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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.

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THE UMPQUA RIVER SHAD FISHERY

Introduction

The Umpqua River, which enters the Pacific Ocean about 200 miles south of the mouth of the Columbia, drains approximately 5,500 square miles and has an average annual mean water flow of about 7,000 cubic feet per second. This river system is composed of two major drainages, the Umpqua River itself and Smith River, a large tributary which enters the Umpqua estuary about 11 river miles from the ocean. The Umpqua is a typical snow-fed stream arising in the Cascades, while the Smith River is typical of the short coastal streams arising in the Coast Range.

Shad were first introduced to the Pacific Coast in 1871 when about 10,000 were planted in the Sacramento River. Other plantings were made subsequently. The first shad taken in the Umpqua River were taken in 1888, but no intensive commercial fishery developed for this species there until about 1918. The first gear used in this fishery was a beach seine which proved very efficient as demonstrated by the fact that on June 19, 1920, about 9,000 pounds of shad were taken in one haul of the seine. Following 1922, the use of beach seines was prohibited in the Umpqua River, so the fishermen turned to gillnets for the capture of shad. Since 1928, from one-third to one-half of the production of shad in Oregon has been taken from the Umpqua system.

Shad Fishing Regulations

A few shad enter the Umpqua system during the latter part of April, but in general the bulk of the run does not appear before the middle of May. By the end of June most of the shad have entered the river and have either spawned and returned to the ocean or are spawned out to a point where they are of no value to the industry.

Regulations on the shad fishery of this river have evolved from a combination of measures adopted to protect other species such as spring chinook salmon, whose runs overlap in time those of the shad.

For many years prior to 1947 the commercial fishing season for shad extended from April 20 to July 1. The minimum size stretched mesh permitted in the nets was six inches measured from center to center of the knots. A 24-hour closed period was provided each week from 6:00 p. m. Saturday to 6:00 p. m. Sunday. Following 1947 the opening of the fishing season was delayed until May 10. This was done to give additional protection to the few spring chinook salmon that were taken inadvertently in the shad fishery. The closing date and mesh regulations were unchanged. Prior to 1947, the 24-hour week-end closure applied to both the Smith and Umpqua Rivers. During 1947, 1948, and 1949, the week-end closure applied only to Smith River.

The Fishery

Shad are taken in the Umpqua River by means of drift gillnets. This is the only type of commercial fishing gear that is permitted in the Umpqua. In Smith River shad are taken for the most part by setnets. Smith River contains so many snags that the use of driftnets is highly impractical.

It is known that some shad ascend the Umpqua for at least 90 river miles, but the greatest concentration seems to occur near "Brandy Bar" about 19 river miles up from the mouth. Although commercial fishing is permitted for another six miles above Brandy Bar, apparently shad aren't numerous enough or perhaps are not concentrated enough in that area to support fishing operations. As on the Umpqua, the shad in Smith River are only taken in any numbers within about 15 miles of the river's mouth, although the commercial fishery is permitted to operate some distance farther up the river.

Previous Survey

In 1946 a preliminary survey of the fish populations of the Umpqua was made, and it was tentatively concluded that the shad population of the Umpqua system was in good condition. This conclusion was drawn chiefly from an analysis of the available shad catch statistics prior to 1945 and a relative index of abundance calculated on a linkage basis as the average annual catch of five Umpqua River drift gillnet fishermen (*"The Umpqua River Study"*, Oregon Fish Commission and Oregon Game Commission, 1946, mimeographed). These statistics are included in Table 1 and Figure 1; a relative measure of fishing intensity has been calculated by dividing the total catch by the average catch per fisherman.

TABLE 1.

UMPQUA SYSTEM SHAD CATCH STATISTICS

Year	Catch (Pounds)	Average Catch per Selected Fisherman (Pounds)	Calculated Number of Fishermen
1923	113,397	8,680	13
1924	419,093	9,078	46
1925	517,586	5,415	96
1926	555,303	5,721	97
1927	568,600	5,904	96
1928	507,620	6,863	74
1929	208,183	4,464	47
1930	424,561	6,663	64
1931	578,017	....*	....
1932	264,213	....	....
1933	143,630	5,502	26
1934	265,491	6,521	41
1935	217,129	5,536	40
1936	301,388	6,429	47
1937	217,476	2,921	74
1938	197,587	1,164	170
1939	551,481	5,480	101
1940	362,467	3,273	111
1941	406,256	6,576	62
1942	422,278	11,434	37
1943	237,462	5,088	47
1944	335,405	9,467	35
1945	580,242	16,645	35
1946	856,685	14,829	58
1947	551,119	7,477	74
1948	573,069	13,100	44
1949**	758,652	14,935	51

* Data lacking.
** Preliminary data.

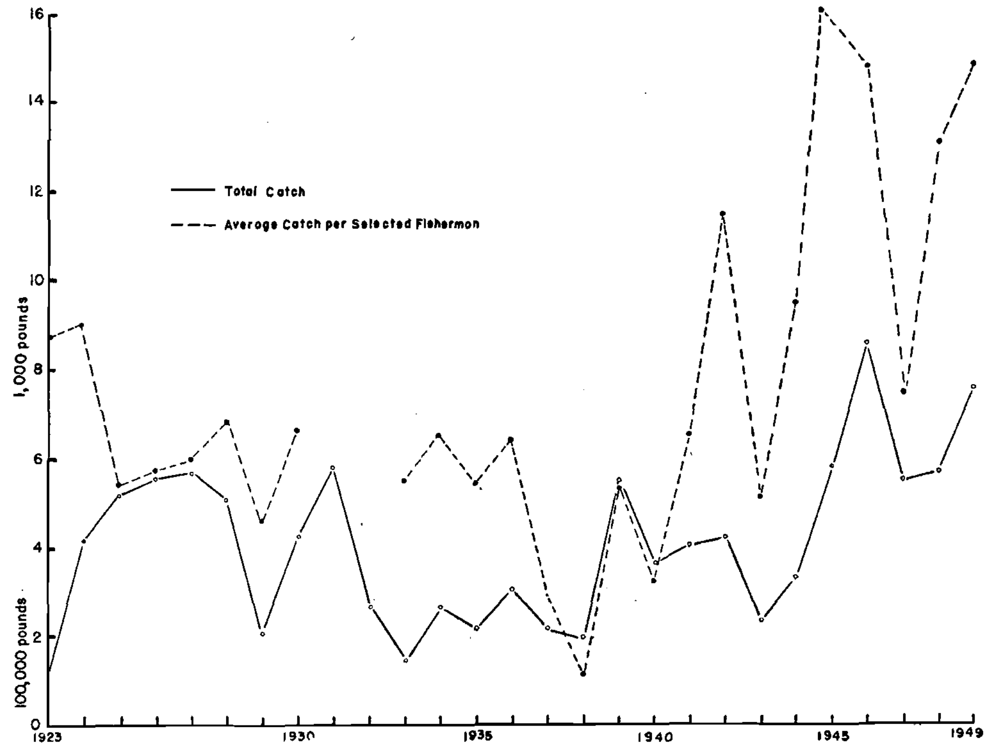

Figure 1. UMPQUA RIVER SHAD CATCH STATISTICS 1923-1949.

Since the demand for shad on the West Coast is not great, its production fluctuates in relation to economic conditions. Also on the Umpqua River, the abundance of the more valuable spring chinook salmon had a direct effect on the production of shad since the seasons of these fisheries overlapped to some extent. Therefore, it was felt that the yearly shad landings would indicate no more than a long range trend of the abundance of the shad populations. In order to obtain a perhaps better measure of abundance, the average annual catch of five selected fishermen was calculated. These fishermen, it was determined from studying their catches, were primarily interested in fishing shad during the shad season. Inherent in both of these measures to a varying degree is a conversion error. Shad are purchased from the fishermen by the piece rather than by the pound. Therefore the dealers reported their purchases to the State by numbers of fish, and these were converted to pounds for tax purposes by a conversion factor of 3¼ pounds for bucks (males) and 4¾ pounds for roes (females). Occasionally the dealers would actually weigh the fish and make their purchase reports to the State in pounds of fish. However, this practice was the exception rather than the rule among the dealers, so the errors thus introduced were probably relatively small. While the trends of these two measures are somewhat the same, it was felt that short-term fluctuations in abundance would probably be reflected more accurately by the average catch per fisherman than by the total catch.

Present Investigation

In order to supplement these preliminary studies and to further test the adequacy of the various measures of the shad population, investigations of the biology of this species have been continued on a limited scale since 1946. Since one yearly license on the Umpqua was used for several different fisheries, the number of licenses sold did not always reflect the intensity of the shad fishery. Therefore, the relative measure as shown in Table 1 was calculated. The trend of this measure corresponds in general with the history of the Umpqua shad fishery. A poor demand for shad coupled with relatively low fishing intensity occurred during the depression. This was followed by a sharp rise in catch to 1938 occasioned by an increase in the number of fishermen. Following 1940, many shad fishermen either went into war work or into the service, and consequently, during the war, the fishing intensity was low. For two years following the war the intensity was increasing, but in 1947 gillnet fishing for salmon was severely curtailed by law on the Umpqua system and a number of fishermen turned to other occupations, thus again reducing the intensity of the shad fishery.

In Table 2 is shown the catch in numbers of fish in the Umpqua River and Smith River from 1946 through 1949, and in Table 3 is shown the seasonal landings for 1947 and 1948. There are no indications at present that the Smith River shad are a different stock from the Umpqua fish. The fish seem to ascend either or both rivers depending on water conditions. The fisheries should be considered as separate units, however, in order that any major changes in the fisheries or ecological conditions in either of the rivers might be more quickly detected.

TABLE 2.

SHAD LANDINGS OF UMPQUA AND SMITH RIVERS IN NUMBERS OF FISH 1946-1949

	1946		1947		1948		1949	
River	Male	Female	Male	Female	Male	Female	Male	Female
Smith	8,680	51,174	9,751	39,743	7,411	35,770	11,748	58,742
Umpqua	18,104	116,188	10,339	62,786	12,174	74,118	12,197	84,590
Total	26,784	167,362	20,090	102,520	19,585	109,888	23,945	143,332

TABLE 3.

SEASONAL SHAD LANDINGS OF UMPQUA AND SMITH RIVERS IN NUMBERS OF FISH, 1947 AND 1948

		May		June		Total	
River	Year	Male	Female	Male	Female	Male	Female
Smith	1947	6,250	19,331	3,493	20,403	9,743	39,734
Umpqua		5,244	22,625	5,095	40,161	10,339	62,786
Total		11,494	41,956	8,588	60,564	20,082	102,520
Smith	1948	4,226	10,541	3,185	25,229	7,411	35,770
Umpqua		4,952	30,161	7,222	43,957	12,174	74,118
Total		9,178	40,702	10,407	69,186	19,585	109,888

It will be noted from the tables that the largest portion of the catch is taken from the Umpqua itself and that more are taken in June than in May. It is also shown that the ratio of bucks to roes in the catch is between one to five and one to six. This is apparently due to the selectivity of the fishing gear. The male shad are smaller on the average than the females and consequently fewer numbers of them are taken by the gear which, as has been pointed out, is limited to a six-inch stretched mesh minimum size. In addition, the shad are valued mainly for their roe, so the demand and consequently the price paid for males is practically nil. During World War II, a large quantity of shad was kippered and canned, but normally a good share of the males and the female carcasses are disposed of for fish bait at a relatively low price. This price differential between roes and bucks has also tended to keep the percentage of bucks in the catch at a low level. Consequently, as long as these fishing and marketing practices are continued, it is the effect of the fishery on the females only that will require consideration.

Tagging

From 1946 through 1949, a small-scale tagging program has been conducted on the Umpqua shad. Most of the fish were caught in a commercial gillnet operated on the lower section of the Umpqua below the mouth of Smith River. It was found that the major part of the run each season passed through this section within a relatively short period of time. This area is also below the commercial fishery since the shad pass through this area in "waves" and their abundance is not as consistent as farther up in the Smith and Umpqua where they are congregating prior to and during spawning. Therefore the tagged fish released in this area were available to the entire commercial fishery.

In Table 4 are shown the number and type of tags released below the mouth of Smith River each year in an attempt to get some estimate of the fishing mortalities on this species. Also shown are the number and per cent returned.

For the first three years of this study, it was considered that the recovery of tags from the fishermen was nearly 100 per cent. The fishermen and dealers were contacted frequently and their cooperation was excellent. Each fish was handled several times before it was processed and the maximum number of dealers in any one year was five. Chi-square tests each year involving a comparison of the ratios of tagged to untagged fish caught by each dealer's fishermen indicated that there was no significant difference between the ratios of tagged to untagged fish handled by each dealer. In 1949, however, the tag recovery program was not conducted as intensively as in previous years. Subsequent investigation and a comparison of the ratio of tagged to untagged shad by individual dealers, using a chi-square test, indicated rather poor cooperation from one of the dealers that year in returning the tagged fish.

Button type tags were used, i. e., plastic discs affixed one to each side of the fish just below the dorsal fin by means of a nickel pin through the body at that point. It was soon evident that many fish thus tagged were recaptured because the tag became entangled in the net and not because the fish itself was caught in the net. In order to avoid this selectivity, a different tag was tried along with the button tags in 1948 and 1949. This tag consisted of a Number 2 commercial pig ring to which was attached a plastic strip about one-quarter of an inch wide and about one inch in length. This strip had the tag number and name of the organization on it and had a hole in the end through which was threaded the pig ring. The tag was attached by clamping the pig ring on the dorsal side of the caudal peduncle at approximately the base of the dorsal, caudal fin ray. The celluloid strip then lay flat alongside the caudal fin. A careful examination of recaptured fish thus tagged revealed no evidence of these tags working loose. Also large numbers of the commercial catch were examined and no fish were observed which appeared to have lost one of the "pig ring" type tags. Many of the fishermen who caught fish bearing this type of tag were questioned, and only one reported that the fish was captured because the tag was tangled in the net. Apparently the pig ring tags used on shad in this manner are practically non-selective. It was found that the pig rings had a tendency to corrode in the brackish water, but since in these investigations it was only necessary that they stay on the fish about a month, this defect was not considered serious.

In 1948, 121 fish were tagged with button tags and 103 were tagged with the pig ring type. (Some of these were tagged and released above the mouth of Smith River.) The tagging localities were comparable but most of the button tags were released about a week previous to the pig ring tags. Of the button tags 38 were returned and of the pig ring tags, 21. This amounts to a recovery of 31 and 20 per cent respectively, indicating that perhaps about 65 per cent as many shad tagged with pig ring tags were recaptured as those tagged with button tags; this assumes of course that the pig ring tags remained on the shad as well as the button type tag.

In 1949, of the 522 fish tagged, 157 button tags and 196 pig ring tags were put out as nearly as practicable on alternate fish at the same tagging locations and time periods, and on fish of very close to the same size distribution. This was done to further study the selectivity of button versus pig ring tags. Due to the reported loss of an unknown number of tags by one of the dealers this year, it became necessary to estimate on the basis of tag returns by other dealers the number so lost. This was calculated to be 25 tags which were prorated according to the ratio of those returned. These were calculated to be 10 button tags and 15 pig ring tags of which six belonged to the "selectivity" experiment. Of the 157 button tags released a calculated 66, or 42 per cent, were recaptured and of the 196 pig ring tags released 58, or 30 per cent, were calculated to have been taken. This indicates that about 71 per cent as many fish tagged with pig rings were recaptured as those tagged with button tags. It was interesting to note that of those returned there was but little difference in size distribution between those taken bearing pig ring tags and those bearing button tags.

TABLE 4.

NUMBER AND TYPE OF TAGS RELEASED BELOW MOUTH OF SMITH RIVER; NUMBER RETURNED; PER CENT AND CORRECTED PER CENT RETURNED 1946-1949

Year	Type Tag	Number Tagged	Number Returned	Per cent Returned	Corrected Per cent Returned
1946	Button	104	52	50	34
1947	Button	81	26	32	22
1948	Button	86	29	34	23
1949	Button	157	66*	42	28
1949	Pig Ring	365	97*	27	....

* Calculated in part.

It is realized that the per cent returned indicates only a relative fishing mortality and probably is subject to considerable error due to the few numbers of fish tagged. It would seem that the selectivity on button-tagged fish should vary with the fishing intensity. If this is so, in order to convert "selective" fishing mortalities to "non-selective" fishing mortalities, a different correction factor would have to be used for each level of fishing intensity. Whether the percentage returns for button tags themselves are compared from year to year or whether they are corrected by the percentages arrived at by testing them against pig ring tags, the problem still prevails if there has been a change in the fishing intensity. Very likely the errors of estimate resulting from the small numbers of tags used in this work would far outweigh any discrepancies thus introduced. Therefore, the best estimate of the actual fishing mortalities on shad of commercial size based on this data can probably be obtained by averaging the two previously calculated selectivity factors, 65 and 71 per cent, and applying this average to the fishing mortalities calculated from button tags. This corrected estimate of the fishing mortality is shown in the last column of Table 4.

In the course of tagging, several interesting migrations have occurred. In 1948 one fish tagged in the Umpqua was recovered 14 days later in the Siuslaw River which enters the ocean about 20 miles north of the Umpqua. Two tagged fish made a similar migration in 1949. Following the closure of the fishing season in 1946, 22 shad captured by dipnet from the Brandy Bar area were tagged. Three of these were recaptured in the Umpqua the following year. In 1947, 89 fish were likewise tagged and two of them were recaptured the following year. Also, one of the tagged fish released in the regular course of operations in 1947 was recaptured in 1948 in the Umpqua and another was recaptured in Coos Bay, about 30 miles south of the Umpqua in May, 1949. No postseason tagging was conducted in 1948. However, one tagged fish was recaptured in 1949 which had been released in 1948; all of the tagged fish described in this paragraph were tagged with button tags.

Population and Fishing Indices

During the course of this investigation, there have been reviewed for the four years 1946 through 1949 several different measures of the abundance of the shad population of the Umpqua system. These are the total catch, the average catch of selected fishermen, and an estimate of the total population of commercial-sized fish entering the river each year. For these four years the average catch of selected fishermen has been calculated in numbers of females for Smith River and Umpqua River fishermen and from these has been derived an average, weighted by the number of fishermen on each river as an index of the whole. That there probably is competition between gear in this fishery and that an increase in the number of fishermen tends to reduce their individual catches is indicated by Figure 2. The log of the average catch per fisherman is plotted against the calculated number of fishermen each year as presented in Table 1, and in spite of other factors such as availability and abundance, a significant curvilinear correlation is evident. The estimates of total population of commercial-sized shad have been calculated in numbers of females on the basis of the total catch and the corrected percentage of tags returned each year.

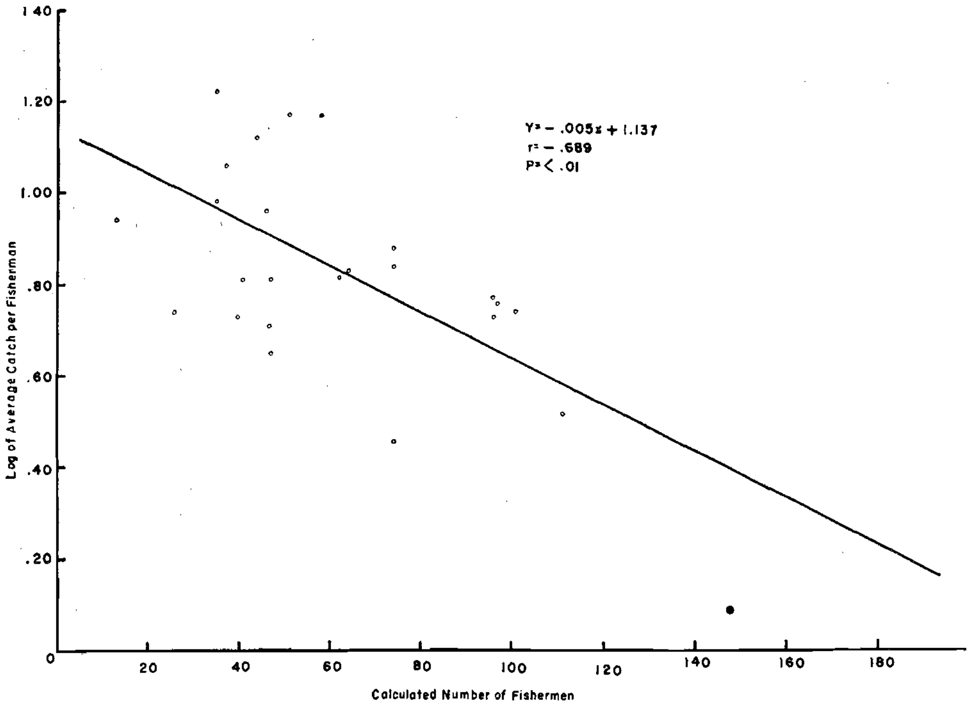

Figure 2. THE RELATIONSHIP BETWEEN THE NUMBER OF UMPQUA RIVER FISHERMEN AND THE CATCH OF SHAD PER FISHERMAN PER SEASON.

Several indices of the fishing intensity have also been derived. The calculated number of fishermen has been computed as in Table 1, except that for this four-year period it is based on the total catch of females and the average weighted catch per selected fisherman. The relative fishing intensity should also be indicated by the percentage of tags returned each year. In addition, the number of fishermen both for the Umpqua and Smith Rivers was determined by actual survey during this period. These various measures are shown in Table 5.

TABLE 5.

MEASURES AND INDICES DETERMINED 1946-1949

Year	Total* Catch	Average Catch per Fisherman* Smith	Umpqua	Average	Est.* Population	Per cent Fishing Mortality	Calculated Number of Fishermen	Number of Fishermen Smith	Umpqua
1946	167,362	6,010	2,836	3,551	492,000	34	47	16	55
1947	102,520	3,964	1,425	2,028	466,000	22	51	19	61
1948	109,888	4,076	2,515	2,837	478,000	23	39	13	50
1949	143,332	6,748	2,839	3,759	512,000	28	38	12	39

* Number of females.

It will be noted that the total catch, average catch per fisherman and estimated populations of commercial sized fish follow the same trend. However, the rate of change from year to year varies between the different measures. This was particularly true in 1947 when an abundant growth of "moss" (filamentous green algae) in the Umpqua River seriously interfered with the Umpqua shad fishery. This condition did not occur to as great an extent in Smith River. The nets became so clogged with the algae and had to be cleaned so frequently that they could not be fished as intensively as in other years. Even while the nets were being fished, they did not operate as efficiently as they normally should. As shown by the tag returns, this actually resulted in a reduction in the fishing mortality from the previous year in spite of the fact that the other measures indicated that the intensity had increased. In 1949, the intensity measures show a reduction from 1948. Actually, according to the tagging data, the fishing mortality was higher in 1949 than 1948. Assuming that this increase in percentage of tag returns did not result from the small numbers used in the experiments, it can be explained by the fact that in 1949 the shad fishery was the only major commercial fishery permitted on the Umpqua, and it was only by intensifying their fishing efforts that the more successful fishermen were able to remain in the fishing business. It appears from this that, if the number of fishermen is used as a measure of the fishing intensity, cognizance must be taken of factors which might affect their efficiency.

Market Samples

Figure 3 shows the length frequencies of samples of shad taken by the commercial fishery of the Umpqua system. As is indicated, the average length of the males is less than that of the females. It seems apparent from these curves that, if many females occurred at lengths from 15 to 17 inches in the river, they should be taken by the fishing gear. Also, if many males occurred between 19 and 20 inches in length, they should be taken by the fishing gear. As mentioned before, factors of 4¾ pounds for roes and 3¼ pounds for bucks have been used to convert catches reported by numbers into pounds for tax purposes. Preliminary studies based on small samples indicate that these factors may be somewhat high. Further study is being made on this problem. These samples indicate that no major change has taken place in the size composition of the catches during the past three years and therefore support the other evidence that the Umpqua shad populations are being maintained under the present fishery.

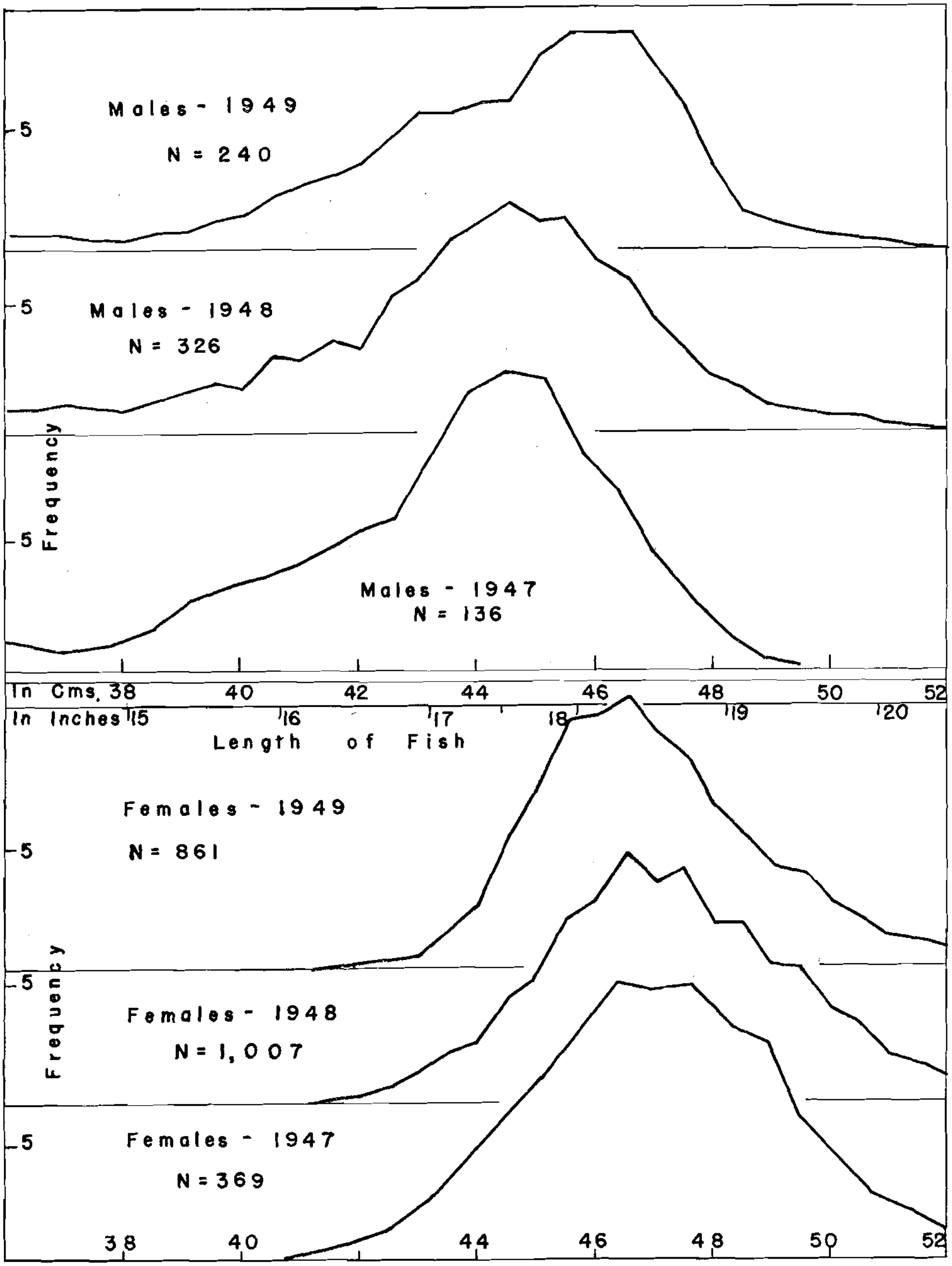

Figure 3. UMPQUA RIVER MALE AND FEMALE SHAD LENGTH FREQUENCY SAMPLES, 1947, 1948, AND 1949.

Discussion

The shad populations of the Umpqua River system support an important commercial fishery, which, as presently regulated, interferes but little with other species of fish in the river. This investigation confirms the findings of the preliminary survey of 1946, namely, that the Umpqua River shad fishery under present regulations is not overfishing the shad population. Whether or not the production is at an optimum level cannot be determined until studies of age determination and growth-rate are completed. Meanwhile, rough but feasible determinations of the relative conditions of the population can be made each year by a careful analysis of such indirect measures as total catch, catch per fisherman, number of fishermen, and the size composition of the commercial catch.

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[1] Manuscript completed after author appointed Research Coordinator for the Pacific Marine Fisheries Commission.

Brown Trout Taken in Columbia River

A brown trout (*Salmon trutta*) weighing about three pounds was taken in an Indian dip net at Celilo Falls on September 3, 1949. The Indian who captured the fish was not willing to part with it and so it was examined superficially. The typical dark, rather large black spots, each surrounded by a pale band were present on the body and opercle. Orange spots were absent. Ten anal fin rays were present. The pattern of the rings on the scales indicated that the fish may have gone to sea, in which case it was truly anadromous.

Brown trout were introduced into this country from Europe many years ago and were once extensively planted in Oregon streams. In recent years there has been no artificial propagation of brown trout in Oregon, but the species has maintained itself in some watersheds, particularly the Deschutes River.

Extensive migrations to the sea and back to native streams are common in Europe, but have been virtually unknown in North American waters. Apparently a small but definitely migratory population of brown trout is now present in the Columbia River. Tagging crews of the Oregon Fish Commission and Washington State Department of Fisheries obtained and marked one brown trout at Bonneville Dam on July 22, 1948. This fish was retaken at Celilo Falls. A third specimen was taken in a trap near Camas, Washington, in November, 1949.

Fishermen at Celilo Falls and near Camas have remarked that a number of brown trout have been taken in recent years.

Laboratory Established on Southern Oregon Coast

A laboratory has recently been established at the Oregon State College Marine Institute at Charleston, on Coos Bay. This is the headquarters for the investigations of salmon, shad, and striped bass in the southern coastal rivers. Facilities here will also be used in the study of shellfish, the ocean troll fishery, and the trawl fishery in this area.

OBSERVATIONS ON PULP AND PAPER EFFLUENTS AND THE PROBABLE EFFECTS OF THIS POLLUTANT ON THE FISHERIES RESOURCES OF THE WILLAMETTE RIVER IN OREGON [1]

Introduction

For years investigators in various parts of the world have studied the effects of pulp and paper mill effluents on aquatic resources. It has been found and reported many times that one of the most obvious effects of dumping great amounts of pulp mill liquor into the rivers and bays has been to reduce the amount of oxygen in the water. This reduction is caused by the tremendous oxygen demand necessary for biological utilization of the organic components of the waste liquor by bacteria.

In the Midwest investigators have found veritable barren wastes devoid of aquatic life for miles below the pulp mills caused by a complete lack of oxygen in the water.

Here in the Northwest complaints have been common for years of the damaging "fish kills" and destruction of all aquatic life in the vicinity of the pulp mills and those waters affected by the waste. A pulp mill began functioning on southern Puget Sound in the vicinity of the town of Shelton during the year 1927. It was not long after that oyster growers and residents along the adjacent bay began complaining about the unexpected high mortality of shellfish and other aquatic organisms. Competent government research men (Hopkins, Galtsoff, and McMillin, 1931) reported that in all likelihood the death of shellfish in this bay was due to the presence of waste sulfite liquor from the pulp mill at Shelton. Investigation after investigation followed in rapid succession in this area with the company owning the pulp mill naturally trying to prove that the mill had no detrimental effects on the fish and shellfish while government scientists concluded that the mill had caused the damage. In 1944 after many lawsuits and in the face of overwhelming evidence of damage to aquatic resources, the mill temporarily shut down and converted its process to a type in which the waste is burned and some portions of the chemicals are recovered. About the time this action was being done the senior author was part of a team of biologists engaged in investigating the causes of the decline in the native oyster populations in Puget Sound. These investigations showed conclusively that not only was the pulp mill the cause of the unprecedented depletion of this resource, but that the waste sulfite liquor was toxic to shellfish and other aquatic organisms in very minute concentrations, actually as low as 13 parts of the liquor in one million parts of water (McKernan, Tartar, and Tollefson, 1949).

Effects of Pollution

Thus, returning to the Willamette River and applying these results to the aquatic resources of this river system, it is evident that the waste liquor from sulfite pulp and paper plants is dangerous to the river environment of aquatic organisms from two different aspects. First, the millions of gallons of waste sulfite liquor entering the Willamette River

[1] Presented at a public hearing of the Oregon Sanitary Authority, February 15, 1950, Portland, Oregon.

at Lebanon, Salem, Newberg, and Oregon City contribute tremendously to the organic material drawing heavily on the dissolved oxygen so necessary for the proper environment of aquatic organisms. Second, the proven toxic fraction of the waste liquor has an undetermined inimical effect on the fish populations directly, and is of equal detriment to those whole groups of microscopic and macroscopic animals upon which the fish feed and which together make up the normal ecological pattern of a river of this type.

Willamette River Salmon Populations

That the Willamette River once contained a large and varied fish population, there can be little doubt. In the early journals describing the country and the Indian inhabitants are colorful accounts of a great Indian fishery at the Willamette Falls where Oregon City is now located. Rough calculations based on the numbers of Indians present and their individual catches indicate a harvest by the Indians of perhaps two million pounds of salmon each year. There seem to have been large runs of fall as well as spring chinook, steelhead trout, and possibly silver salmon. All that now remains of these formerly large populations of fish is a declining run of spring chinook salmon of less than 50,000 adults. This run of spring chinooks has been protected from the commercial fishery to a great extent for about forty-five years, although a sport fishery exists which harvests at the present time about 10,000 adults each year.

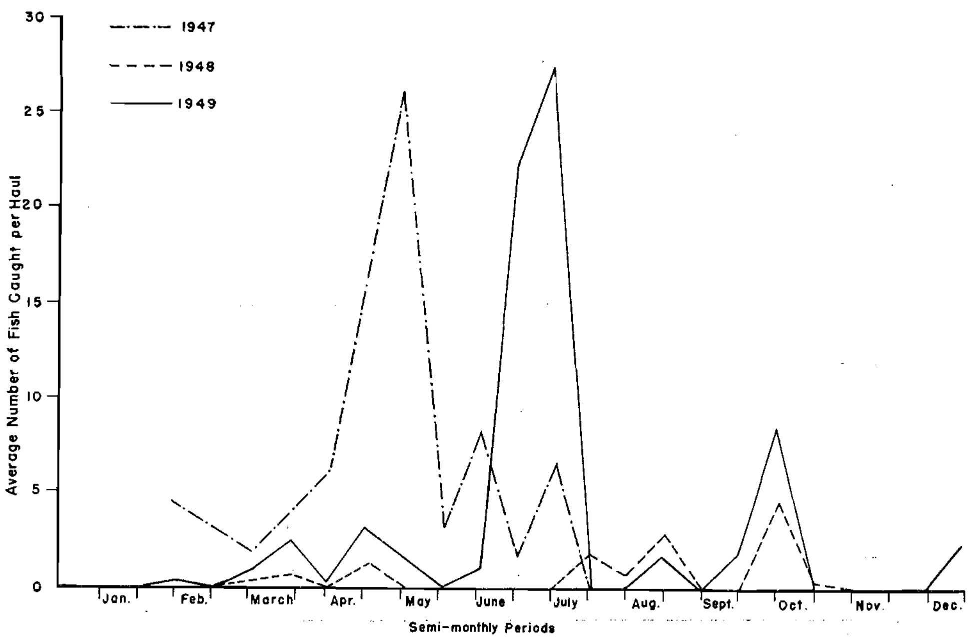

Figure 1. AVERAGE NUMBER PER HAUL OF SPRING CHINOOK SALMON MIGRANTS TAKEN DURING THE PERIOD OF SAMPLING AT THE OSWEGO STATION FOR THE YEARS 1947, 1948, AND 1949.

Pollution as a Limiting Factor to the Salmon

Without equivocation it can be stated that one of the major factors limiting the population of salmon in the Willamette River is pollution, and of all the pollution present in the river that from the pulp and paper mills is undoubtedly the most serious.

Data on the life history of the various runs of salmon provide interesting information. In 1941, Dr. Lawrence Townsend of the Fish and Wildlife Service began studies on the life history of the spring chinook salmon of the Willamette River (Craig and Townsend, 1946). These studies have been continued more intensively since 1946 by the Oregon Fish Commission. The objectives of these researches have been to determine not only the time and size at which the small salmon migrate downstream to the sea, but also the proportion of the young which survives to become adults. Figure 1 shows the migration of the spring chinook by two-week periods in the lower part of the Willamette River below Oregon City Falls in 1947, 1948, and 1949. It should be noted that at the present time the majority of the migration takes place between April 15 and July 15. In 1948 exceptionally high water prevented successful investigations of the numbers of young salmon migrating through the river during May and June. The migration dropped sharply in July, 1949, from the peak

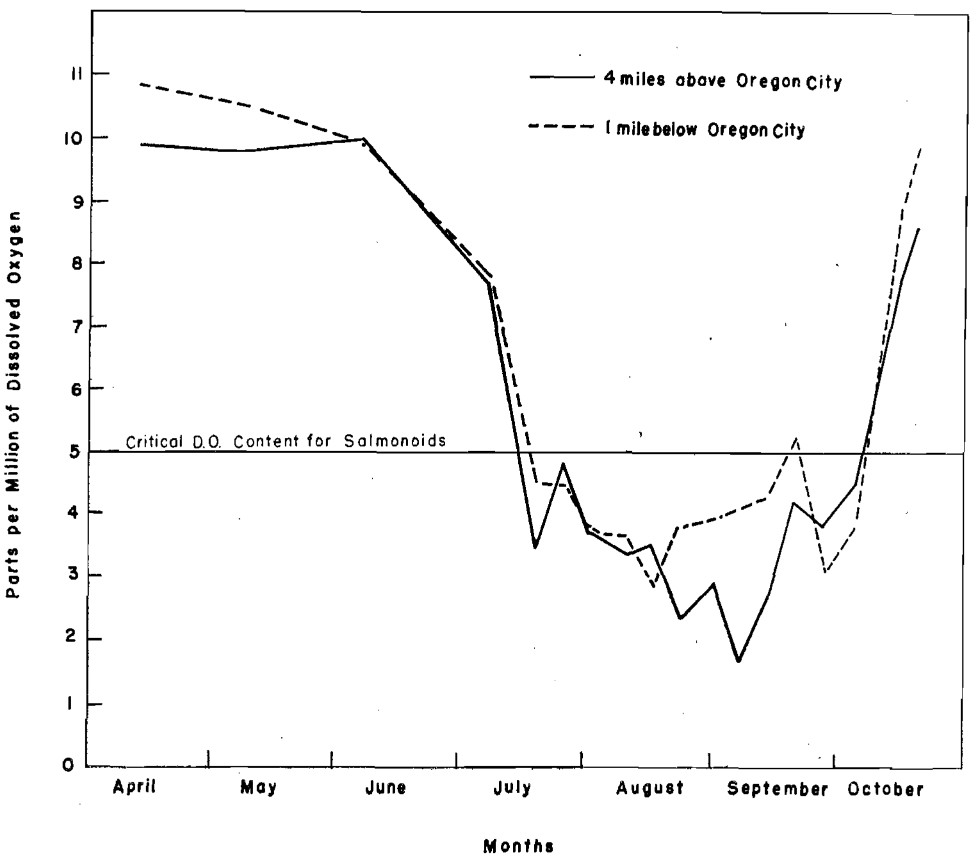

Figure 2. DISSOLVED OXYGEN CONTENT OF THE WILLAMETTE RIVER IN 1949.

migration to zero. It seems rather obvious that some factor had caused this rather drastic decline in the migration other than the normal tapering decline which one might expect. Practically no additional fish were taken again until October. Studies by various investigators indicate that salmon and trout require a dissolved oxygen content of at least five parts of oxygen for every one million parts of water to live and prosper in an aquatic habitat. Data collected in 1949 by Drs. F. F. Fish and R. A. Wagner of the Fish and Wildlife Service are shown on Figure 2 (Fish and Wagner, 1950). It may be seen that the dissolved oxygen content fell rapidly in the lower Willamette River during June, reaching the critical state during the first few days of July, and dropping to almost zero in early September in the Portland Harbor. On Figure 3 may be seen the number of migrant salmon fingerling taken during each two-week period and also the decline of the dissolved oxygen content of the water in the Portland area. The date of the sharp drop and disappearance of downstream migrants found

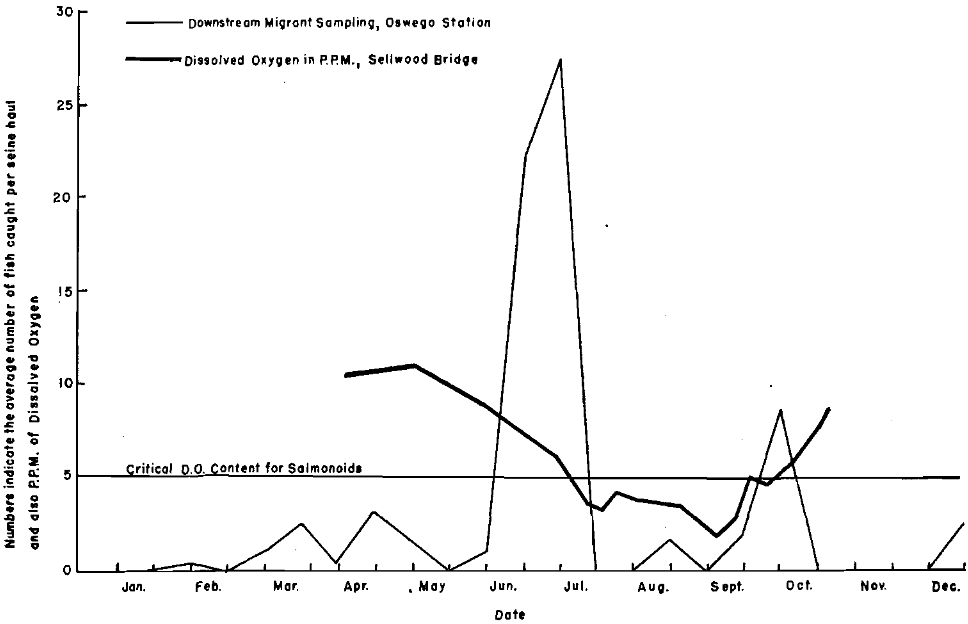

Figure 3. AVERAGE NUMBER OF SPRNG CHINOOK SALMON CAUGHT PER SEINE HAUL AND THE DISSOLVED OXYGEN CONTENT OF THE WATER IN THE LOWER WILLAMETTE RIVER IN 1949.

in the river corresponds almost identically with the date the oxygen content of the lower Willamette River dropped below five parts per million. At the same time the temperature of the water in the river rose, but never reached the upper tolerance level of salmonoids (approximately 80°F.). Figure 4 shows the temperatures of the Willamette River near Oswego at the site of one of the migrant seining stations. The temperature never rose above about 75°F., and was below that when the young salmon disappeared. It seems highly probable that the disappearance of the salmon migrants was associated with the decline in oxygen content of the water rather than with any other factor. When the oxygen content of the water rose above 5 p.p.m., fingerling salmon were again taken (Fig. 3).

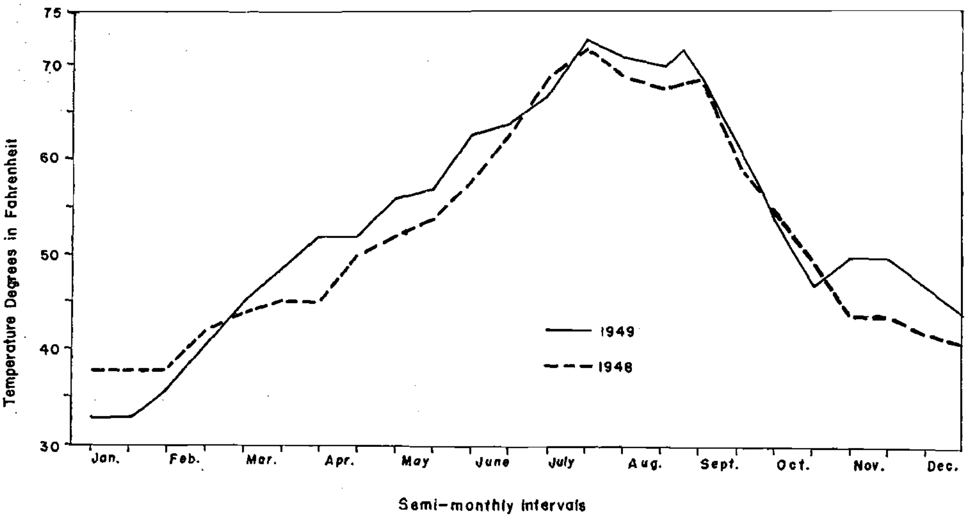

Figure 4. WATER TEMPERATURES AT THE OSWEGO SEINING STATION FOR 1948 AND 1949.

Studies by Merryfield and associates over a period of years from about 1929 to the present have conclusively shown the gradual increase in pollution in the main river and the decrease in dissolved oxygen content of the water during the summers of the past two decades (Rogers, Mockmore, and Adams, 1930; Gleeson, 1936; Merryfield, Bollen, and Kachelhoffer, 1947; and others).

Figure 5 shows the egg-take on the Willamette River since 1918 by the four hatcheries of the Oregon Fish Commission. Although various factors influence the egg-take in any one year, in general the magnitude may be assumed to depict the general size of the runs with a fair degree of certainty. It may be seen that the egg-takes (i. e., runs of salmon) have declined about 80 per cent since the peak in 1928. During this time no significant changes have been made in commercial fishing seasons although it is true that the sport fishery in the Willamette has increased to some extent. It is significant to note that the observed decline in the spring chinook salmon as depicted by the hatchery egg-take has occurred during the period when the pollution of the Willamette has increased so tremendously. The abundance of spring chinook salmon in the Columbia River, as measured by the counts over Bonneville Dam and the total river catch, has declined about 33 per cent since 1928. The Willamette River chinook run, on the other hand, as measured by the egg-takes at the four Willamette hatcheries, has declined about 80 per cent. Thus, it is obvious that some additional factors are operating on the Willamette River salmon which are not operating on the Columbia River spring chinook populations. The most serious of these would seem to be pollution, and data substantiate the hypothesis that the most serious limiting effects of the pollution appear to be operating on the young salmon migrating to sea during the late spring and summer.

Sizeable runs of fall chinook formerly entered the Willamette River and spawned in various tributaries including the Clackamas River. These runs of salmon have been eradicated. Of course the fall chinook, migrat-

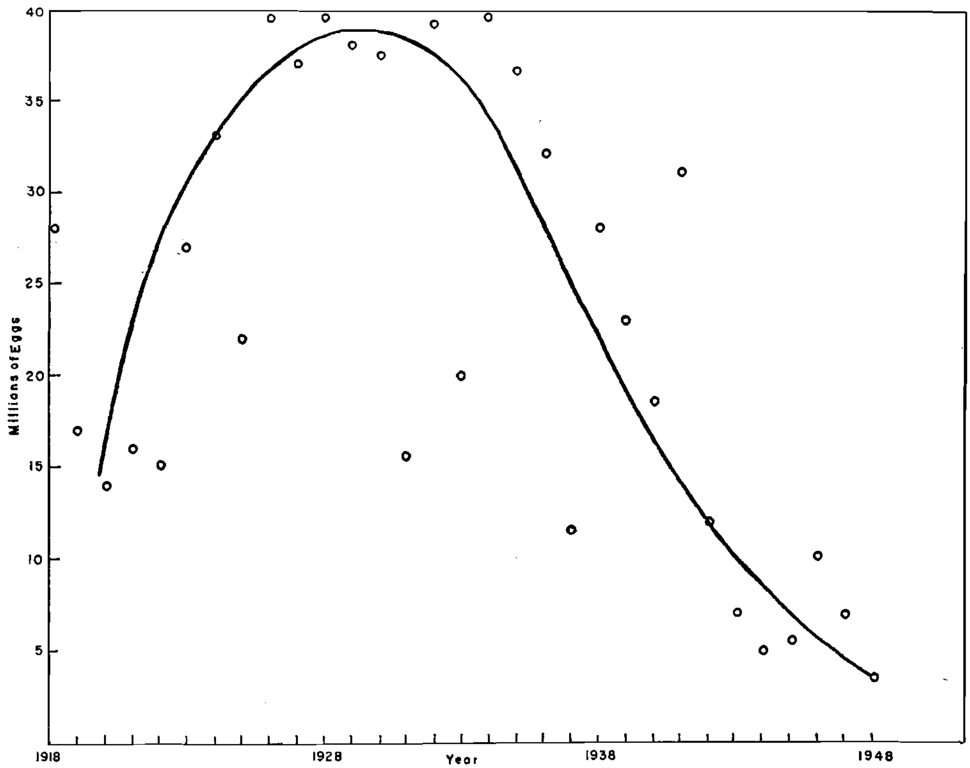

Figure 5. EGG TAKES AT THE WILLAMETTE RIVER SALMON HATCHERIES OF THE OREGON FISH COMMISSION, 1918 TO 1948.

ing into the Willamette in August and September, would find a complete block to their migration because of the absence of sufficient amounts of oxygen in the water in the lower river.

Silver salmon also have been similarly affected. Even though this species migrates much later, entering the Willamette probably in October and November, the pollution block coupled with the poor fish passage facilities at the Willamette Falls have resulted in keeping the silver salmon stocks of the Willamette at a very low level of abundance.

Steelhead have been similarly affected. The young steelhead, migrating out in the early summer, have come into contact with the oxygen block in the lower Willamette.

A sizeable shad run appears below Oregon City each spring, and a large population occurs in the Willamette Slough. Both areas are directly affected by the summer pollution block since shad spawn in late spring and early summer in these areas. The young as well are forced to leave the lower Willamette River before the oxygen block occurs.

Sturgeon are found in considerable abundance in the Willamette as far up as the falls at Oregon City, but disappear in late June, presumably forced out by the lack of oxygen in the lower Willamette during the summer.

Value of the Willamette Chinook Runs

Estimates made by the Oregon Fish Commission place the present value of the Willamette River spring chinook run at $1,000,000. At present levels of values, a return to the moderate productivity of the river in 1928 would increase the value of the resource to at least $5,000,000 (present stocks being less than 20 per cent of 1928 level). Considering the other stocks of fish which in past years have been produced in the Willamette River in numbers, it seems that a potential annual value of between seven and 10 millions of dollars can be realized from the fisheries resource of the Willamette if it is carefully nurtured and developed to its maximum productivity.

Consider for a moment the value of a fall sport fishery on the lower Willamette within Portland city limits which can most certainly be developed if fall runs of fish can be reintroduced into the river system and the lower river is again made a suitable habitat for aquatic life.

The river development program on the main Columbia River threatens to destroy the most productive salmon areas of the middle and upper Columbia River through the erection of numerous barriers in both the main Columbia and Snake Rivers. The Federal Government, in cooperation with the states of Oregon and Washington, has begun a program of lower river development to develop in all possible haste the fisheries resources of the Columbia River tributaries below McNary Dam. This of course includes the Willamette River. If the fisheries resources of the Willamette are to be improved, then the serious pollution of the river must be abated. Since the runs of salmon and steelhead in this system seem to be limited to a marked degree by the pollution of the lower river, it is urged that the serious pollution by various industrial plants as well as municipalities be corrected immediately. Pollution by the pulp and paper industry is especially serious because of the amount of the pollutant, its high organic content, and the probable toxic properties of waste sulfite liquor on salmonoid fishes.

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Occurrence of Marine Flounder in Columbia River

Unlike the salmon, shad, and other anadromous fishes, which regularly migrate from the sea to fresh water for the purpose of spawning, there are but a few marine species of fishes which can ascend the rivers and remain in fresh water without any harm to them. However, it is not unusual to find occasionally some species of marine fishes, particularly flounders in certain rivers, far above the tidal water. A number of different flounders in many parts of the world have such a habit of leaving their native sea and swimming up the streams.

The Pacific starry flounder, the sole representative of the genus *Platichthys*, which is widely distributed in the northern part of the Pacific Ocean from Bering Strait to California and Tokyo, has also such a peculiar habit. The Russians even call it "Pacific river flounder," because it occurs so often in Amur River in Eastern Siberia as far as 100 miles from the Sea of Okhotsk. The same fish ascends the Columbia River, probably as far as Bonneville Dam. Some specimens of this flounder were obtained from a fish trap near the mouth of the Sandy River, about 100 miles from the sea.

This comparatively large (up to 15-20 lb.) species is an important commercial fish, which constitutes a considerable portion of the total catch of flounders on our coast. It can be easily distinguished from other flounders by the numerous stellate tubercles, especially along the bases of dorsal and anal fins, and by wide black bars on dorsal, anal, and caudal fins.

STUDY OF THE WATER SUPPLY AT THE NEW MARION FORKS HATCHERY ON THE NORTH SANTIAM RIVER

Introduction

With the erection of the Detroit and Big Cliff Dams on the North Santiam River, a tributary of the Willamette River which is in turn a tributary of the Columbia River, 40 to 45 miles of the upper North Santiam River and its tributaries will be lost for natural reproduction by spring chinook salmon and steelhead trout. The North Santiam River above the town of Stayton, with its tributaries, Little North Santiam River, Breitenbush River, Marion Creek, Minto Creek, Whitewater Creek, and Pamelia Creek, as well as smaller tributaries, forms one of the best natural spawning areas for the spring run chinook salmon in the entire Willamette River system.

To compensate for loss of spawning grounds a hatchery has been constructed in the Marion Forks area, which is 16 miles east of Detroit and 36 miles east of Mill City (Fig. 1). This paper deals with the experimental work which took place prior to the building of the hatchery to determine the feasibility of the site. The work was done between September, 1948, and July, 1949.

Water Supply

Marion Creek is a clear, cold, swift mountain stream which heads in Marion Lake about seven miles north of Marion Forks. The flow is about 100 cubic second-feet at low water, and the temperature of Marion Creek varies from a summer high averaging about 55 degrees to a winter low of 32 degrees with much anchor ice being formed. Horn Creek, one of the possible water supply sources, empties into Marion Creek at the Marion Forks Bridge area. This creek is formed by the confluence of many scattered springs and heads about two miles east of Marion Forks. Horn Creek varies little in flow with the seasons, and has a summer temperature of about 45 degrees and a winter temperature of from 35 to 38 degrees. The minimum flow of Horn Creek is about 15 second-feet. Bcause of the unique temperature and water flow conditions it was planned to use both Marion Creek and Horn Creek water, in varying proportions, depending upon the time of year for the hatchery water supply.

Problem and Objectives of Experiment

Since it was thought that both water systems (Horn and Marion Creeks) would have to be used in the proposed hatchery, it was decided that an experimental hatchery would be set up in such a way as to compare the waters of Horn and Marion Creeks with regard to the success of the incubation of salmon eggs and subsequent survival and growth of the fry. Operations of the proposed hatchery would be simulated to see how the eggs and young fish would react.

Experimental Setup

During the month of September, the Marion Forks area was visited to prepare the troughs for the eggs. Four troughs 8″ x 14″ x 15′ were placed

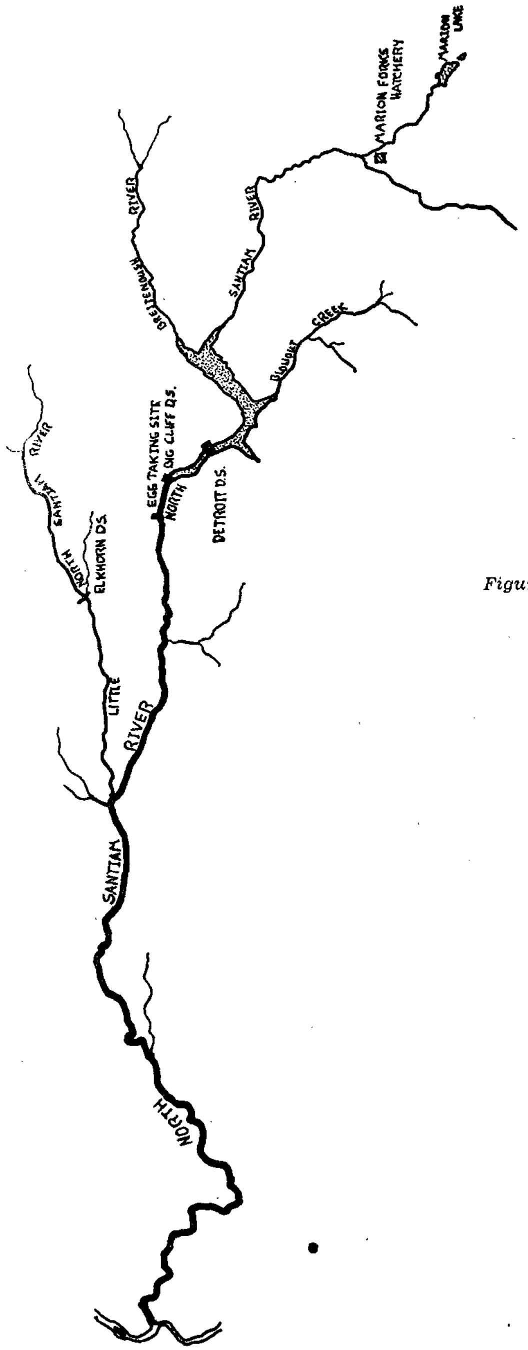

Figure 1. THE NORTH SANTIAM RIVER SHOWING THE LOCATION OF DETROIT AND BIG CLIFF DAMS AS WELL AS THE SITES OF THE NEW HATCHERY AND EGG TAKING RACKS.

in Horn Creek just below a small dam. Water was piped to the troughs from the dam, and insofar as possible flows were held at five gallons a minute for each trough. Water for a second set of troughs was obtained from Marion Creek. The water flow into these troughs was likewise kept as close to five gallons per minute as was possible.

Handling the Eggs

On the 24th of September, 30,498 water-hardened spring chinook eggs taken by Mr. Orval Greer at the Breitenbush fish racks on the North Santiam River were transported by truck to the Marion Creek site. These eggs were placed to incubate in a regular hatching basket in the Marion Creek water. This lot of eggs was designed as Lot 1.

On the 29th of September, 22,506 water-hardened spring chinook eggs also taken at the Breitenbush racks, were transported to the Horn Creek troughs and placed therein to incubate. The distance to both Marion and Horn Creek troughs from the Breitenbush racks was the same (19 miles). Two miles of this was over a graded dirt road and the other 17 over a good oiled highway. This lot of eggs was also placed to incubate in a standard hatching basket and was designated as Lot 2. Records as to temperature, temperature units, mortality, etc., were kept throughout the incubation period and are summarized in Table 1.

TABLE 1.

SUMMARY OF DATA RELATIVE TO INCUBATION AND HATCHING OF SPRING CHINOOK SALMON EGGS HELD IN EACH OF TWO ALTERNATE WATER SUPPLIES AT MARION FORKS, UPPER NORTH SANTIAM RIVER, OREGON, FROM SEPTEMBER 1948 TO MAY 1949

	HORN CREEK					MARION CREEK				
Date	Avg. Daily Temp. °F.	Lot 2 Cum. T. U. [1]	Mort.	Lot 3 Cum. T. U.	Mort.	Avg. Daily Temp. °F.	Lot 1 Cum. T. U.	Mort.	Lot 4 Cum. T. U.	Mort.
Sept. 24-30	44°	25	29	....	...	49°	116	0	....	....
Oct. 1-15	44	198	0	....	...	46	334	0	....	....
16-31	41	349	242	....	....	42	501	86	....	....
Nov. 1-15	41	477	246	....	....	40	618	260	....	....
Nov. 16-30	40	590	455	724[3]	0	38	714	457	....[4]	....
Dec. 1-15	38	682	48	816	26	37	782	24	658	27
16-31	36	753	52	886	8	34	822	20	698	32
Jan. 1-15	37	821	19	954	7	34	852	14	728	8
16-31	37	905	50	1036	12	37	934	45[2]	810[2]	2410[2]
Feb. 1-15	37	986	51	1117	0	37	1017	29	889	2665
16-28	38	1062	35	1195	0	38	1095	0	967	106
Mar. 1-15	40	1178	84	1310	54	40	1211	47	1081	95
16-31	40	1298	3	1430	6	40	1330	30	1202	35
April 1-15	39	1408	16	1541	19	39	1441	10	1312	6
16-30	40	1524	17	1656	7	40	1557	7	1428	29
May 1-15	40	1650	10	1782	5	40	1682	4	1554	11
16-31	42	1809	8	1875	7	42	1841	5	1713	19
June 1-15	43	1970	15	....	....	43	2003	8	1875	29
16-30	43	2135	6	....	....	43	2168	3	2040	32
July 1-15	44	2318	6	....	....	44	2347	1	2222	7
16-18	44	2346	0	....	....	44	2384	0	2259	1

[1] Temperature units (T. U.): the degree of incubation measured by the degrees Fahrenheit above freezing for one day, i. e., 33°F. for one day furnishes one T. U.
[2] All eggs moved to Horn Creek, Marion Creek freezing.
[3] Lot 3 obtained from Lot 1 and placed in Horn Creek on November 23.
[4] Lot 4 obtained from Lot 2 and placed in Marion Creek on December 1.

By late October the steadily dropping temperature of Marion Creek resulted in its becoming colder than spring-fed Horn Creek (Fig. 2). It became obvious by late November that this situation was going to continue throughout the winter so Lots 1 and 2 were each split in order to get a combination of groups of eggs ranging from those having the maximum temperatures obtainable from both water supplies to the minimum that could be provided by either. The purpose of this, in line with the general objectives of the experiment, was to simulate the conditions proposed for operations for the projected hatchery and at the same time to study the effects of each separate water supply upon the development of the eggs and young.

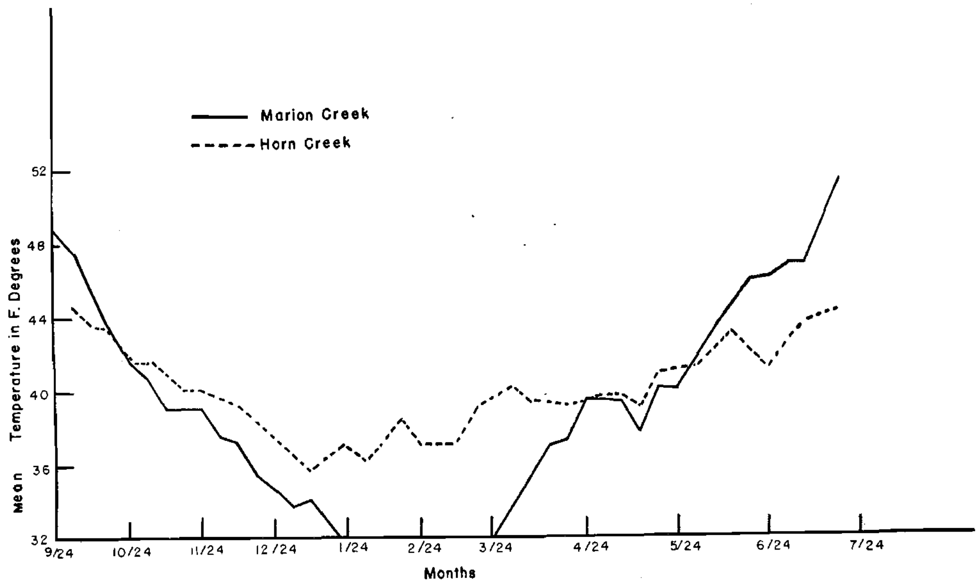

Figure 2. AVERAGE TEMPERATURES OF MARION AND HORN CREEKS, THE WATER SUPPLY FOR THE NEW NORTH SANTIAM HATCHERY, SEPTEMBER 1948 TO JULY 1949.

Splitting of Lots 1 and 2 was accomplished on two separate dates because of the time involved, the short winter days, and the fact that the eggs in Lot 2 were slower in becoming eyed than Lot 1.

On November 22 approximately one-half of the eggs in Lot 1 were transferred from Marion Creek to the Horn Creek troughs and designated at Lot 3. At this time the eggs in Lot 1 were well "eyed up." By December 1 the eggs in Lot 2 were well eyed, so one-half of the lot was transferred from Horn to Marion Creek water and designated as Lot 4. The heavy mortality noted for late November in Lot 1 (Table 1) actually consists of the mortalities that became apparent when the eggs were rolled and did not necessarily occur in that particular period.

Rolling or bumping is a term used by fish culturists to denote the process of siphoning the eggs through a hose about one inch in diameter into a pail after which the eggs are poured back into the hatching basket. This is done when the eggs are well eyed and all dead or unfertilized eggs turn white when so treated. Viable eggs are not injured by this process if proper care is exercised. As far as could be determined by examination of the egg mortalities prior to the eye-up time, the fertilization was at least 98 per cent.

Weather a Problem

On December 24, 1948, due to the freezing conditions prevailing in the Marion Creek water at the trough head-box, it was deemed advisable to combat—insofar as possible—the icing conditions. Consequently, the troughs were covered with tar paper and two kerosene illuminating lanterns were placed, one under the upper end and one at the lower end of the troughs. These lanterns were kept burning almost every night to keep the troughs free of ice and allow movement of the water.

Word was received on January 10, 1949, that the troughs at Marion Creek were slowly freezing over, so a trip was made to Marion Forks on the following day. Upon arrival at 9:30 a. m. it was noted that the water in the head-box was frozen and that there was no water coming into the troughs. At this time Lots 1 and 4 were in the Marion Creek troughs. The illuminating lanterns had permitted the outlet screens of the trough in which the Lot 4 eggs were located to remain free of ice and to drain. This fact with the leaking of the troughs through the bottom allowed the basket of eggs (Lot 4) to become high and dry and be subjected to the below-zero temperatures. Lot 1 trough froze from the outlet screen back, freezing the basket of eggs in the trough. Although there was ice about an inch thick covering the basket of eggs and on both sides of the trough the eggs were still intact in water.

Lot 4 was taken in the basket to the Horn Creek troughs a distance of about 400 yards. The basket containing the Lot 1 eggs was chipped free of the ice and the eggs poured out into a three-gallon bucket of water and transported to the Horn Creek troughs and placed in a basket there. The air temperatures for this period were a —1°F.,—3°F., and —1°F., on the 9th, 10th, and 11th of January respectively, and the eggs had been exposed for a period of possibly six to 10 hours.

No attempt to pick off the frozen eggs was made at that time. Subsequent pick-off showed the losses of the frozen eggs to be about 50 per cent. The figures show that 5,512 mortalities occurred in Lot 4 from December 1, 1948 through July 18, 1949. Of this number approximately 90 per cent of the 5,512 mortalities could be directly attributed to freezing. Fungus on the dead eggs also caused a heavy unmeasurable mortality. It was interesting to note that fungus growths persisted in water of near freezing temperatures. Examination of the mortalities in this lot showed that there was a high incidence of mortality due to premature hatch caused by the freezing of the eggs. The fry and feeding fingerlings showed a greater number of cripples than the other lots not subjected to freezing.

Lot 1, although chipped from the ice in the troughs and taken to Horn Creek amid chunks of ice, showed no abnormal losses and the number of cripples did not exceed those of Lots 2 and 3 which were in the Horn Creek water and not subjected to the icing conditions.

On one occasion only, in mid-December, was ice noted on the pond above the trough site in Horn Creek, and this was a thin film extending about four inches out from the shoreline.

During the winter of 1948-49 about 16 feet of snow fell at the experimental site and at one time the measured snow on the ground was more than eight feet. Normal snowfall at the Marion Forks area is about 60 inches a year, according to Mr. Young, who has been a resident of this area for the past 15 years.

Trips were made once a week during the fall, winter, and early spring to check on the eggs and fry and to pick off mortalities which were recorded and preserved for later study. A local resident examined the troughs each day and kept an account of the temperatures.

Hatching

Attention is drawn to Table 2 which shows the temperature units required for hatching of the various lots of eggs. It is interesting to note that the eggs subjected to very low and freezing temperatures hatched with less temperature units than did those held in slightly warmer water.

TABLE 2.

HATCHING TIME OF RESPECTIVE LOTS OF EGGS RELATIVE TO TEMPERATURE CONDITIONS TO WHICH THEY HAD BEEN SUBJECTED

			Temperature Units Expended to Hatch		
Lot Number	Water Supply	Began Hatching	Beginning	Mid-Point	Completion
1	Marion-Horn	Jan. 18	867	965	1,017
2	Horn	Jan. 26	872	991	1,084
3	Marion-Horn	Jan. 7	920	983	1,057
4	Horn-Marion-Horn	Feb. 3	830	882	988

Absorption of Yolk Sac and Feeding

The average mid-point of hatching was about February 6. Absorption of the yolk sac was accomplished by about June 1. Specifically, on May 26, it was noted that about 50 per cent of the fry in Lot 3—the most advanced group—had begun to surface in search of food, so feeding operations began on that day.

Since fish at the proposed Marion Forks hatchery would be subjected to temperatures in many respects unlike those prevailing elsewhere where spring chinook are reared, and since this experiment presented an opportunity to add to the meager information available on spring chinook rearing, varied diets in use elsewhere were fed to subdivisions of Lot 3. These subgroups were designated, respectively, A, B, C, D, E, and F and the diets and water supply were as follows:

Group	Water Supply	Diet
A	Horn Creek	Liver, 100%
B	Marion Creek	Liver, 100%
C	Horn Creek	Leavenworth Diet [1]
D	Marion Creek	Leavenworth Diet
E	Marion Creek	Dry Meals [2]
F	Marion Creek	Liver, 5%, and Salmon Viscera, 95%

Since Marion Creek had become warmer than Horn Creek about June 1 (Fig. 2) and the warmer temperatures would be required for good growth, four of the six lots were held in Marion Creek water, Lots A and C in Horn Creek having diets duplicating B and D (Marion Creek). The fish were fed twice daily until liberated in mid-July.

[1] The Leavenworth production diet consisted at that time of: beef liver, 20%; hog liver, 20%; hog spleen, 20%; salmon viscera, 30%; salmon meal, 10%; and salt, 2%.

[2] The "meal" diet consisted of beef liver, 40%; alfalfa meal, 18%; wheat germ, 18%; tomato meal, 18%; brewer's yeast, 6%; plus an addition of 2% salt.

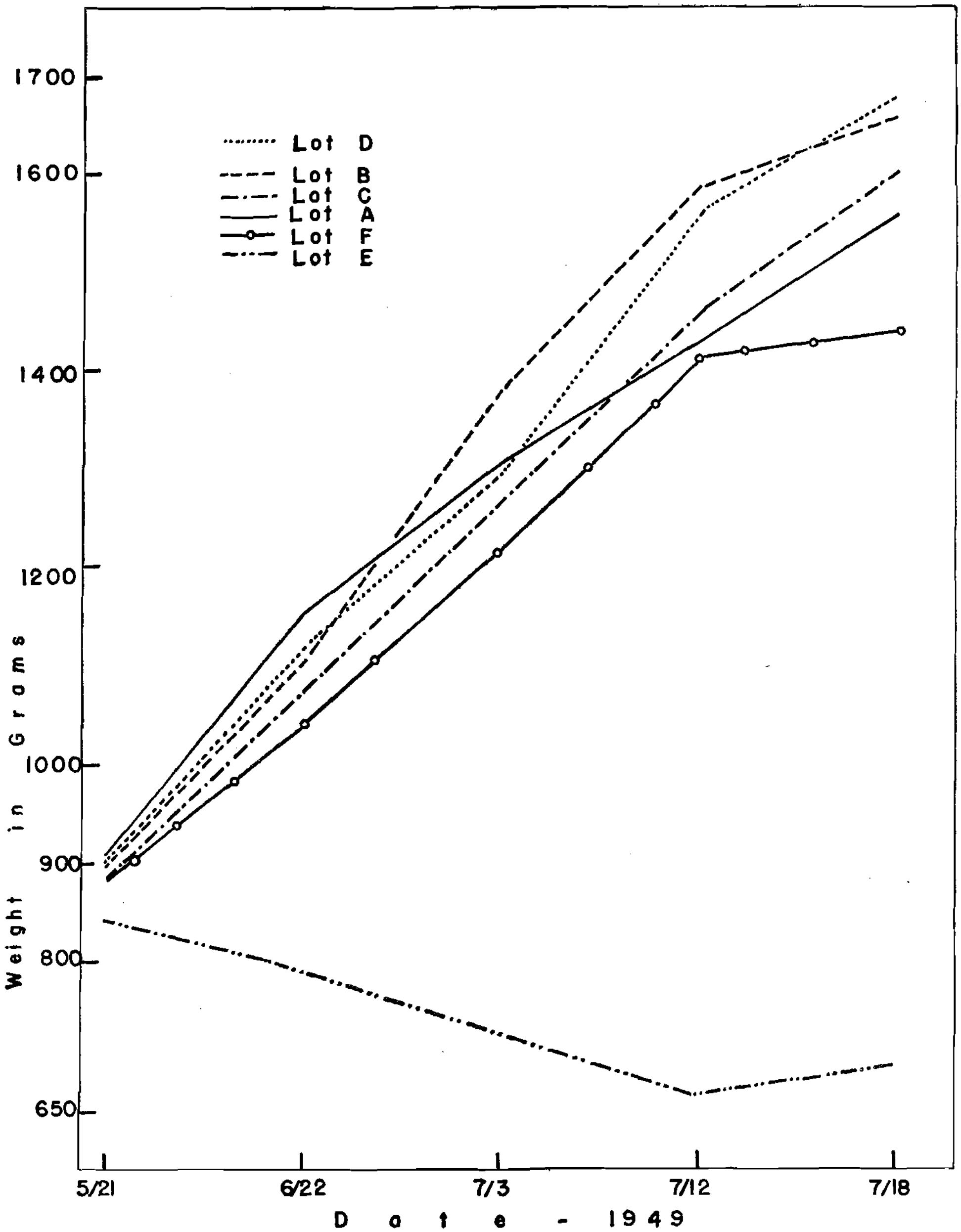

Figure 3. GROWTH OF SPRING CHINOOK SALMON FINGERLING FED DIFFERENT DIETS AT MARION FORKS ON THE NORTH SANTIAM RIVER, 1949.

Attention is drawn to Table 3 and to Figures 3 and 4. Table 3 summarizes the results of the feeding experiment. Several items are of considerable interest. In the first place the diet developed at the Leavenworth, Washington, Fish Hatchery (U. S. Fish and Wildlife Service) was generally superior to all other diets used, including straight beef liver, from the standpoint of weight gain. Fish fed in cold Horn Creek water gained less than fish fed in warmer Marion Creek water, although diets of two pairs of lots were identical. The diet of 5 per cent beef liver and 95 per cent viscera, which is comparable with that used in some Oregon Fish Commission hatcheries, was mediocre from the standpoint of weight gain, only fair from the standpoint of mortalities, but best from the standpoint of economy, i. e., cost of food per pound of fish. The dry meal diet was a failure from all standpoints and was the only one which produced heavy mortalities.

Perhaps the two most useful observations that can be made relate to diets E and F. The dry meal diet proved unsatisfactory as is obvious, so on July 12 the meal diet was abandoned and liver substituted, with the result that the weight sharply improved within six days. Mortalities were severe beginning about July 3. While weight gain had been almost immediately apparent after the diet change, mortalities did not decrease in the aforementioned six days. The fish subjected to diet F "broke" about July 12 since mortalities rose and weight gain dropped about that time. It appears that longer rearing would definitely reveal that diet F was likewise unsatisfactory (this despite the fact that the weight gains of this group up to the end of the experiment had cost the least per pound).

TABLE 3.

SUMMARY OF PERTINENT DATA RELATIVE TO EXPERIMENTAL FEEDING OF YOUNG SPRING CHINOOK SALMON OF NORTH SANTIAM RIVER STOCK AT MARION FORKS, OREGON, 1949

Lot	Initial Weight	Wt. Grams	Increase Per cent	Amt. of Food Fed	Kind of Food	Cost per lb. of Fish	Mortalities
A	909	645	71	2943	Liver	$0.67	22
B	904	757	84	2981	Liver	0.59	55
C	885	716	81	2260	Leavenworth	0.28	31
D	889	791	89	2475	Leavenworth	0.28	57
E	846	–149	–18	1335	Dry Meal	Lost Wt.	237
F	892	546	61.2	3315	5% Liver 95% Viscera	0.16	76

With regard to the liver and Leavenworth diets, the latter was slightly superior, as has been noted. The best gains were in warmer Marion Creek water, while the lowest mortalities were in Horn Creek troughs.

Characteristics of the Water

In April, 1949 the waters of both Marion and Horn Creeks were analyzed by a representative of the Fish and Wildlife Service who reported that chemically the two water supplies were very similar. Both creeks were saturated with oxygen and both were relatively mineral free.

Summary and Conclusions

Perhaps the best way to summarize the work is by reference to Table 4 along with the previously discussed material. If the frozen lot of eggs be omitted from consideration along with the high-mortality lot fed dry meals, the total loss experienced from egg-take to liberation in mid-July would have been less than five per cent. Even with the freezing losses, the total mortality was only 16 per cent.

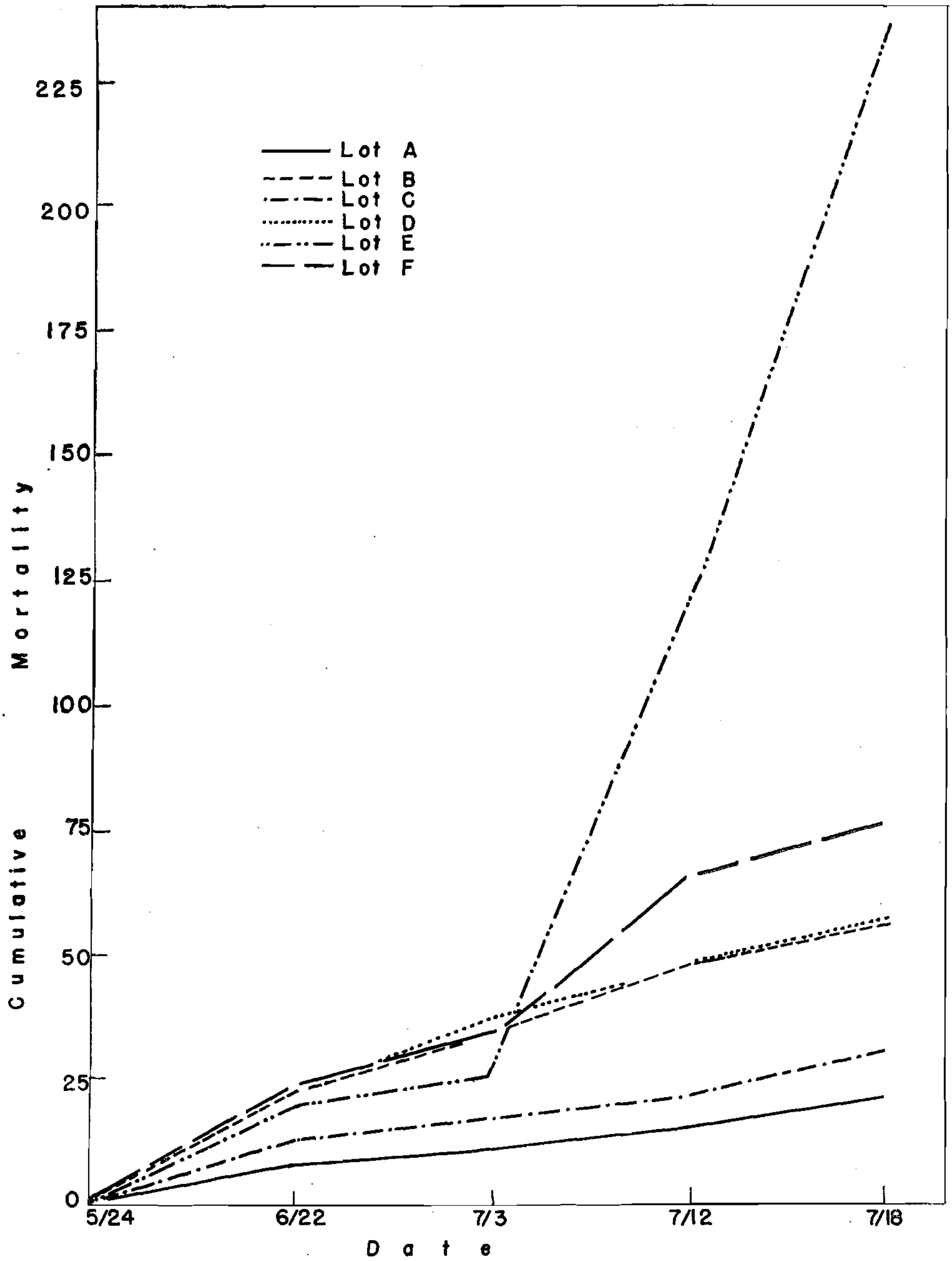

Figure 4. THE CUMULATIVE MORTALITY OF SPRING CHINOOK SALMON FINGERLING FED DIFFERENT DIETS AT MARION FORKS ON THE NORTH SANTIAM RIVER, 1949.

TABLE 4.

RECAPITULATION OF THE OPERATION OF THE EXPERIMENTAL HATCHERY AT MARION FORKS, SEPTEMBER 1948 TO JULY 1949

Lot	Actual Count Initial Number of Eggs [1]	Egg Loss to "Eye-up" and Eyed Eggs [2]	Egg Loss in Per cent of Total Egg No.	Fry Loss [3]	Fry Loss in Per cent of Total Egg No.	Fingerling Loss [4]	Fingerling Loss in Per cent of Total Eggs	Fingerling Liberated [5]
Orig. 1	27,041	To eye-up 813	3.0	....	....	....	....	....
Orig. 2	25,386	To eye-up 972	3.8	....	....	....	....	....
Lot 1	11,523	Eyed eggs 87	0.75	104	0.9	18	0.15	11,314
Lot 2	13,920	Eyed eggs 255	1.1	128	0.84	35	0.25	13,502
Lot 3	14,705	Eyed eggs 53	0.36	96	0.65	....	....	....
Lot 4	10,494	Eyed eggs 5,320	50.6	102	0.9	88	0.8	4,984
Lot A	Fingerling 2,426	....	....	....	....	22	0.9	2,404
Lot B	Fingerling 2,426	....	....	....	....	55	2.2	2,371
Lot C	Fingerling 2,426	....	....	....	....	31	1.2	2,395
Lot D	Fingerling 2,426	....	....	....	....	57	2.2	2,369
Lot E	Fingerling 2,426	....	....	....	....	237	9.8	2,189
Lot F	Fingerling 2,426	....	....	....	....	76	3.1	2,350
TOTALS	52,427	7,500	....	430	....	619	....	43,878

[1] Total eggs obtained from Hatchery Division—53,004 measurement count.
[2] Total egg loss all lots: 7,500=14.4% of total number of eggs.
[3] Total fry loss of all lots: 430=0.8% of total number of eggs.
[4] Fingerling losses all lots: 619=1.2% of total number of eggs.
[5] Liberations all lots: 43,878=83.6% of total number of eggs.

Further evidence of the effect of water temperatures on developmental rate is reflected in the feeding portion of the experiment. For the feeding period May 24 to June 22 the greatest gain in weight was in the Horn Creek troughs. At this time the Horn Creek water was slightly warmer than Marion Creek water. However, subsequent weighings show that the Marion Creek troughs of fish developed much faster, because the water in Marion Creek was warming up much more rapidly than Horn Creek waters (Figs. 2 and 3).

As close as can be determined, 97 per cent to 98 per cent of the eggs were fertilized. Lot 4 showed a definitely higher percentage of cripples due to the freezing of the eggs. The freezing prompted a heavy premature hatch which resulted in death of those individuals.

The data obtained showed that a hatchery in the Marion Forks area was feasible. As is shown in the temperature unit and development charts, no one water supply (either Horn or Marion Creek) will suffice. This is because of the warmer winter water temperatures in Horn Creek and warmer summer water temperatures in Marion Creek. For best utilization of the water, it is necessary to use the warmer water at the hatchery at all times. Egg Lot 3, which was in the warm water in Marion Creek until the water temperature dropped below that of Horn Creek and then the Horn Creek water to hatching, shows a mid-point of hatching on January 21, whereas Lot 4 which was taken from the colder water of Horn Creek and placed in Marion Creek, with lower temperatures at that time, had a mid-point of hatching on February 13. This date would have been March 1 or after if the eggs had not been moved to Horn Creek on January 10 for completion of the incubation period, thus clearly showing the advisability of utilizing the warmest water.

Acknowledgments

A number of people helped greatly with this experiment and thanks are extended to them for their cooperation. Messrs. Orval Greer and Reed White of the North Santiam River Fisheries Station were very helpful. Others who helped in various ways were Mr. and Mrs. Scott Young and Mrs. Dorothy Morgan of Marion Forks Lodge, Mr. George Streff of Detroit, Oregon, and the Willamette National Forest Group, especially Messrs. Bruckhart, White, Moore, and Elliott. Messrs. Lee Douglas and John Wiese, biological assistants, assisted in caring for the fish.

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Is the Clam, *Tellina bodegensis,* on the Increase?

During the past several years numerous inquiries have been received and specimens gathered of a heretofore relatively scarce bivalve, *Tellina bodegensis*. This small elongated clam with a heavy white shell has been taken in edible quantity in Yaquina Bay under the Highway 101 Bridge and specimens have been collected just inside the north jetty of Yaquina Bay. Recent reports from old-time Tillamook Bay residents claim this clam to be present for the first time. With the inclusion of specimens from Coos and Netarts Bays it seems this clam is well represented along the Oregon coast.

Some individuals having seen this clam for the first time suggested that it was probably introduced from Japan by the importing of Japanese oyster seed. However, I. S. Oldroyd in her book *The Marine Shells of the West Coast of North America,* 1924, gives the range of this pelecypod as "Queen Charlotte Islands, British Columbia, to the Gulf of California. In the Miocene in Oregon, etc. . . ." It is therefore improbable that this species was introduced from Japan when it is a native of the West Coast, and was first reported here in 1844.

THE SALMON CATCH OF THE SPORT FISHERY IN THE COASTAL RIVERS OF OREGON IN 1949

Introduction

One of the important phases in the management of any of the natural resources is the determination of the production. Accurate statistics of the salmon catch of the commercial fishery have been collected for many years in Oregon, and in the past the commercial catch has represented almost the entire production of the rivers. However, in recent years the rapid development of the salmon sport fishery has made it imperative that adequate statistics be gathered for this fishery also if the salmon resources are to be properly managed.

In 1946 studies were conducted jointly by the Oregon Fish Commission and the Oregon Game Commission to determine the magnitude of the anglers' catch of salmon on the Umpqua River. In 1947 and 1948 the Oregon Fish Commission conducted similar surveys on the Nehalem River, Tillamook Bay and tributaries, the Nestucca River, and the Alsea River. Studies were continued on these rivers in 1949 and were expanded to include the Yaquina, the Siuslaw, and the Coquille Rivers.

The catch consists primarily of silver salmon (*Oncorhynchus kisutch*), but a considerable number of chinook salmon (*Oncorhynchus tshawytscha*) are also taken. The fall run chinook salmon predominate on the rivers being studied with a few spring chinook being caught on Tillamook Bay.

The biggest portion of the catch is made by small boats equipped with outboard motors. These boats troll principally in the tidal areas of the rivers. On some of the rivers, however, there exists a large bank fishery where the fishing is done by casting from shore. This takes place primarily in the area above tidewater, but on some rivers a considerable bank fishery exists on the sand spits at the mouths.

Calculation of Catch

The calculation of the catch of the boat fishermen has been dependent on records of the moorage operators on the various rivers. These operators have been requested to keep daily records of the numbers of boats fishing and the numbers of fish landed. Their cooperation has been execllent and has contributed greatly to the success of the study. Counts of all boats on the rivers are made by airplane or car periodically throughout the season. These counts must be corrected, however, for all of the boats which fish on a given day will not be observed at any one time of the day. This correction is made by determining a curve for the fishing intensity during the day through day-long observations of the activities of the boats at one moorage. Figure 1 shows these curves computed for the various rivers.

Having determined the average percentage that the moorage boats represent of the total, it is then possible to calculate the total numbers of boats fishing each day of the season. By multiplying the average catch per boat (as determined from the moorage records) by the total number of calculated boats, a reasonably accurate estimate of the total number of

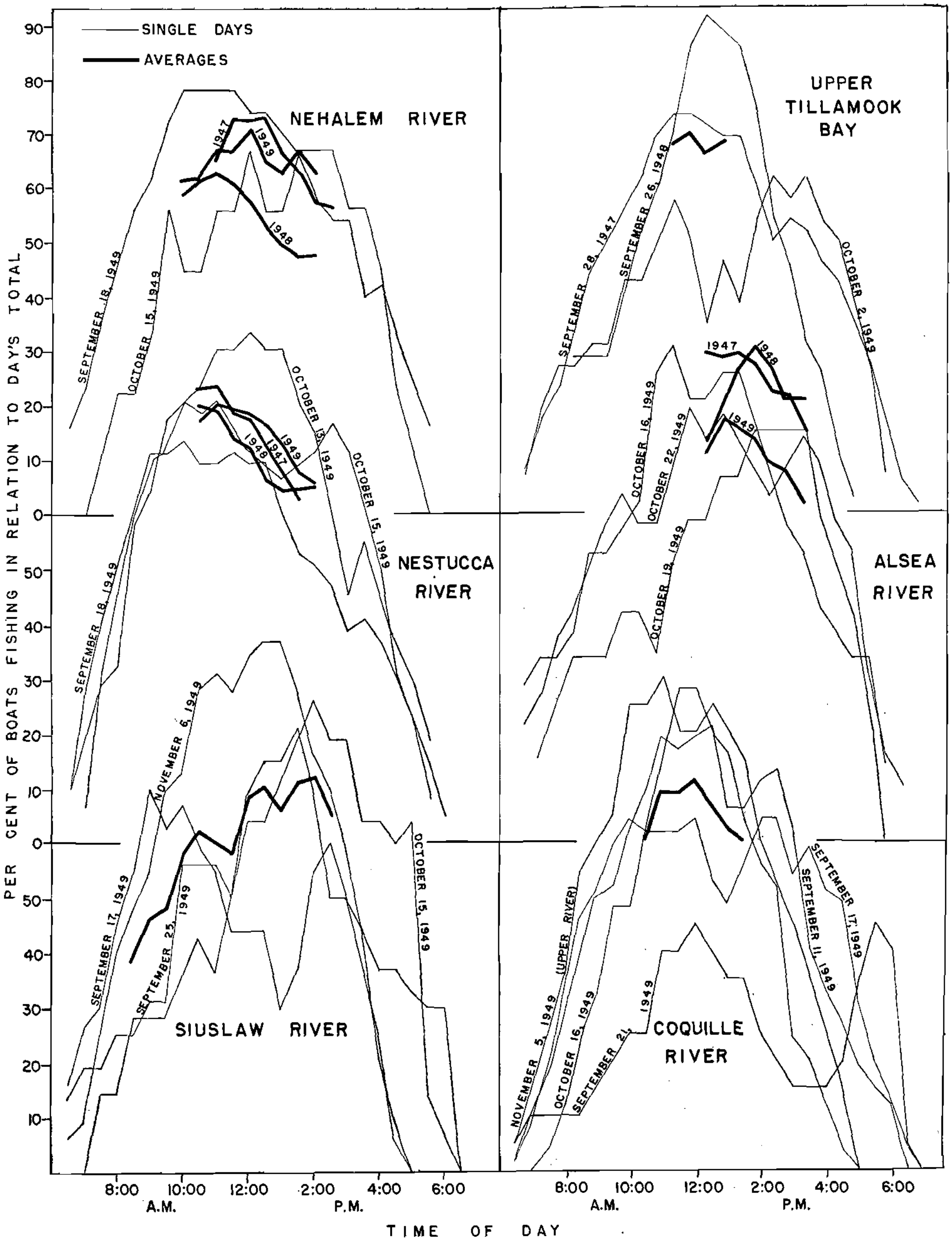

Figure 1. THE CALCULATED SPORT FISHING EFFORT DURING THE DAY ON VARIOUS OREGON COASTAL RIVERS.

fish caught each day can be made. The methods used here are described in more detail by McKernan and Jensen (1946), Johnson and Mattson (1949) in studies of the Willamette River spring chinook fishery, and Hodges (1948) in studies of the salmon sport fishery in the coastal rivers of Oregon.

An estimate of the catch of the bank fishermen has been based on interviews of anglers and operators of fishing resorts on the rivers and in some cases from records of state police officers who have recorded catches at the time they were checking anglers' licenses.

Discussion

In Table 1 are summarized the more important statistics for all the rivers studied in 1947, 1948, and 1949. The amount of boat fishing (calculated boat-days) has varied considerably between the various rivers and between years on a given river. It appears to be increasing but varies somewhat according to general fishing conditions, that is, weather and water conditions and angling success.

TABLE 1.

SUMMARY OF SPORT CATCH STATISTICS FOR OREGON COASTAL RIVERS STUDIED IN 1947, 1948, AND 1949

(Catch given in numbers of fish)

				Av. Catch per Boat			Total Catch [1]		
River	Year	Calculated Boat-Days	Lines per Boat	Silvers	Fall Chinook	Jacks	Silvers	Fall Chinook	Jacks
	1947	3,563	2.3	0.44	0.07	....	2,150	380	....
Nehalem	1948	6,350	2.1	0.47	0.08	....	3,250	570	....
	1949	4,526	2.4	0.36	0.05	0.08	2,350	350	420
Tillamook Bay	1947	580	2.4	0.22	0.03	....	2,150	340	....
and	1948	1,072	2.4	0.42	0.09	....	1,600	270	....
Tributaries [2]	1949	1,853	2.5	0.13	0.06	0.24	1,400	760	450
	1947	3,442	2.4	0.32	0.14	....	1,500	590	....
Nestucca	1948	4,496	2.4	0.49	0.09	....	2,400	470	....
	1949	3,525	2.3	0.19	0.02	0.02	900	130	90
	1947	3,618	2.7	1.18	0.04	....	4,750	150	....
Alsea	1948	4,509	2.3	0.73	0.03	....	3,350	150	....
	1949	5,157	2.2	0.33	0.03	0.10	1,750	150	590
Yaquina	1949	....	....	....	....	....	250	100	15
Siuslaw	1949	5,869	2.3	0.45	0.04	0.11	2,900	240	660
Coquille	1949	3,412	2.4	0.62	0.05	0.04	2,100	190	140

[1] Boat plus bank fishing.
[2] Boat-days and catch per boat based on Upper Bay fishery only.

The average catch per boat and the total catch of the boat and bank fisheries are of considerable importance from a management standpoint. The catch per boat or angler when compared over a period of several years provides a very useful measure of the condition of the salmon populations in any river. The total catch and catch per boat are not suitable measures of abundance for making comparisons between the various rivers due to the differences between the fisheries of one river and those of another.

Figure 2 shows the catch of the boat fishermen for each week of the 1949 season for all rivers surveyed except the Yaquina. The major part of the fishery on the Yaquina had already taken place at the time the survey was started. Only a very few fish were caught on the other rivers prior to the beginning of the surveys. Since jacks were not recorded by species, they are not included in this figure. They tend to appear in the catches in greater abundance in the earlier part of the season; however, the seasonal appearance of the two species of salmon as portrayed in Figure 2 would remain practically unchanged with their inclusion. The bulk of the boat catch of silver salmon was made between the middle of September and the middle of November with most of the fall chinook being caught in the early part of the same period. The catches of the bank fishermen occur somewhat later than this, generally from the first of October until the end of November.

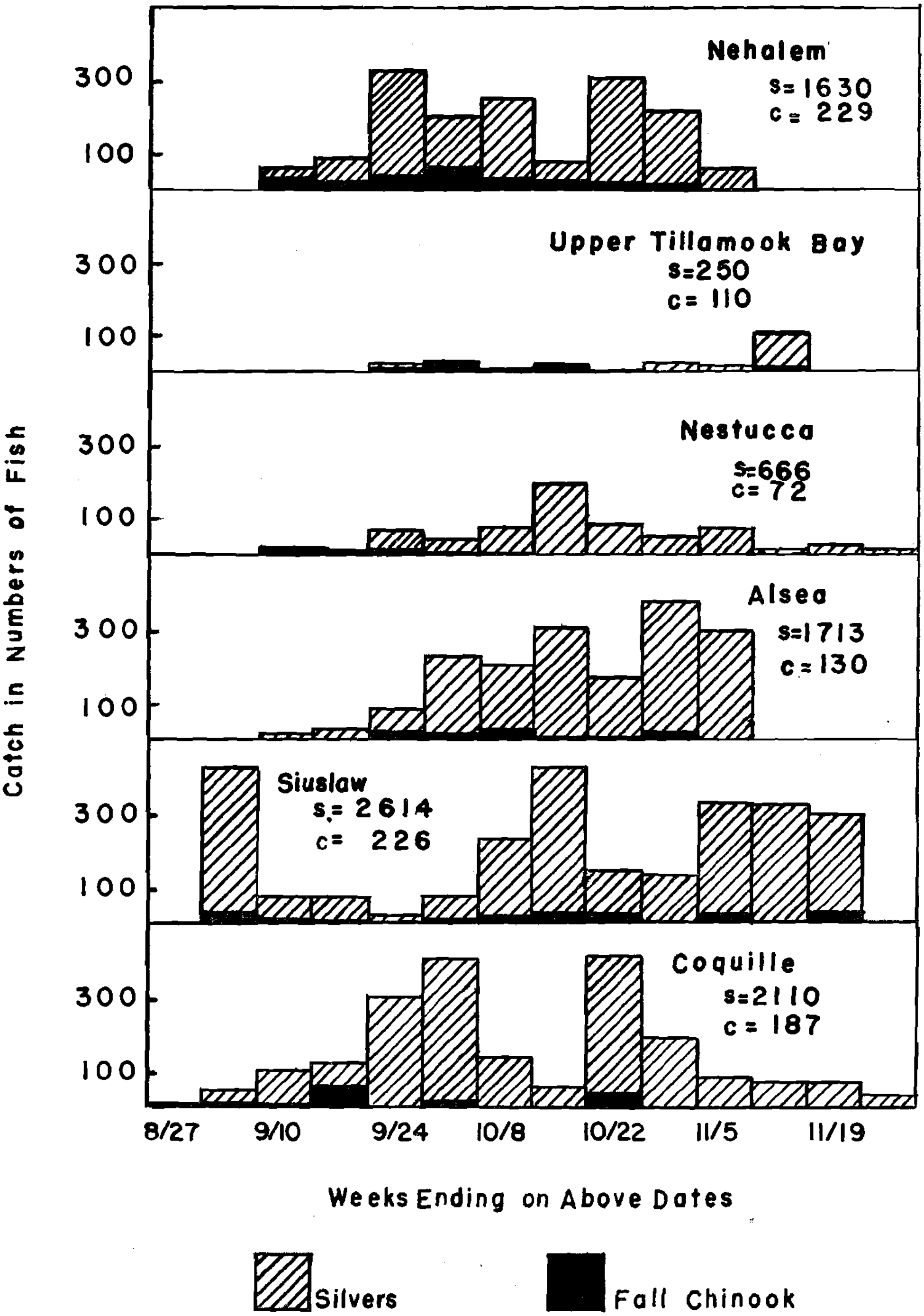

Figure 2. CALCULATED SPORT CATCH OF SALMON BY BOATS ON VARIOUS COASTAL RIVERS, 1949. (S=Season's Total Catch of Silvers; C=Season's Total Catch of Fall Chinook.)

The total catch of the boat fishermen plus the bank fishermen is shown graphically in Figure 3 for all the rivers studied in 1949. The calculated catch of jacks as shown in Table 1 for each river has been broken down into species in Figure 3 and is shown by the broken lines above the bars. These were determined on the basis of the percentage composition of adult silvers and chinooks in the catches calculated for each river.

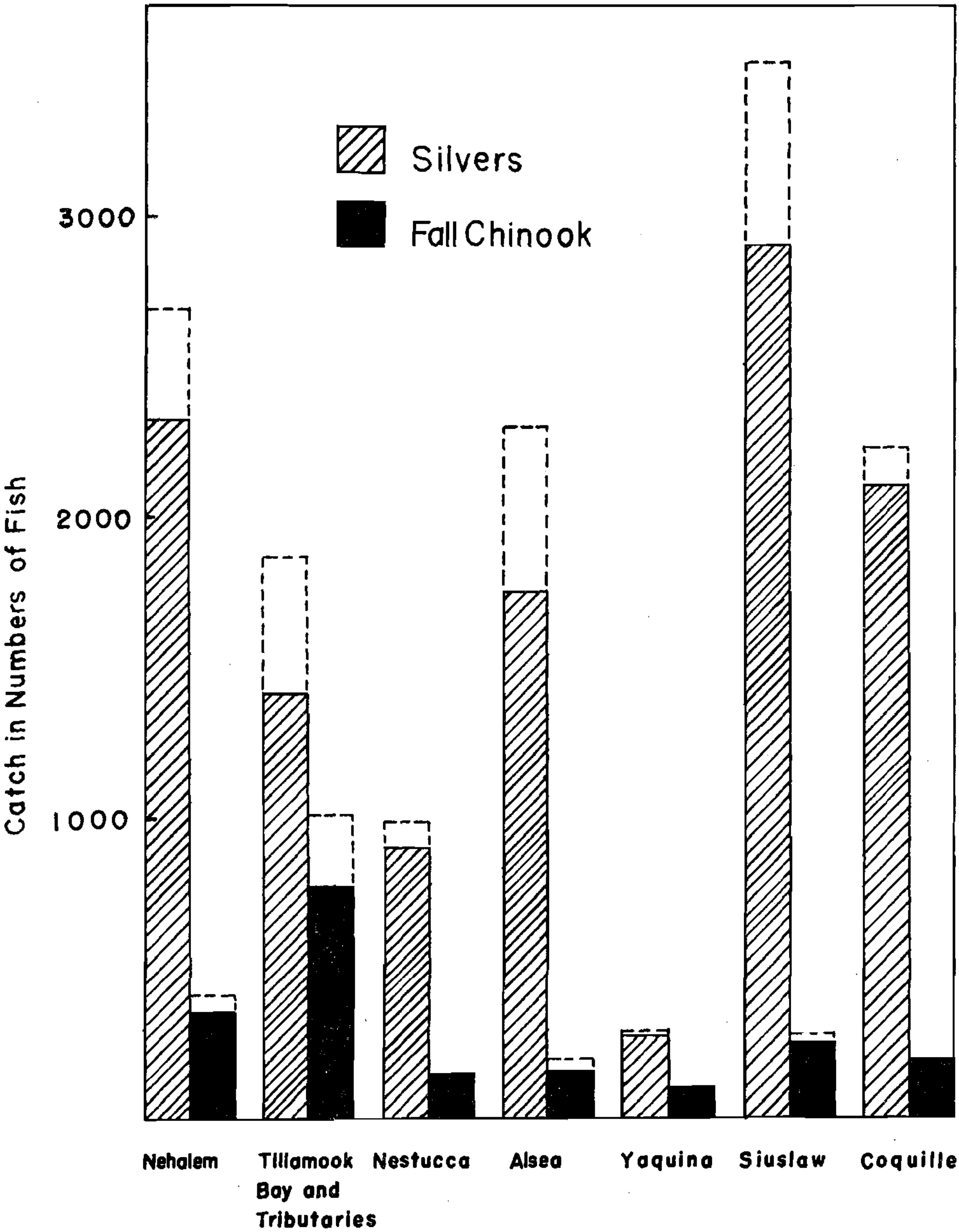

Figure 3. CALCULATED SPORT CATCH OF SALMON BY BOATS AND BANK FISHERMEN COMBINED ON VARIOUS COASTAL RIVERS, 1949. (Dotted extensions indicate Jack Salmon.)

The catch of the sports fishermen is influenced considerably by weather conditions. The prevalence of storms during the fall limits the amount of fishing that can be done. Both bad weather and muddy water resulting from heavy rains cause unfavorable fishing conditions. The fall of 1949 in general provided good weather and water conditions for angling.

During the three years of study, a total of 179 fall chinook salmon and 786 silver salmon has been weighed on the various rivers. The Chinooks have averaged 25.2 pounds and the silvers 9.2 pounds.

Summary

(1) As the salmon sport fishery increases in intensity on the Oregon Coast, it becomes increasingly more important that adequate statistics of the sport catch continue to be gathered. The Oregon Fish Commission is at present obtaining the data on a number of the coastal rivers, and it is planned to expand this phase of the program.

(2) The catch consists primarily of silver salmon and fall chinook salmon on the rivers being studied. These are taken for the most part in the months of September, October, and November.

(3) The fishing intensity, catch per boat, and total catch vary considerably from one river to another in a given year and between years on a single river. Of chief importance is a comparison of the catch per boat or catch per angler over a period of years for a single river. Such a comparison will give valuable information on the trends in the salmon populations. Comparisons of catch per unit of effort between rivers as a measure of abundance are not possible due to the differences in the fisheries of various rivers.

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THE 1949 SOUPFIN SHARK FISHERY OF OREGON

Introduction

Soupfin shark (*Galeorhinus zyopterus*) have been eagerly sought by fishermen for the last 12 years because of the high prices which have been paid for the livers of high vitamin A content. The male livers contain more vitamin A than the female livers and consequently are more valuable to the fishermen.

Prior to 1941 there were a few Oregon boats fishing for these shark by means of long line gear in California waters. An account of the fishery in California has been given by Ripley (1946). The first northward expansion of the fishery into Oregon and Washington waters took place about 1940 or 1941. As the shark fishery expanded and more efficient gear was developed, there was a sharp rise in the Oregon landings to a peak in 1943 of over 270,000 pounds of livers (Fig. 1). The landings then fell off rapidly to a low in 1948 of about 50,000 pounds. The landings of the

Figure 1. OREGON LANDINGS OF SOUPFIN SHARK LIVERS FROM JUNE 13, 1941* TO DECEMBER 31, 1949.

* First collection of records by Fish Commission of Oregon.

Oregon vessels increased somewhat in 1949, probably due to the exploitation for the first time of new fishing grounds in Hecate Straits.

The marketing methods underwent considerable change during the rise of the fishery. Originally in California the whole fish were sold and the livers extracted at the fish plant. During this period the price rose from $40 per ton in 1937 to $2,000 per ton in 1941 (Ripley, 1946); however, after 1941 the fishermen removed the livers at sea, and the price was quoted per pound of liver. When it was found that the livers varied considerably in vitamin A content, the price was based on the tested potency of vitamin A per pound of liver. This latter method is currently in use.

In general, then, the price per pound of liver began at about $0.20 in 1937 and rose with many fluctuations to a peak of approximately $18 per pound for high-test livers in early 1949. The great fluctuation in vitamin A potency with respect to size of fish, sex, area of capture, and time of year makes it extremely difficult to quote an average price per pound.

Subsequently the price has dropped precipitately to about $2.50 per pound in January, 1950. The major cause for this drastic decline in the price has been the great influx of imported livers and liver oils from abroad; in addition synthetic vitamin A has now appeared on the market at a price comparable with that obtained from natural sources. At the time of this writing, June 1950, there are no Oregon boats fishing for soupfin shark. Two Oregon boats began fishing in California waters during April of this year, but soon gave up when the liver prices dropped to about $1.80 per pound.

Fishing Gear

The soupfin shark was first caught with long line gear adapted from the halibut fleet. This method consisted of using a string of baited hooks set along the bottom of the ocean in depths of less than 100 fathoms, but by 1943 this method had been largely supplanted by the so-called "diver net."

The diver net was introduced in 1941 and proved to be more efficient than the long line gear. It is a fixed net anchored on the bottom in an upright position, but its use is limited to relatively shallow water from 20 to 80 fathoms. The nets which are 10-inch mesh and 20 to 30 meshes deep are usually laid out in sets approximately 400 fathoms in length (Pacific Fisherman, 1943a). Each boat fishes two to four such sets of gear. The diver net fishery proved to be most successful during the winter months and is currently limited to the period of October to March.

The floater net was introduced at about the same time as the diver net (Pacific Fisherman, 1943b) but did not become important until about 1945 when it was found that the soupfin shark could be caught during the spring and summer months near the surface of the ocean up to 100 miles from shore. The floater net fishery has been the major source of soupfin shark livers landed in Oregon since 1945. The nets range from 750 to 1,600 fathoms in length, have a 10- to 10½-inch mesh and are 50 to 90 meshes deep. The nets are laid out in the evening from three to 11 fathoms beneath the surface and allowed to drift during the night attached to the boat. They are then picked up the following morning.

The information presented in this report deals entirely with the floater net fishery. There are no detailed catch data available at this time on the Oregon diver net fishery. Astoria, Depoe Bay, Newport, Coos Bay, and Port Orford have small local diver net fisheries which are carried on from October to March. However, with the rapid decline in the price of livers, these fisheries were sharply curtailed during the winter of 1949-50.

Current Program

The current program was initiated in 1949 by the Fish Commission with the cooperation of the members of the Oregon soupfin shark fleet. During the spring and early summer the fishermen were provided with log books and Peterson-type disc tags.

The fishermen agreed to keep a daily log of their catches and to tag, whenever possible, the small soupfin shark males and females which they found alive in their nets. The livers of these small shark have little or no market value since the vitamin A content is very low, and as a consequence they are usually discarded when caught.

The tags used are celluloid discs approximately ⅝ inch in diameter. Two discs, one on each side of the back of the fish, were fastened together by means of a non-corrosive nickel pin which was driven through the narrow fleshy area beneath the dorsal fin. One disc has a serial number and the inscription, "Ore. Fish Com., Astoria (Portland or Newport), Oregon," and the other disc is blank.

Tagging

The floater-net fishery in 1949 took place from April to November and ranged from Pt. Conception, California, to Hecate Straits, British Columbia. A total of 291 soupfin shark were tagged by the Oregon fishermen throughout this area (Table 1). In addition, 18 soupfin shark had been tagged during 1948.

TABLE 1.

NUMBERS OF SOUPFIN SHARK TAGGED BY OREGON FISHERMEN DURING THE 1949 FLOATER NET FISHERY BY AREA AND SEX

Sex	Area I (Pt. Conception to Eureka, Calif.)	Area II (Eureka, Calif., to Columbia River)	Area III (Columbia River to Hecate Straits)	Total
Males	54	23	80	157
Females	28	13	86	127
Unknown	3	0	4	7
Total	85	36	170	291

There were two tag recoveries during 1949. The first fish was recovered in a floater-type shark net in the southeast corner of Queen Charlotte Sound on August 7, 1949. The fish was a male, 56 inches long, and had been tagged August 5, 1949, west-northwest of Cape Scott. It had migrated approximately 75 miles eastward during its two days of freedom.

The second recovery, by unknown means, was made on August 28, 1949, in Halfmoon Bay, California. The fish, also a male, 51 inches long and 19 pounds in weight, had been tagged May 7, 1949, 50 miles west of Pt. Sur, California. The fish had grown approximately four inches in three months, according to the measurements provided. A migration of 90 miles northward was estimated.

Log Book Records

The following information was requested in the log books which were provided the fishermen: area fished, depth of water in fathoms, hours gear fished, remarks, length and depth of gear, mesh size, numbers of marketable males, non-marketable males, alive females, and dead females. In addition space was provided for the necessary tagging data, i. e., tag number, length of fish in inches, sex, and condition when tagged.

The males were separated into the categories marketable and non-marketable in order to determine whether the mesh sizes used caught an undue number of small, non-marketable fish. On the basis of the lengths provided by the tagging data, the non-marketable males ranged in size from 42 to 61 inches with a mean of approximately 54 inches. The tagged females also averaged 54 inches with a range of 36 to 74 inches. However, there was only one tagged female (36 inches long) less than 42 inches and three (68, 70 and 74 inches, respectively) greater than 62 inches. The marketable males were the larger fish (averaging about 72 inches according to estimates of the fishermen) which contained the valuable livers. The females were classified as alive or dead in order to ascertain the proportion which were killed by the nets.

Fishing Areas

Examination of log books at the end of the season showed that the fishing grounds of the Oregon fleet could be divided into three areas (Fig. 2).

Area I extends from Pt. Conception to Eureka, California; this region was fished during the months of April, May, June, and July. Practically all the fishing was done outside the 1,000-fathom line to an extreme depth of 2,500 fathoms. The fishing began near Pt. Arguello (just north of Pt. Conception) in April and moved northward, terminating off the Farallon Islands (west of San Francisco) in June and early July. Little fishing was done north of Pt. Arena in this area.

Area II extends from Eureka, California, to the Columbia River. Practically all the fishing was done between Cape Blanco (near Port Orford, Oregon) and Yaquina Head (Newport, Oregon) during the months of June, July, and August. The single exception was a small Astoria boat which fished between the Columbia River and Cascade Head during the month of November. The summer fishing was all outside of the 1,000-fathom line.

Area III extends from the Columbia River to Hecate Straits, British Columbia. The fishing began in June off Cape Flattery and moved to the west coast of Vancouver Island during July. In August the fleet fished mainly off the northwest coast of Vancouver Island and in Queen Charlotte Sound. The season ended in late September and early October with the fleet fishing in Hecate Straits. There was considerable fishing inside the

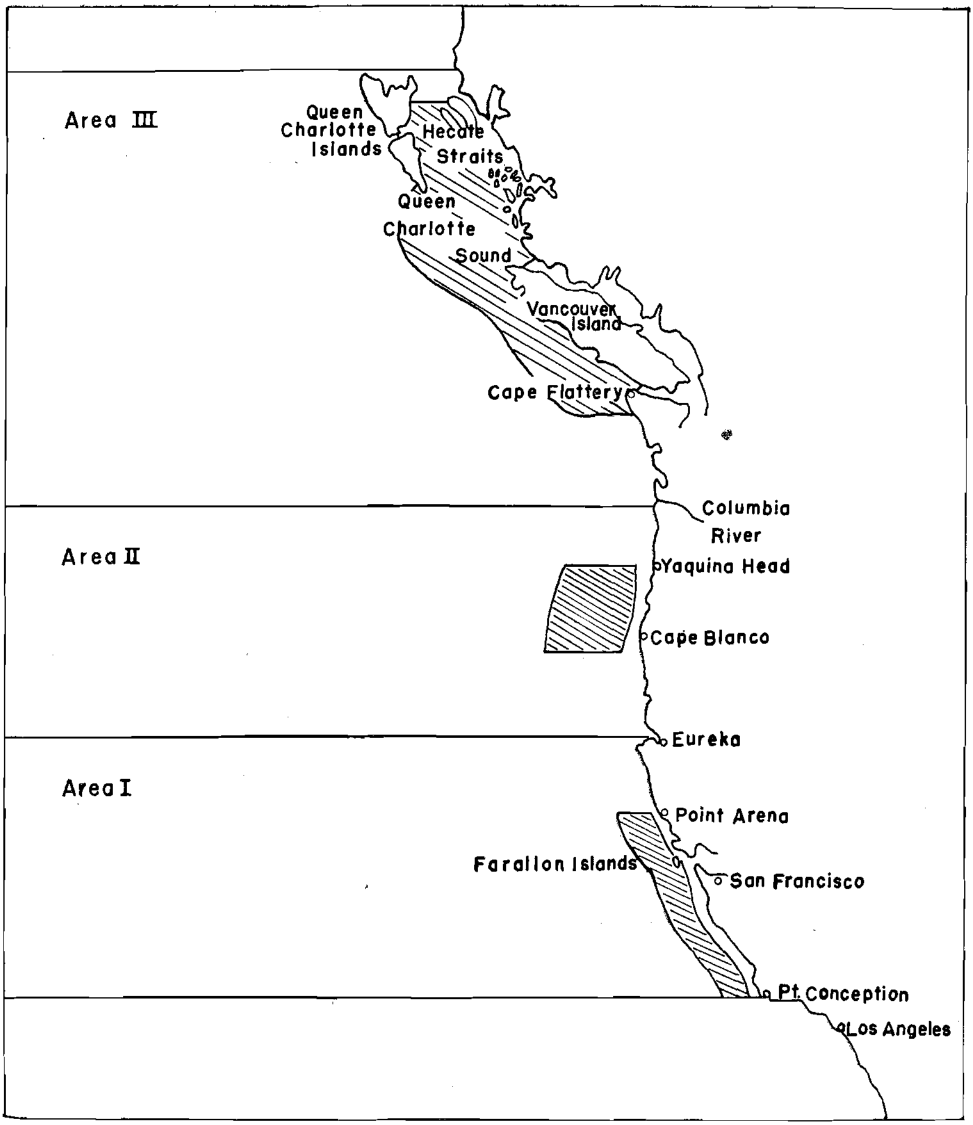

Figure 2. MAP SHOWING THE PRINCIPAL REGIONS (STRIPED AREAS) FISHED BY THE OREGON SOUPFIN SHARK FLOATER-NET FLEET DURING THE 1949 SEASON.

1,000-fathom line in this northern area. The season ended in late September and early October with the fleet fishing in Hecate Straits. The depth of water fished ranged from 30 to 2,000 fathoms.

As the season progressed there was a general movement of the fleet northward (Fig. 3). Each bar in Fig. 3 represents the number of boats fishing for one or more days during any given month in each area with the striped areas indicating the number of boats whose records were utilized. The location of each boat was determined by log book records and from interviews with those fishermen whose records were incomplete.

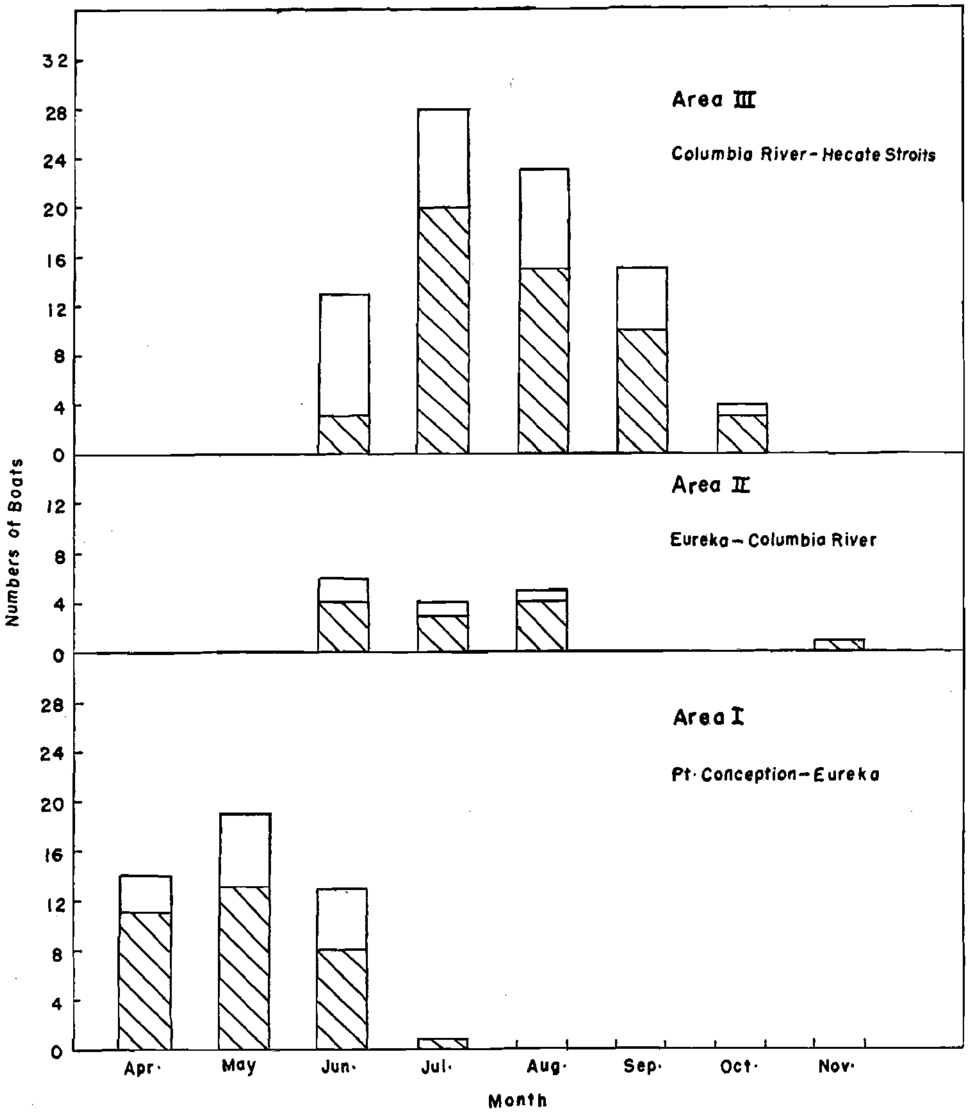

Figure 3. NUMBERS OF OREGON SOUPFIN SHARK BOATS FISHING DURING THE 1949 FLOATER-NET SEASON, BY MONTH AND AREA. (Striped Areas Indicate Numbers of Boats Whose Records Were Utilized in the Analysis of the Catch Records.)

Catch Records in 1949

There were 30 Oregon boats fishing for soupfin shark during the 1949 floater-net season. Of these, 13 maintained a good log for their entire season. Two of these 13, however, only kept a record of the numbers of fish caught each day (without a breakdown by sex or size) and the location of the catch. Eight additional boats maintained a good log for a portion of their season.

The catches of the 13 "complete" boats were summed separately from those of the eight "partial" boats. A statistical test by chi-square was applied to the ratios of total males to total females, marketable males to non-marketable males, and alive to dead females and failed to show any significant difference between the data from the partial and complete records. The tests were only applied in the cases where complete and partial data were both available for the same month and area. Consequently, the two sets of data were combined for the following periods: Area I, April and May; Area III, July, August, September, and October. There were no partial records available for Area II. In no month were partial records alone available for compilation in any area.

Sex Ratios

Throughout the 1949 floater-net season the males predominated in the catches. Area I had 97 per cent males; Area II, 95 per cent; and Area III, 92 per cent (Table 2). In order to determine whether these ratios were statistically different from one another, the test of chi-square was applied to the three areas as a group. There was a significant statistical difference. When the same test was applied to the areas by pairs, the sex ratio for Area I was found to be significantly different from Areas II and III. There was a higher percentage of females present in the catches of Areas II and III than in Area I.

TABLE 2.

SUMMARY OF THE CATCHES OF SOUPFIN SHARK FOR 19* OREGON BOATS DURING THE PERIOD FROM APRIL TO NOVEMBER, 1949, BY SEX AND AREA

	Males				Females				Totals			
	Marketable		Non-Marketable		Alive		Dead		Males		Females	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Area I: (Pt. Conception—Eureka)												
April	405	89	52	11	4	33	8	67	457	97	12	3
May	1482	97	49	3	16	42	22	58	1531	98	38	2
June	640	95	36	5	12	48	13	52	676	96	25	4
July	1	100	0	0	0	0	0	0	1	100	0	0
Total	2528	95	137	5	32	43	43	57	2665	97	75	3
Area II: (Eureka—Columbia River)												
June	229	87	35	13	8	50	8	50	264	94	16	6
July	50	96	2	4	2	67	1	33	52	95	3	5
August	290	92	24	8	1	6	15	94	314	95	16	5
November	18	100	0	0	0	0	0	0	18	100	0	0
Total	587	91	61	9	11	31	24	69	648	95	35	5
Area III: (Columbia River—Hecate Straits)												
June	134	91	13	9	3	20	12	80	147	91	15	9
July	3514	95	200	5	41	15	225	85	3714	93	266	7
August	1403	96	53	4	20	11	170	89	1456	88	190	12
September	1939	97	53	3	10	9	101	91	1992	95	111	5
October	44	100	0	0	0	0	7	100	44	86	7	14
Total	7034	96	319	4	74	13	515	87	7353	92	589	8

* Catches of 11 boats with complete records and eight boats with partial records.

Referring to Table 1 it is interesting to note that the sex ratio for the tagged fish exhibits no such paucity of females. The percentage of males varies around 50 per cent (48 to 66 per cent). A chi-square test was applied to these data in the same manner as was done with the sex ratios of total males and total females. There was a significant difference between the three areas when taken as a group. When the test was applied to pairs of areas it was found that Areas I and II, and II and III had no significantly different sex ratios. Areas I and III did differ significantly in their sex ratios, there being a greater percentage of females in Area III.

The sex ratio in the catch of the Oregon floater-net fleet varies with the size of the fish caught. The males constitute 92 to 97 per cent of the total fish. There is a slight increase in percentage of females in the northern area. Among the smaller fish the males constitute only from 48 to 66 per cent of the catch. The smaller females also increase in percentage as the fishery moves northward.

Marketable and Non-Marketable Males

The non-marketable males constituted a small proportion of the total males caught (Table 2). Area I had five per cent non-marketable males; Area II, nine per cent; and Area III, four per cent. For the entire season the non-marketable males constituted only five per cent of the total males caught.

In order to estimate the percentage of total (males and females) non-marketable fish in the catch, the ratios of males to females among the tagged fish were used as a representative proportion of the males to females among all the smaller fish. The estimates were made for each area separately and the results summed. The percentages of total non-marketable fish, males and females, in the catch of the Oregon floater-net fleet is approximately nine per cent for the entire season. Area I had an estimated eight per cent non-marketable fish (males and females); Area II, 14 per cent; and Area III, eight per cent.

Alive and Dead Females

The ratio of alive females to total females, expressed in per cent, declined as the fishery moved northward (Table 2). Area I had 43 per cent alive females; Area II, 31 per cent; and Area III, 13 per cent. The average for the entire season was 16 per cent alive females.

It was suggested that the decline was due to an increase in the length of the fishing day as the fleet moved northward and the weather improved during the summer. However, no such increase in fishing time was obtained from the log book data. The average number of hours fished per day for the 11 boats with complete records was as follows: Area I, 16 hours; Area II, 15 hours; and Area III, 17 hours. In addition, it was found that for the most part the individual boats tended to fish the same number of hours per day regardless of area.

A correlation was obtained between depth of water fished and the percentage of alive females in Area III (Table 3). As the depth of fishing increased, so did the percentage of alive females. However, even at depths comparable to those fished in Areas I and II, i. e., 1,000 fathoms and greater, the percentage of alive females (23 per cent) was lower than in the other two areas. No obvious explanation is apparent at this time for the decline in percentage of alive females in the catches as the fishery moved northward.

TABLE 3.

SUMMARY OF THE CATCHES OF ALIVE AND DEAD FEMALE SOUPFIN SHARK IN AREA III FOR 11 OREGON BOATS DURING THE PERIOD OF JUNE TO SEPTEMBER, 1949, BY DEPTH OF WATER IN WHICH CAPTURED

Depths in Fathoms	Females			
	Alive		Dead	
	No.	%	No.	%
Less than 100	7	8	83	92
100-250	17	9	181	91
250-500	10	17	50	83
500-1,000	15	26	43	74
1,000 and Greater	11	23	37	77
Total	60	13	394	87

Fishing Success by Area

The total number of fish caught per "boat-day" of fishing was selected as a relative measure of the fishing success of each area (Table 4). The boat-day represents one boat fishing one day. The gear varies in length and depth among the boats and is more or less a function of the size of the boat. From a sample of 24 of the 30 boats in the Oregon fleet

TABLE 4.

TOTAL CATCHES, TOTAL DAYS FISHED, NUMBER OF BOATS FISHING, AND NUMBER OF FISH/BOAT-DAY, BY AREA AND MONTH, OF 21[1] OREGON SOUPFIN SHARK BOATS FOR THE 1949 FLOATER-NET SEASON

	No. of Fish Caught						
	Males	Females	Unclassified	Total	Total Days Fished	No. Boats	Fish/Boat-Day
Area I: (Pt. Conception—Eureka)							
April	457	12	159	628	59	11	11
May	1531	38	379	1948	173	13	11
June	676	25	427	1128	65	8	17
July	1	0	0	1	2	1	1
Total	2665	75	965	3705	299	33	12
Area II: (Eureka—Columbia River)							
June	264	16	0	280	24	4	12
July	52	3	0	55	10	3	6
August	314	16	0	330	27	4	12
November	18	0	0	18	5	1	4
Total	648	35	0	683	66	12	10
Area III: (Columbia River—Hecate Straits)							
June	147	15	0	162	28	3	6
July	3714	266	1106	5086	271	20	19
August	1456	190	562	2208	146	15	15
September	1992	111	175	2278	118	10	19
October	44	7	16	67	22	3	3
Total	7353	589	1859	9801	585	51	17

[1] Catches for 13 boats with complete records and eight boats with partial records.

it was found that the mean length of gear was approximately 1,050 fathoms with an extreme range of 750 to 1,600 fathoms. The depth of the nets ranged from 50 to 90 meshes. The comparison of fishing success between areas involved, for the most part, the same boats fishing in all three areas so the variation in the length and depth of the individual nets was not important when comparing the "fishing success" in one area with another.

The length of a "fishing-day," as discussed before, was relatively constant within areas and did not vary greatly between areas. The average was 16 hours per fishing-day for the entire season.

The high for June of 17 fish per boat-day in Area I represents a concentration of fish in the vicinity of the Farallon Islands, west of San Francisco, California. A group of fish off the northwest coast of Vancouver Island and in the Queen Charlotte Sound area was the principal contributor to the July peak of 19 fish per boat-day. The September high of 19 fish per boat-day represents the results of the first major exploitation by floater nets of the soupfin shark in Hecate Straits, British Columbia. There has been a Canadian diver net fishery for dogfish for several years in Hecate Straits which also took some soupfin shark (Barraclough, 1948). It would appear that the boats in Area III had the greatest fishing success during the 1949 season.

Summary

1. The soupfin shark has been sought by the fishermen for the past 12 years because of the high prices which have been paid for the livers which are rich in vitamin A. The male livers contain more vitamin A than the female and consequently are more valuable.
2. The price rose from $0.20 per pound of liver in 1937 to $18 per pound in 1949 and has subsequently declined to $1.80 in 1950. The Oregon landings, which began in 1941, rose to a peak of 270,000 pounds in 1943 and then declined to a low of 50,000 pounds in 1948.
3. Soupfin shark were originally caught on long-line gear, but are now fished for with floater nets from April to October and with diver nets from October to March.
4. The Oregon fishermen tagged 291 soupfin shark during the 1949 floater-net season. There have been two recoveries of tagged fish.
5. The fishermen maintained log books in which they entered their daily catches, location of catch, and other pertinent information.
6. The floater-net fishing grounds were divided into three areas: a southern area off California; a central area off Oregon; and a northern area off Washington and British Columbia.
7. Sex ratios taken from the log book records indicated that the male soupfin shark predominated in the catches. The percentage of males varied from 92 to 97 per cent by area with a lesser percentage of males in the catches of the northern area. Among the tagged fish, the percentage of males varied from 48 in the northern area to 66 per cent in the southern area.
8. Non-marketable males constituted four to nine per cent of the total males. The central area had the greatest percentage of non-marketable males. It was estimated that nine per cent of the total catch for all three areas consisted of non-marketable soupfin shark, males and females.

9. No explanation could be found for the decline in the per cent of live females in the catches as the fishery moved northward. The percentage declined from 43 per cent in the southern area to 13 per cent in the northern area. In the northern area the percentage of live females increased as the depth of water fished was increased.

10. A relative measure of fishing success, "fish per boat-day," was selected to compare the three areas. The northern area had the greatest fishing success.

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