areas in question. While all of Oregon's razor clam beds have not yet been thoroughly surveyed, most of them have been examined, at least briefly, and reliable reports have been obtained regarding others from local residents. Figure 1 shows all the beds now known.

That part of the Clatsop County beaches extending from the Columbia River to Tillamook Head (bed No. 1 on the map) supports the greater part of the razor clam fishery of the state (an estimated 75 percent of the sport fishery and an even greater percentage of the commercial fishery). Because of its predominant importance, the major effort of the investigation has been limited to this area. The total length of the beach is approximately 19 miles. Motor vehicles are permitted north of the Necanicum River only, a total distance of about 16 miles. Roads lead onto the beach near the Gearhart Hotel, Sunset Beach, and the wreck of the sailing ship, "Peter Iredale". From the Necanicum River south to "T" Avenue, including the Seaside bathing beach, a distance of 2.3 miles, is a heavily dug but productive strip of beach. The Cove Area, south of "T" Avenue to Tillamook Head, contains only a 600-yard length of beach. Previous regulations have closed the Cove Area to all commercial digging.

Farther south, but still in Clatsop County, the seven-mile-long Cannon Beach area (No. 2, Fig. 1) has undergone marked fluctuations in productivity in past years. At the present time only occasional small catches are taken, although once good digging occurred. The Arch Cape Beach (No. 3) immediately south of Cannon Beach and less than two miles long has yielded limited catches for the last two years. Fair catches have also

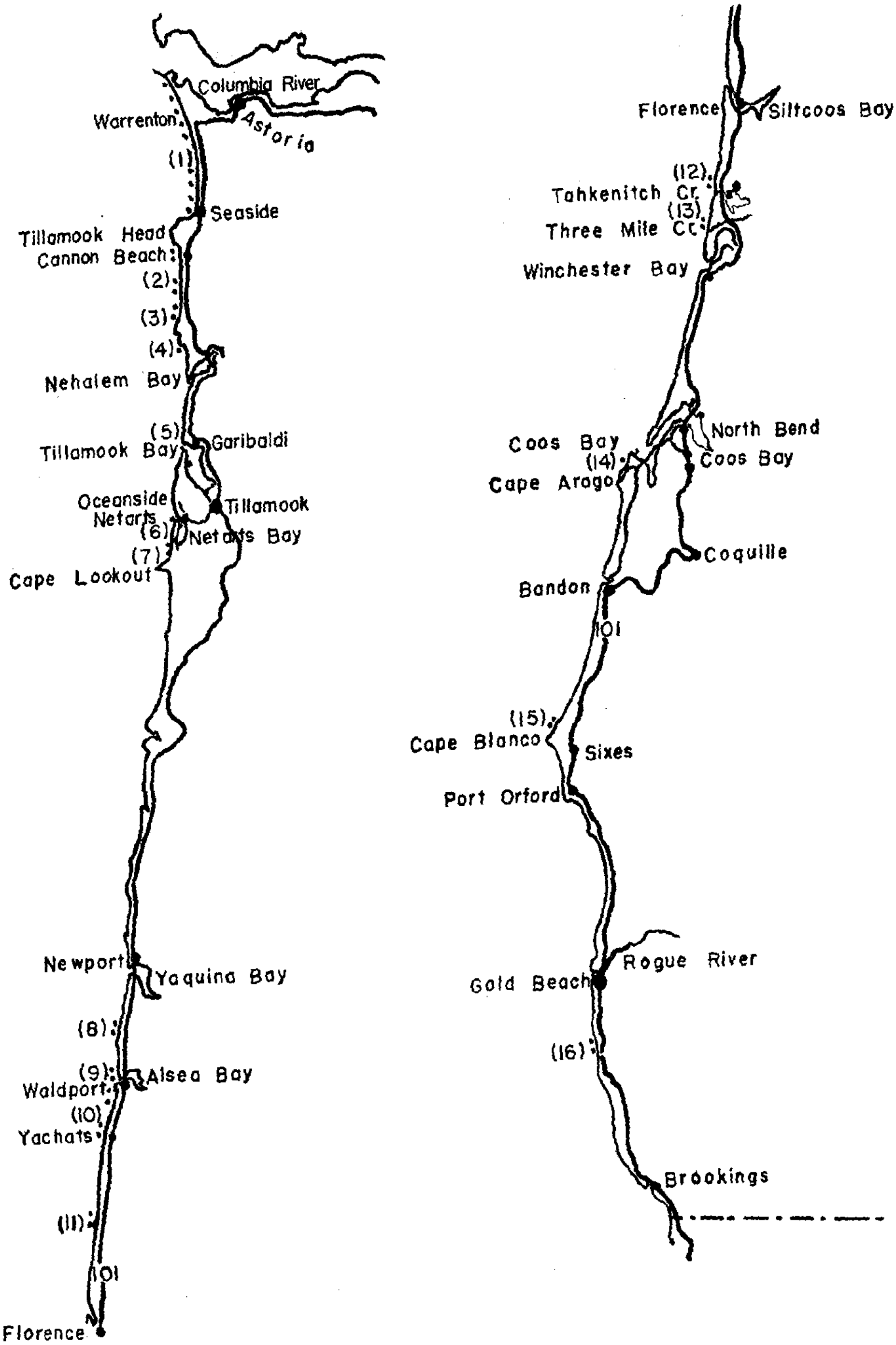

Figure 1. AN OUTLINE OF THE OREGON COAST SHOWING THE LOCATION OF THE KNOWN RAZOR CLAM BEDS. (Beds indicated by dots and numbered consecutively from north to south)

been taken at Short Sand Beach (No. 4) less than one-half mile in length and accessible only by trail.

The next productive areas to the south are in the vicinity of Tillamook Bay (No. 5), on the inside of the spit near the mouth of Netarts Bay (No. 6), and on the spit immediately north of Cape Lookout (No. 7).

Between Newport and Yachats the beaches are second in productivity of razor clams only to the Northern Clatsop County beaches. The largest concentration of diggers is recorded from the vicinity of Seal Rock (No. 8), the north spit of the Alsea River (No. 9), and the entire length of the Alsea Beach (No. 10) south of the Alsea River to Yachats, a distance of about 10 miles and adjacent to the highway over the entire length. No passable roads exist onto the beach. These areas have yielded good catches of clams to large numbers of sportsmen and a few commercial diggers for the past three years. In previous years, especially in 1945 and 1946, few clams were taken. The area in the vicinity of Heceta Head (No. 11) is reported by residents as reliable for year round digging. The data available indicate an average take of about two dozen clams.

South of Heceta Head the distribution of razor clams is very spotted. Many small isolated pockets of razor clams are found, but only a few yield significant numbers of clams. North of Tahkenitch Creek (No. 12) a bed has been reported, but a check failed to detect an appreciable number of clams. Razor clams occur between the mouth of Three Mile Creek and the Umpqua River (No. 13), but the take there has been small.

Occasional catches of clams are known from isolated beds immediately south of Coos Bay between the mouth of the Bay and Cape Arago (No. 14) but sizeable beds have never been found. Other beds are present on various beaches from Coos Bay to Cape Blanco, but for the most part they yield only occasional catches to local residents familiar with the areas. A short section of beach just north of Cape Blanco (No. 15), however, is dug frequently by local residents with fair results.

A few isolated beds are known south of Cape Blanco, but the only bed supporting a significant amount of digging is situated in the vicinity of Meyers Creek about 10 miles south of Gold Beach (No. 16). Residents and tourists find the digging favorable in most years. The location of clams on the beach varies from year to year. Although no commercial digging occurs, it reportedly supports the best digging south of Heceta Head.

Magnitude of the Sport Fishery

The Clatsop Beach area north of Tillamook Head was divided into six easily recognized areas for facility in obtaining data on the recreational fishery. The areas are as follows: (1) The Cove Area from Tillamook Head north to "T" Avenue in Seaside; (2) "T" Avenue north to the Necanicum River; (3) the Necanicum River north to the Gearhart Road onto the beach; (4) the Gearhart Road north to the Sunset Beach entrance; (5) the Sunset Beach entrance north to the wreck of the "Peter Iredale"; and (6) the "Peter Iredale" north to the South Jetty of the Columbia River.

Data on the sports catch were obtained by the following enumerated methods. Beach counts were made routinely, counting the total number of diggers. Counts included everyone on the razor clam beds, since distinguishing between diggers and non-diggers would have been difficult in the limited time beach counts were possible. Counts were made by driving the length of the beach or by observation from suitable view points where driving was impossible (the Cove Area and from "T" Avenue to the Necanicum River). Counts were made as close as possible to the time when the maximum number of diggers was found to be on the beach.

A beach count seldom gave the total number of diggers digging during the course of any one low tide period regardless of when the count was made. Certain diggers came early and left before low water; other diggers came after low water and left 2 to 3 hours later. Thus no interval of time existed when the total number of diggers digging any one tide was present. It was essential that a method be devised to correct for this error in beach counts.

A modification of the method used by McKernan and Jensen on the Willamette River salmon sport fishery (1946) was employed to compute the necessary correction. A limited area small enough for accurate observation was selected for a certain tidal period. The diggers entering and the diggers leaving the designated area were recorded separately for each half-hour period. Provided the observations started before the first digger arrived and continued until the last digger left the area, the total for all half-hour periods of diggers entering equals the total for diggers leaving. Either sum gives the total number of diggers present during the tidal period. By adding the total number of diggers entering up to a given half-hour period and subtracting the total leaving up to that period the net number of diggers present for the given half-hour period can be computed. The number of diggers present for every half-hour period is similarly computed, and then each is represented as a percentage of the total for the entire tidal period. This is then represented graphically: the time before and after low water plotted against the percentage of diggers present at any one time (Fig. 2). The illustrated distribution of digging effort over a low tide period is for the beaches north of the Necanicum River.

The time of each beach count is known in reference to low slack water, which through reference to the above illustration gives the percentage of diggers on the beach at any one time; the count of diggers on the beach, representing a percentage of the total, can then be corrected to yield the total for the tide or 100 percent.

In the above method several assumptions are made: (1) the area selected must be typical of the entire beach for which the count is made, and (2) since the distribution of digging effort over a low tide period was not necessarily taken the same day as the beach counts were made, the distribution of diggers on the beach throughout the tide must be reasonably constant. The above assumptions were checked by making frequent charts and comparing the differences in the percentage distribution of digging effort under varying conditions. In all 13 such charts were made. Similar charts were grouped into a single chart, dissimilar ones were drawn separately and the conditions responsible for the variations noted were studied. The time available limited the number of charts that could be made. Thus all conditions leading to variations were not detected.

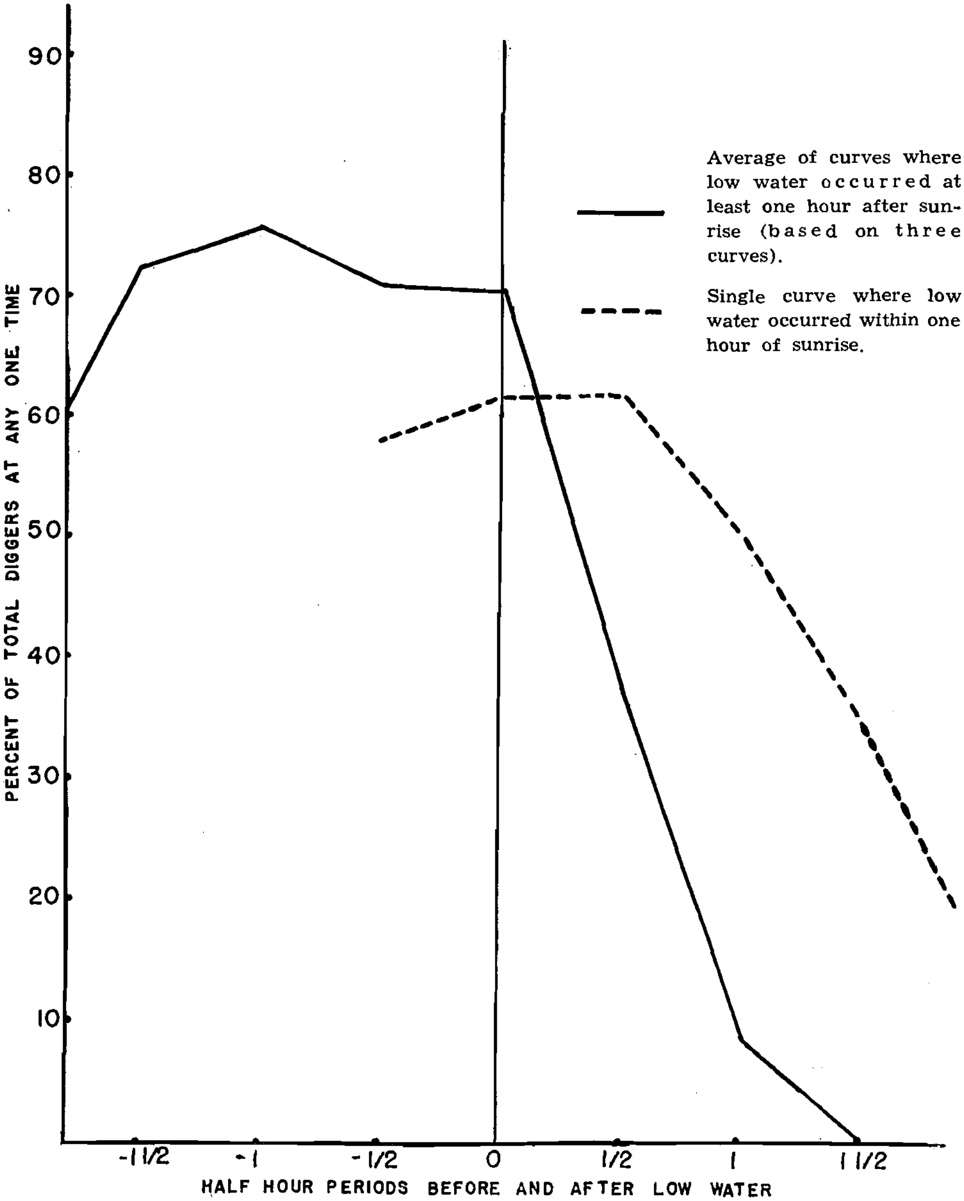

Figure 2. THE PERCENTAGE DISTRIBUTION OF DIGGERS ON THE BEACH THROUGH A LOW TIDE PERIOD.

Two conditions brought marked differences in the charts: (1) the time of low water in relation to darkness; and (2) the area chosen (three areas were found to have similar conditions thoughout: the Cove Area, "T" Avenue to the Necanicum River, and the northern extremes of the beach). Separate computations have been made for each condition and each beach count has been referred to the more applicable charts for correction.

The catch-per-digger was ascertained regularly as a necessary part of determining the total take. During the process of sampling, random measurements of the length of the clams were also taken to give necessary information on the size of clams constituting the sport fishery.

The 1949 Summer Fishery

The results of the 1949 census of sport diggers are based on 23 counts of diggers taken between June 25 and September 8. Ten of these counts were complete counts of diggers for the entire area of beach. From the above 10 counts the average percentage of the total diggers on each area was calculated and shown in Table 1. These percentages are the basis for calculating total diggers in the remaining 13 counts where counts of from 1 to 4 areas were missing in the original data.

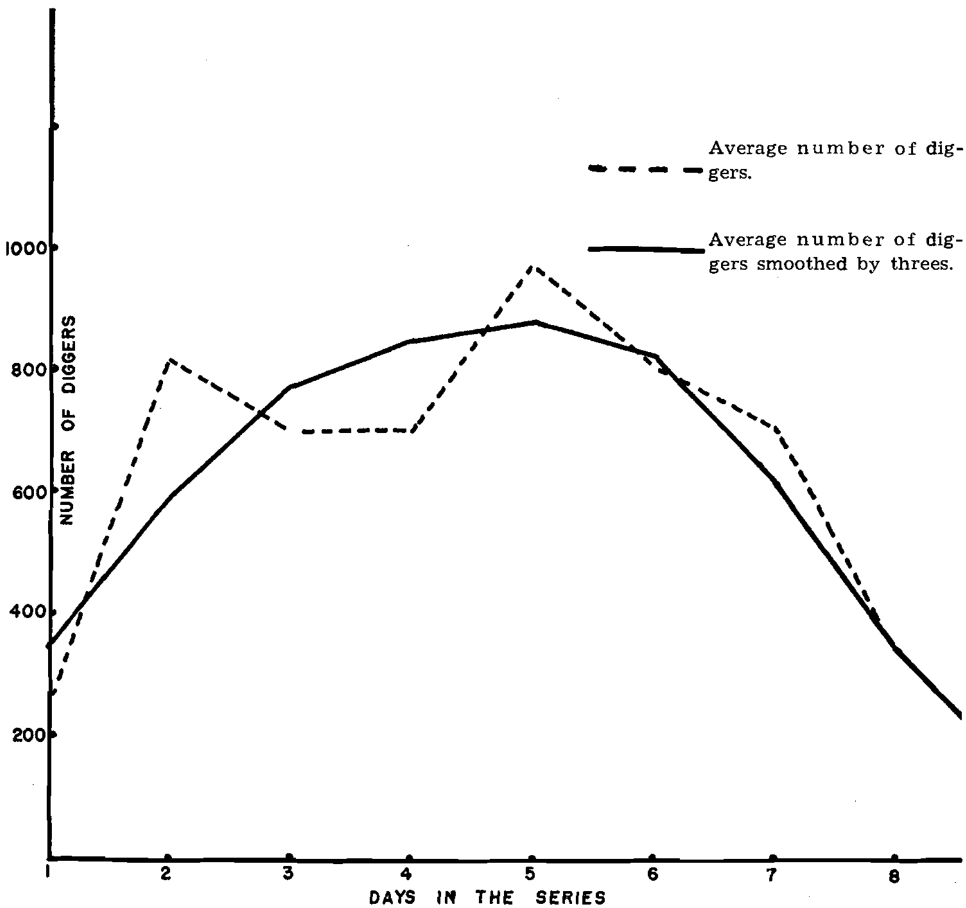

Figure 3. DISTRIBUTION OF DIGGING EFFORT OVER A TIDAL SERIES.

TABLE 1

CALCULATED PERCENTAGE OF TOTAL DIGGERS ON VARIOUS PORTIONS OF BEACH

	Cove Area	T-Ave. to Nec. R.	Nec. R. to Gearhart	Gearhart to Sunset Beach	Sunset B. to Peter Iredale	Peter Iredale to S. Jetty
Percent Diggers	22.7	29.1	13.0	17.5	10.7	6.9

The average distribution of digging effort through the tidal series (varying from 8 to 10 days in a series and designated numerically from the first to last day during the period the low water fell to zero feet or below) was computed from the 23 counts. The average gave the distribution of digging effort throughout the series (Fig. 3). This distribution was used to correct later inadequacies in the data.

Random sampling of the catch gave information on the average number of clams per digger and the size distribution of clams taken. The results (Table 2) are based upon a total of 674 diggers checked over the course of the summer under varying conditions and on different areas of beach. The Cove Area through the last tide series in July was recorded separately. After July the catches resembled the area from "T" Avenue to the Necanicum River.

The average sizes (Table 2) were derived from a total sample of 931 clams: 335 from the Cove Area, 260 from "T" Avenue to the Necanicum River, and 336 from the Necanicum River to the Columbia River.

TABLE 2

CALCULATED RESULTS PER AREA PLUS THE TOTALS FOR THE ENTIRE BEACH FROM TILLAMOOK HEAD TO THE COLUMBIA RIVER

JUNE 24 TO SEPTEMBER 8, 1949

Area	Number of Non-Com'l Diggers	Average Catch of Clams	Total Catch of Clams	Average Size of Clams in Millimeters	Clams per Pound	Total Pounds of Clams
Cove Area June 24 to July 30	5,533	17.2	95,168	109.86	5.2	18,301
Cove Area Aug. 3 to Sept. 8	2,705	8.7	23,533	86.96	12.2	1,928
"T" Avenue to the Necanicum R.	9,957	8.7	76,838	86.96	12.2	6,297
Necanicum R. to the Columbia R.	17,938	12.0	190,944	99.04	7.2	26,520
Total for above four subdivisions	32,982		386,483			53,046

The percentage of commercial diggers encountered among the diggers checked for catch was 11.3 percent, and the counts were adjusted accordingly. From Table 2 it can be noted that a total of approximately 33,000 people dug a total of 386,500 clams or 53,000 pounds.

After September 8 the non-commercial digging declined except for a very few diggers equipped with lanterns for night digging. Early morning low tides appeared before daylight. Evening low tides came after dark. This changeover from early morning to evening spring-tides, during which time neither was very low coincided with a period of poor clamming weather during which a heavy surf made digging difficult. An appropriate end period then exists for the analysis of summer catch before the beginning of the much lighter fall and winter sports digging.

Summary

1. The beach between Tillamook Head and the Columbia River supports the majority of the razor clam fishery of the state, estimated at approximately 75 percent of the total. Only for the above area was the magnitude of the sport fishery calculated. Farther south the productive beds are scattered and digging is sporadic from year to year.

2. The methods used to compute the size of the sport fishery were: first to determine the number of diggers by beach counts and then correct for total counts through charts showing the distribution of digging effort over a low tide period, and second to find the average catch per digger.

3. A total of 33,000 non-commercial diggers were present on the beach between June 24 and September 8, and they dug a total of 386,500 clams weighing about 53,000 pounds.

4. The average lengths of the clams taken were: 110 mm. in the Cove Area through July, 87 mm. in the Cove Area after July and between "T" Avenue and the Necanicum River, and 99 mm. for the beaches north of the Necanicum River.

Literature Cited

McKernan, D. L., and C. C. Jensen
1946 '46 Willamette River spring chinook sport fishery. Oregon State Game Com. Bull. *1* (6):3-6, Portland.

Donald W. Twohy
Aquatic Biologist
Fish Commission of Oregon

Silver Salmon Being Studied

Studies of the life history of the silver salmon are being conducted on a small tributary of the Wilson River, one of the short coastal rivers of Oregon. Some of the information being obtained here includes: time of seaward migration of the young fish and their age and size; comparative efficiency of artificial versus natural propagation; and sex ratios, sizes, and time of appearance of the adult fish on the spawning grounds.

Silvers Use Newly Opened Areas

Silver Salmon were found spawning in the upper part of the Devil's Lake Fork of the Wilson River during the middle of November of this year. Fish have had access to this area for the first time in several years as a result of the removal of a log jam by the Engineering Division of the Commission.

Soupfin Shark Tagging

A soupfin shark *(Galeorhinus zyopterus)* tagging program has been undertaken by the Oregon shark fishermen, with the cooperation of the Fish Commission of Oregon. During the 1949 floater net season (April to October) the fishermen tagged approximately 300 small soupfin shark (48 to 60 inches long). The fish have been tagged from Point Conception (California) to Hecate Straits (British Columbia).

There have been two returns this year. The first was a male (56 inches long) which was tagged on August 5, 1949, west northwest of Cape Scott (Vancouver Island) in 120 fathoms, by Mr. Cliff Hall on the "Pacific Queen" (Newport). It was recovered on August 7, 1949, in the southeast corner of Queen Charlotte Sound (across from Goose Island by Mr. Erling Pedersen on the "Nanna" (Seattle). A northeasterly migration was estimated at 75 miles.

The second fish, also a male (47 inches long), was tagged on May 7, 1949, 50 miles west of Point Sur (California) in 1600 fathoms, by Mr. John Ennis on the "Signe S" (Astoria). It was recovered on August 28, 1949, in Halfmoon Bay (off Princeton, California) by a sportsfisherman. According to the measurements at tagging and recovery, the fish had grown approximately four inches. A northeasterly migration was estimated at 80 miles.

Indian Fishing Relics Recovered from the Banks of the Willamette River

On November 28 two Indian stone net weights were found by biologists of the Fish Commission at the mouth of Oswego Creek on the Willamette River near Oswego. Apparently they had been covered by sand for many years and thus were in an excellent state of preservation. Heavy rains had eroded a two-foot deep gully, and both stones were found lying one foot apart in the bottom of this ditch. The stones were about seven inches long and weighed about five pounds. Both weights were encircled by grooves one inch wide and one-eighth to one-quarter inch deep. Presumably these grooves were used for attaching them to the nets by means of thongs.