UNITED STATES
DEPARTMENT OF THE INTERIOR
Julius A. Krug, Secretary

U.S. FISH AND WILDLIFE SERVICE
Albert M. Day, Director

* * * * * * *

ANNUAL REPORT for the FISCAL YEAR 1947
DIVISION OF FISHERY BIOLOGY
(With Report for the Quarter April-June, 1947)

* * * * * * *

Issued September 1947
Washington, D. C.

National Oceanic and Atmospheric Administration

Report of the United States Commissioner of Fisheries

ERRATA NOTICE

One or more conditions of the original document may affect the quality of the image, such as:

Discolored pages
Faded or light ink
Binding intrudes into the text

This has been a co-operative project between the NOAA Central Library and the Climate Database Modernization Program, National Climate Data Center (NCDC). To view the original document contact the NOAA Central Library in Silver Spring, MD at (301) 713-2607 x124 or Library.Reference@noaa.gov.

HOV Services
12200 Kiln Court
Beltsville, MD 20704-1387
May 19, 2008

TABLE OF CONTENTS

INTRODUCTION

This report, the fourth in the series of Quarterly Reports initiated in July 1946, presents not only a summary of the biological investigations of fish and fisheries conducted by the Division of Fishery Biology during the months of April to June, inclusive, of the fiscal year 1947, but also a general resume of the progress of investigation during the entire fiscal year. It may, therefore, be termed properly the annual report of the Division.

In addition to presenting a record of research activities and administrative functions of the Division for future reference this series of Quarterly Reports is intended to serve as a medium of exchange of information among the widely scattered members of the research team and to overcome to some extent the effects of isolation of individuals and small groups of workers who have relatively little opportunity for personal conferences and few other means for an interchange of ideas. While the report may be of interest to other workers in the field of fishery science, it is intended primarily as a house organ distributed to all members of the staff of the Division.

Another important purpose of these reports is to permit current appraisal of the projects of research undertaken, the progress made in their development, and the relative value of the various efforts to the broad field of conservation in general and to the specific field of development and protection of the fishery resources.

The detailed reports of the activities of the field organizations and investigators which follow should serve these several purposes in varying degree, but it should be realized that the specific bits of scientific information included with an account of the respective activities are in nearly all cases in preliminary form, tentative in content, and fragmentary in scope. The results of many of the investigations here reported will be presented at a later time in formal publications after they have been thoroughly scrutinized for adequacy of method, accuracy of analysis, and soundness of interpretation. Until such publications, reviewed and approved by the Service, are issued it would be premature to judge and evaluate the various research projects solely on the basis of the information here presented. In the meantime, however, a free exchange of comment and criticism among the members of the staff is cordially welcomed.

The fiscal year of 1947 may be characterized as a continuation of the period of transition from war to peace. The concentration of attention on the research objectives, the assignment of personnel to uninterrupted investigation and the completion of the considerable backlog of research reports interrupted by the war has not yet achieved the full efficiency and completeness desired. During almost the entire year most of the biologists attached to the staffs of the North Pacific Fishery Investigations and the Central Valley Investigations were detailed to assist the Coordinator of River Basin Studies in the

preparation of a very large number of reports for the construction agencies on the effects of river impoundments and other engineering developments. Personnel seriously needed for investigations in Alaska and in a number of other areas were difficult or impossible to recruit, and the shortage of trained workers was further accentuated by transfers or details to various military activities and by employment in missions or expeditions to foreign countries. Construction or repair of physical facilities was difficult or long delayed, with corresponding impairment of research work depending upon them. Toward the end of the fiscal year uncertainties with regard to appropriations resulted in the curtailment of the staff and closure or curtailment of stations and programs. A Congressional mandate to reorganize the research program gave impetus to the Service-recognized need for a realignment of the research organization, and much thought and attention was given, following the staff conference in mid-year, to these problems of reorganization which bore fruit early in the following fiscal year.

Paralleling the self-appraisal and self-criticism within the Service and the Division which has disturbed administrators and investigators alike, a large-scale analysis covering the entire field of governmental and private research has been under way by the President's Scientific Research Board. In providing factual information and completing questionnaires for this Board a considerable amount of information bearing on the structure of the Division's research program was compiled. Classifying all fields of scientific research into three categories: (1) basic, with its special divisions of (a) fundamental and (b) background, (2) applied, and (3) developmental, it was found, for example, that the research program of this Division, judged by the amount of funds allotted to each field, is divided as follows:

1.	Basic Research	39.0%
	a. Fundamental 4.2%	
	b. Background 34.8%	
2.	Applied Research	51.1%
3.	Developmental Research	3.7%
	Total	93.8%
	Overhead	6.2
	Grand Total	100.0%

It will be noted that more than half of the work of the Division is concerned with applied research and that more than a third of the remainder is background research. Little opportunity is afforded for work in the developmental field or in the fundamental field of pure science, although many of the studies conducted are of the highest theoretical importance. Background and applied research is research with a purpose, and it is for this reason that virtually all of our efforts are classified in this way. The purpose ever kept in mind is the discovery and development of means and systems of managing . . fishery resources to assure their complete utilization and permanent productivity.

Funds for the support of these activities during the fiscal year 1947 were increased appreciably over those available during 1946, although a large share of these funds was derived by transfer from construction agencies for background and applied studies in connection with water impoundments. The following table presents a summary of the funds available and expended during the two fiscal years for the five budgetary projects for which they were appropriated.

APPROPRIATIONS - DIVISION OF FISHERY BIOLOGY

Project		1946 Avail.	1946 Expend.	1947 Avail.	1947 Expend.
114	Commercial Fishery Investigations:				
	Regular	$333,000	$332,000	$ 552,100	$ 552,000
	Transferred	295,500	190,600 1/	264,100	208,300 1/
	Sub-total	628,500	522,600	816,200	760,300
115	Shellfisheries	115,600	115,500	176,000	176,000
116	Inland Fisheries	53,000	53,000	49,800	49,800
117	Water Quality & Pollution	40,200	40,200	47,700	47,700
110	Operating of Fish Screens	28,000	27,000	34,000	34,000
	Grand Total	865,300	758,800	1,123,700	1,067,800

1/ Unexpended balance remains available in following fiscal year.

Contrary to expectation funds available for the publication of technical reports of investigations were again inadequate. The reflection of this condition is seen in the list of publications by members of the Division which appears as the last section of this report, particularly the small number of papers published in the official series of the Fish and Wildlife Service. This list, however, does not show the very considerable number of reports on completed investigations which should be published in order to make the information useful.

ALASKA FISHERY INVESTIGATIONS, George B. Kelez, Chief of Section

GENERAL

During the fiscal year of 1947 investigations were continued on the red salmon populations of Bristol Bay and the Karluk River, the pink salmon populations of southeastern Alaska, and on the herring populations of Kodiak, Prince William Sound, and southeastern Alaska. The collection and analyses of statistics of the fishing areas of Alaska were continued. A new project "Improvement and expansion of Salmon Spawning Areas" was initiated in southeastern Alaska.

In Bristol Bay important experiments were conducted to measure the effect of gill-net mesh of various sizes on the populations of red salmon. Aerial photographs were made of migrating salmon which proved of considerable value in the determination of the magnitude of escapements. Investigation of red salmon at Karluk provided sufficient data for the prediction of low abundance in the season of 1947. Observations made at Little Port Walter indicate that the pink salmon fishery will continue to fluctuate at a low level of abundance during the next two cycles. The herring investigation through studies of the abundance of the populations was able to recommend catch quotas for each of the major fishing districts. A notable recovery in the southeastern district has been effected by this system of management. Statistical information relative to the condition of the various Alaskan fisheries was prepared by the statistical staff for use by members of the Service.

Field work was conducted by staff members in Alaska during the greater part of July through October of 1946 and April through June of 1947. Cooperative use was made of the Service's aircraft and surface vessels to carry on the investigations.

PROJECT 1. SALMON RESOURCES IN BRISTOL BAY

Investigations of the red salmon populations of Bristol Bay, which were practically suspended during the war period, were pursued on a somewhat larger scale this year. Field activities during the first quarter included continued observations at Brooks Lake weir, pilot experiments on stream tagging of adult fish and effects of crowding on success of spawning, further experiments on aerial measurements of spawning populations and general surveys of the Bristol Bay spawning areas.

The run of red salmon through the Brooks Lake Weir, which terminated during August, was 122,114 red salmon. This very closely approximated the count during 1941, when 125,948 fish passed the weir. Since the majority of this population are individuals in their fifth year, 1941 is the "parent" year for a considerable proportion of the 1946 fish. The salmon pack of 647,325 cases in the Bristol Bay district was approximately 15 percent below the average number anticipated but well within the limits of the prediction.

During the winter months a report on the predicted runs for each of the 4 major fishing districts of Bristol Bay was prepared, together with an analysis of fishing intensity which these runs could normally maintain, for the Division of Alaska Fisheries prior to the annual fisheries hearing in Seattle.

Subsequent to the completion of this report, a survey was completed of all data obtained during the period of years when only seasonal collections were maintained and no analysis was possible due to lack of personnel. This very considerable mass of data has now been largely carried through preliminary preparation and tabulation. This material includes sex, size, weight, and age data for adult fish, together with various morphological characteristics for racial separations, and age and size data on downstream migrant fingerlings. A portion of the statistical data on the inshore fishery has also received preliminary treatment prior to analysis.

During April Mr. George Eicher was appointed to the staff of the investigation. His four years of previous field experience in Bristol Bay and subsequent experience as biologist for the Arizona Game and Fish Commission will greatly facilitate progress on the limnological phases of the investigation.

Mr. Eicher and Mr. Peck, with temporary personnel, left for the field in May. An exceptionally late spring break-up has greatly hampered activities to date, but the Brooks Lake weir has been reinstalled, quantitative limnological samples obtained, collections of migrant fingerlings taken and traps installed in the Naknek and Kvichak Rivers for obtaining adult fish for tagging. It is anticipated that several thousand fish will be tagged during the coming month to obtain information on the time of appearance and specific distribution on the spawning grounds of various races of salmon in each of these rivers.

Cooperation has been maintained with the research staff of the Alaska Salmon Industry, Inc., who will conduct studies in the Nushagak and Egegik River areas of the district during the 1947 season.

PROJECT II. SALMON POPULATIONS OF THE KARLUK RIVER, KODIAK ISLAND.

In the pursuance of the sockeye studies at Karluk, the enumeration of the annual runs and the determination of the age composition of each run has been carried out each year since 1921, and is one of the most important and enlightening phases of the Karluk work, since it yields data which are necessary to the conduct of the other sub-projects as well as to the immediate control of the fishery. This phase of the work is covered by sub-projects 1 and 2, which are so closely tied up as to be almost inseparable. Together they make possible a measure of the number of fish comprising each run (catch plus escapement), a determination of the number of fish in each run which have been produced by each of the several preceding brood years, and an account of the relative success of each of the various sized escapements obtained. These data are obtained through counting the annual escapement, through analyzing the catch data each year, and through obtaining and reading the ages of an adequate number of scales taken each year from the Karluk run fish.

The 1946 counting weir at Karluk continued in operation until October 20 by which time the run was definitely over. Four hundred and forty-two thousand, seven hundred and seventy-two fish passed through the weir during the season, with 130,472 of these constituting the fall escapement. This was the lowest total escapement obtained since 1922. When the catch data became available it was determined that the entire run of 1946 totaled only 670,000 sockeyes. This was approximately half the lowest run ever recorded (1922), and thus marked an alarming decrease in the Karluk population.

During the early winter the age composition of the run was determined through reading scales obtained from Karluk fish during the summer of 1946. Return-from-escapement data were brought up to date, and a study of these data made it evident that the poor run of 1946 was caused by the low survivals of the broods from 1940 and 1941. (1940 produced few 6-year fish, and 1941 produced very few 5-year fish.) As the ratio of 5-year fish of one year to 6-year fish of the next is relatively constant, it became evident that we could expect the 1947 run to have very few 6-year fish. On the average, 5-year fish plus 6-year fish constitute about 93 percent of the run of any one year. It was evident, therefore, that unless the brood year of 1942 proved to have been extremely successful, a very poor run was in prospect for 1947. A memorandum was prepared and submitted to Mr. Seton Thompson advising him that we could not reasonably expect a run of more than 589,000 fish at Karluk in 1947, and that it might prove to be considerably less than that amount.

A further study of the data brought the conclusion that, under present productivity levels obtaining in Karluk Lake, we might reasonably expect the best returns to be obtained from an escapement of approximately 700,000 fish, the escapement to be divided equally between the spring and fall runs. This information was included in the aforementioned memorandum.

The 1947 field season began when Mr. Shuman and Mr. Nelson, accompanied by four temporary assistants, left Seattle via Naval Air Transport Service airplane for Kodiak on May 20. Some delay was caused by adverse weather, but the counting weir was installed and closed at 7:00 P.M. May 26. The following evening 18 fish passed through the gates. By the end of the first week in June it had become apparent that the spring run was not developing well, and on June 7 at 6:00 P.M. all fishing in the Karluk area (and throughout the entire Kodiak district) was halted indefinitely. Despite this protection the escapement by June 28, was only 166,479 red salmon. Thus the dire prediction seems to have been justified.

When the counting weir was moved to the outlet of the lake in 1945 it became necessary to establish the time required by the fish to swim the 30 miles from the site of the fishing grounds to the weir. This was necessary that the escapements might be correlated with the catch each day. Tagging was done at the river mouth in 1945, the fish being recorded over the counting boards at the weir. An analysis of these

data indicated that the correction factor of 11 days (which had been chosen arbitrarily prior to the tagging work) was sufficient. To be sure of the results, this tagging was repeated in 1946. When the 1946 work was summarized it was found that the results were approximately the same for the two years. Thus it has been established that mean traveling time for the spring run fish is 6.5 days, while the mean time for the fall fish is approximately 11 days.

The study of the individuality of the spring and fall runs continued throughout the year, chiefly through a study of the history of the two runs. All data for the Karluk run were broken down into the spring and fall periods. It was found that the spring runs from 1921 to 1945 were rather constant, only the 1946 spring run showing a marked decrease. On the other hand, the fall run has decreased constantly (though not steadily) during the same period. These data were graphed, the spring runs being shown as a straight line, while the fall runs were represented in percent of the spring run each year. An exponential curve (fitted to the data by least squares) was prepared for the fall runs. This showed a geometrical decrease in the ratio between the two runs. In 1921 the fall curve was 210 percent of the spring; in 1936 they were equal; in 1946 the fall curve was 62 percent of the spring curve. Thus, the fall run has suffered far greater depletion than has the spring run. These and other data indicate that the two runs are separate and independent, though this is by no means proven. This is an important point, for no intelligent study of the biological problems, nor control of the fishery can be made until the relationship has been established.

The individuality of the populations within the lake system was studied through 1946 and is being studied more intensively in 1947 through a tagging and tag recovery program. During 1946, 0.5 percent of each day's escapement was tagged at the weir, recoveries being made later on the spawning beds. It was found that a mean time of 34 days elapsed between the time of tagging and the appearance on the spawning gravels. On the beds all fish were counted, both tagged and untagged, the ratio between the two being of prime importance. It was found that the recovery of tagged fish was only 72 percent of that expected for the spring run. Recoveries were too few during the fall period to permit any conclusion. Had the escapement (during the spring run) been calculated on the ratio of tagged to untagged fish on the spawning beds, the figure would have been set at 430,500. Actually it was 312,000, a difference of 118,500 or an error of 38 percent. Thus, the method does not appear to be dependable.

It was decided to conduct a more comprehensive program in 1947. This year the regulation half-inch celluloid tags, applied with all-nickle pins are being used. Each day 1.0 percent of the escapement is tagged at the weir, and it is planned to conduct, throughout the season, stream surveys twice each week, at which time a recording of all fish,

both marked, and unmarked, will be made. The use of several different colors makes it possible to tag with a different color combination each day, so that the date of application can be determined without molesting the spawning fish. It is believed that considerable information can be obtained on the time of appearance on the streams of the fish which enter the lake. It is also believed that the degree of reliability can be established for this method of enumerating the escapement in streams where no counting weir can be maintained.

From the tagging results of 1946 it appears that there is a definite tendency for the early run fish to enter the smaller spawning streams, though the number of recoveries (96 for the season) was too small to be conclusive. It also appears that the fall run fish spawn less in the tributary streams (and therefore, more in the littoral zones of the lake) than had been believed, for almost no fall-tagged fish were recovered on the stream gravels. It is hoped that the 1947 program may yield more definite data on these points.

Sub-project 4 was approached for the first time since the beginning of the last war. Chemical analyses of the lake and stream waters are being made throughout the 1947 season. The stations established by Juday, Rich, Kemerer and Mann (1926-1930) are being used, and their methods, so far as possible, have been adopted. Besides the chemical work, a quantitative plankton study is being conducted. It is hoped that these studies will yield some information regarding the ecological changes which are believed to have taken place during recent years.

During the past several months, considerable time was devoted to the preparation of a manuscript which presently will be submitted for approval. This deals with the condition of the fish populations in the Karluk system, advances theories regarding the causes of the declines, and suggests remedial measures. It summarizes the data on each of the several phases of the recent Karluk investigations.

PROJECT III. PINK SALMON RESOURCES OF SOUTHEASTERN ALASKA

The commercial pack of pink salmon in southeastern Alaska in 1946 dropped to a low of 991,713 cases. This was the fourth consecutive year of below-normal pink salmon catches in southeastern Alaska and the lowest production since 1927. The pack fell 855,000 cases short of the 10 year average. This low pack can be attributed to three outstanding factors; first, the poor showing of pink salmon in the northern section of southeastern Alaska; second, the size of the pink salmon that returned to the streams in all districts; and third, the time of appearance of the runs. The poor return had been indicated in the spring of 1945 by the small fry migration at Little Port Walter. The unexpected small size of the individual pink salmon, returning to all districts further reduced the size of the pack. The canneries required 25 pink salmon per case instead of the normal 17 pinks per case. This factor in itself reduced the commercial catch by one third. The time of appearance influenced, somewhat, the size of the pack. In some districts runs never developed and in others they appeared so late that the fishing gear was limited for time in which to make their catches. The recommended flexibility for seasonal closure in all districts proved very satisfactory in administering the fishery. If it had not been for this flexibility of closure the 1946 pink salmon pack would have been

considerably smaller. This system will be employed again during the 1947 season.

The upstream migration at Little Port Walter was the poorest thus far recorded since 1934. A total of 933 pink salmon moved into the stream to spawn from September 9 to October 10, 1946. Of this number 60 percent were males. Length and weight samples revealed those fish to be quite small, thus corroborating the industry's high fish per case figure. Observations were continued at the station throughout the winter on fertility, incubation and mortalities caused by meteorological conditions affecting the eggs and fry. By December it had been determined that approximately 40 percent of the pink salmon eggs spawned in Sashin Creek died either through lack of fertilization or improper environmental conditions at the time of spawning. Observations made in the stream during January, February and March revealed heavy losses of pink salmon fry due to continued sub-normal temperatures prevailing over all of southeastern Alaska at this time. Here again the loss of developing fry was excessive, which practically wiped out the few remaining pink salmon fry that had survived to the yolk sac stage. Thus the absence of pink salmon fry at Little Port Walter this spring was not unexpected, since all indications pointed toward a low fresh water survival. If other streams in the district suffered similar losses, then it is reasonable to expect that the return of pink salmon to the eastern district in 1948 will be considerably below average.

The anticipated delay in the downstream migration of pink salmon fry at Little Port Walter became a reality as climatological conditions continued at sub-normal levels. On April third Messrs. Robert Bridge and Leslie Ensign left Seattle, Washington, aboard the motor vessel "Brown Bear" to assist with the operation of the downstream fry counting weir at Little Port Walter. Upon the vessel's arrival at the station the field crews assisted with the installation of the fry counting weir and had it in operation April 9th. The first migrating pink salmon fry did not appear at the weir until April 15th, the latest date on record for the start of the pink salmon fry migration at the station. Messrs. Bridge and Ensign assisted station foreman Jerrold Olson with the operation of the weir until May 8th, at which time they proceeded north to work with the Bristol Bay Investigation and were replaced by Messrs. Kenneth Stanton and Ralph Williams. Mr. Stanton was relieved for stream survey duty on May 29th, by Mr. James Drewry who assisted at the weir until June 11th, at which time it was dismantled and stored until next season.

The operation of the weir this spring completed the seventh consecutive year of pink salmon fry counts from Sashin Creek. It was the smallest downstream fry count recorded at the station to date. A record low of 1,184 pink salmon fry were counted at the weir and of this number 966 live fry were released to proceed seaward. See table next page:

PINK SALMON FRY COUNT AT LITTLE PORT WALTER, ALASKA
April 14 through June 2, 1947

Date	Weir count	Date	Weir count	Date	Weir count	Date	Weir Count
April		April		May		May	
14	0	27	3	10	147 + 200*	23	1
15	1	28	0	11	3	24	11
16	0	29	3	12	9	25	0
17	0	30	0	13	3	26	0
18	2	May 1	2	14	31	27	0
19	0	2	3	15	11 + 1*	28	0
20	0	3	23	16	60 + 5*	29	0
21	0	4	7	17	6	30	0
22	6	5	15	18	3	31	0
23	0	6	32	19	490	June 1	1 + 2*
24	11 + 1*	7	4 + 6*	20	13	2	0
25	0	8	6	21	8	Total	966.

* Fry killed at weir - total 218.

This year the migration was very spasmodic and at no time did it develop any consistent pattern of nightly movement from its freshwater to marine environment. The greatest number of pink salmon fry (490) migrated on May 18th, at which time the water in the creek was at a normal level and the night was partly cloudy, affording darker than usual night time conditions.

From a potential 736,000 pink salmon eggs spawned in Sashin Creek in the fall of 1946, a total of 1,184 fry were counted at the weir this spring, which gave a freshwater survival factor of 0.2 percent. This is the lowest freshwater survival figure that has been obtained, at Little Port Walter. This year's survival is eleven times lower than the average freshwater survival of 2.2 percent. Adverse climatological conditions prevailing at Little Port Walter and throughout southeastern Alaska during the incubation period greatly reduced the freshwater survival of the 1946-47 stock of pink salmon.

Additional observations taken at the weir included counts of 551 coho salmon fry, 1 chum fry, 44 Dolly Varden trout, 340 Rainbow trout, and 61 Steelhead trout. Approximately one hundred steelhead trout move into the stream to spawn each spring in April and May. The steelhead complete their spawning by the middle of June and immediately return downstream to saltwater where they take up a feeding migration, not to return to freshwater until the following spring.

PROJECT IV. THE HERRING RESOURCES OF ALASKA

Through continued study of the Alaska herring fishery current data on the abundance of the stocks in each fishing district were obtained. Conclusions, reached through the analysis of these data, were submitted to the Division of Alaska Fisheries, which is charged with the management of the fishery.

A biologist was stationed in each major district during the fishing period to sample the catch for composition as to size and age of fish. A total of 12,500 individual fish were measured and weighed with the age of each being determined by examination of the scales.

Analysis of the data involved the measurements of relative abundance through calculation of the return per unit of fishing effort, the determination of the rates of recruitment and mortality within the stocks, and the prediction of abundance and age composition in the coming year. Specific recommendations on the amount of catch that should be allowed in each district in 1947 were also prepared. Results of the investigation as they pertain to the condition of the fishery in each district are briefly reviewed.

KODIAK

Herring operations in this district during 1946 were very successful, as shown by the fact that four plants employing a total fleet of 16 vessels, received a total of 378,000 barrels of fish. A total of 305,000 barrels were taken within the quota area, 60,000 in the Resurrection Bay area, and the remaining 13,000 in the Cook Inlet area.

Relative abundance, as calculated from the return per unit of fishing effort, declined from that of the previous year. Although exceptionally large catches were made during the latter part of September and early October the below average catches of July and August lowered the index for the season as a whole.

Analysis of the age composition data demonstrated that the fishery was supported principally by the year classes of 1943, 1942, 1941 and 1940 as 3-, 4-, 5-, and 6-year fish respectively. The percentage contribution of these year classes (13, 18, 23 and 25 percent) closely approximated the composition as predicted from the data of the preceding year. The greatest deviation occurred in the 1942 class where the percentage contribution of 5-year fish exceeded that which had been anticipated. The entering 1944 year class contributed 11 percent, as 3-year fish, which is more than the average contribution made by year classes entering the fishery for the first time.

A forecast of the abundance and the anticipated percentage contribution of each year class was made for the season of 1947. This prediction was based on the average ratios of increment and decrement, or the manner in which a year class will augment or decline in available numbers with an increase of age. These ratios which have been calculated from the percentage contribution in successive years of all year classes contributing to the fishery in the past, were recalculated to include the data obtained in the season of 1946. They show that on the average there have been 4.4 fish in the catch in their fourth year for each one present in its third; 1.4 individuals in their fifth year for each one present in its fourth; 0.7 individuals in their sixth year for each one in its fifth; 0.8 individuals in their seventh year for each one present in its sixth; and that the established ratio of 0.5 individuals past age 7 surviving for each one present in the catch of the preceding season, has remained substantially the same.

These ratios were used to estimate the potential yield of all year classes now within the fishery on the basis of their contributions to date. These calculations show that in 1947 the principal support of the fishery will come from the year classes of 1944, 1943, 1942, and 1941 as 4-, 5-, 6-, and 7-year fish. As judged from the estimated strength of these year classes it is anticipated that the abundance will be slightly less than in the season of 1946.

PRINCE WILLIAM SOUND:

Operations in this district remained on a small scale. Only two plants operated and they received a total catch of 103,000 barrels. Of this amount 77,000 barrels came from the adjoining Resurrection Bay area and only 26,000 from within the Sound. The fall run which has been the most important contributor to this fishery in the past again failed to appear for the sixth consecutive year.

The collection of data on the catch and its composition was continued during the 1946 season. The small operations of the recent years and the failure of the fishery to make significant catches within the district has not provided adequate data for the calculation of ratios of increment and decrement for use in predicting abundance. Since fishing operations in this district have not been normal indices of abundance as calculated from the return per unit of fishing effort are not available. The assessment of the strength of the year classes has been obtained only from a consideration of their percentage contribution to the catch in relation to the estimated abundance of that year. A promise of increased abundance for the summer period of the 1947 season arises through the fact that the 1944 class will then be in its fourth year. Since the catch of 1946 consisted mainly of this year class it can be expected to dominate the catch in 1947. In the Kodiak and Southeastern districts this year class has proven to be exceptionally successful and since there is a positive correlation of size of year class among the major fishing areas it may be of dominant character in Prince William Sound. If so, it should be able to make a substantial contribution to the fishery in its fourth year.

The possibility of a fall run in this district rests with the number of the 1942 class that still remain in the stocks. This year class will attain its sixth year in 1947 and should, therefore, contribute principally during the fall period. If its failure to contribute in numbers to the summer fishery of 1945 and 1946 was due to factors of availability rather than to low abundance it may yet be sufficiently numerous to contribute during the fall period of 1947.

recommendation which was submitted and subsequently adopted provides for a common catch quota for the two districts of Prince William Sound and Resurrection Bay for the 1947 season. This recommendation was based on the observation that the catch in the latter area had markedly increased over the past several years while at the same time the catch within the Sound had declined. No positive data is available as to the relationship of these populations since funds have not been available for a tagging program. The shift of the fishery suggests, however, that these populations may belong to a common stock which may vary its feeding migration between the two localities. It is also possible that the Prince William Sound stocks may be joined by populations from other areas on the Resurrection Bay feeding grounds in a situation comparable to that existing in the Tebenkof area of Southeastern Alaska where the area is jointly occupied by a portion of both the Sitka and the Craig populations. In view of the low abundance of the Prince William Sound stocks it was considered advisable to protect them against the probability of excessive exploitation in the Resurrection Bay area.

In view of the growing importance of the latter area all data available are being tabulated for analysis. Mr. Elling has completed tables on the catch of each year; the catch by statistical areas and ten day periods; the return in barrels per each set of the nets; and the mean weight and length at each age for each year.

SOUTHEASTERN

The 1946 season was the most successful since the area was reopened in 1943. Three plants, employing a total fleet of 12 vessels, obtained a combined catch of 300,000 barrels. Of this total 214,000 barrels were taken from the Cape Ommaney area and the remainder from the Kuiu Island grounds. This catch, made by a relatively small fleet, indicates the extent to which these populations have been restored.

The catch data which were collected during the fishing season were analyzed to obtain an index of abundance for 1946. This index was 116 as compared to 104 in the preceding year. The rise in abundance was caused principally by the entrance of the exceptionally successful 1944 year class into the fishery in its third year. Contributing factors were the maturing of the fairly successful 1943 year class into its fourth year and the large contribution of the dominant 1942 year class in its fifth year. The contributions of these three year classes constituted 83 percent of the total catch.

The data accumulated since the reopening of the fishery was used to establish rates of increment and decrement for the purpose of forecasting abundance and age composition in the season of 1947. The ratios show that for each individual of a given brood that has entered the fishery in its third year there have been 4.4 individuals of the same brood year as 4-year fish in the succeeding year; for each 4-year fish 0.7 individual as 5-year fish; for each 5-year fish 0.6 individuals as 6-year fish; for each 6-year fish 0.5 individuals as 7-year fish; for each 7-year fish 0.5 individuals as 8-year fish; and that for each age over eight the number will diminish by approximately three-quarters in each succeeding year.

The measurement of the potential yields of the various year classes within the fishery and the probable size of their contribution in 1947 indicates that the abundance will be high. A series of exceptionally successful spawnings (1940, 1942, and 1944) have been instrumental in restoring the abundance in this district. The anticipated increase over the already high level of 1946 will result from the attainment of its fourth year by the year class of 1944. It is at this age that each year class makes its maximum contribution to the catch. As measured by the contribution of its third year this brood appears to equal in numbers that of 1926 which contributed approximately one billion individuals during its span in the fishery. It is anticipated that 70 percent of the catch will be from this year class as 4-year fish, six percent from the 1943 class as 5-year fish, and 11 percent from the 1942 class as 6-year fish.

An article entitled the "Decline and Restoration of the Southeastern Herring Fishery" has been under preparation by Mr. Kolloen during the final quarter. The purpose of this report is to account for the marked fluctuation in abundance in the light of the biological data accumulated over the years of investigation; to review the methods used in predicting abundance; and to comment on the probable future of the fishery in this district.

PROJECT V. FLUCTUATIONS IN TIME OF APPEARANCE AND ABUNDANCE OF ALASKA SALMON RUNS.

It was shown in a manuscript, "Time of appearance of pink salmon runs in Southeastern Alaska" published in Copeia, that, in general, the runs of pink salmon have been getting later in the season as the

years progress. No attempt was made to explain this general trend. However, since the pink salmon migrations have become late in the season throughout southeastern Alaska and since they comprise approximately seventy-five percent of the catch in this area, the opening and closing dates for the fishing seasons have been set from two weeks to a month later in 1947 than in previous years. The effect of this later season upon the catches of other species should be studied. Chum salmon are second in importance in this region, comprising 15 percent of the catch. Therefore an analysis of the daily catch of chum salmon by traps was begun.

Assistance had been given various members of the biological staff with statistical problems arising in their work. Aid was given Mr. Hooker in the compilation of statistics of the Alaska Peninsula red salmon trap fishery and the Bristol Bay gill net fishery.

The planning of an experiment to determine the effect on the Vitamin A content of dog-fish livers during storage was discussed with Mr. F. B. Sanford of the Technological Section. Since the livers are very expensive and the analysis of the livers for Vitamin A involves a great deal of labor, it was desirable to determine how small a sample could be used and yet obtain reliable results. The experiment as planned was carried through and the results analyzed by members of the Technological staff under Miss Vaughan's direction. Two reports on this experiment have been written for publication and are in the process of being reviewed for publication in Commercial Fisheries Review.

PROJECT VI. ALASKA FISHERY STATISTICS

The months of July, August and September were devoted to giving assistance to the Division of Alaska Fisheries in Juneau, by supplying data on the current abundance and time of appearance of the pink salmon runs in southeastern Alaska. Current daily trap lifts were obtained by radio from all of the canneries operating in the area. From these data comparisons were made with former years to determine how the present runs compared with those of former years.

During the months of October and November the work of summarizing the Cook Inlet trap data was begun, but was put aside at the end of that time to work on Bristol Bay data which was in more urgent need of attention. Work on this Bristol Bay pack data were carried on through December, January and February. During March a comparison was made between the runs at False Pass and Bristol Bay. The same method of comparison was employed as that used by Rich and Ball, but whereas they found that the two areas fluctuated together prior to 1928, the years 1936 to 1946 were found to vary independently of one another. Adverse weather conditions and war both interfered seriously with operations in these latter years and may account for the fact that the catches in the two areas varied more or less independently of one another.

Mr. Hacker devoted some of his time to purchasing supplies for the Alaska Investigations and to supervising the repair and conditioning of the vessel HERON so that it can be used this season. Further work was also done with the Bristol Bay pack data as well as with the False Pass data.

Tabulation of the trap catches of salmon in Southeastern Alaska was continued throughout the year. The daily records of all salmon traps operated in Alaska during the 1946 season were received and indexed. Mr. Hacker left via air for Bristol Bay on June 22, to statistically analyze the red salmon runs as they occur.

PROJECT VII. IMPROVEMENT AND EXPANSION OF SALMON SPAWNING AREAS

The Alaska stream improvement program, authorized to begin initial surveys in July 1946, has completed its first year of activity. The purpose of this survey is to determine the barriers to the ascent of the spawning salmon, the evaluation of the spawning areas now unavailable to the salmon and the development of plans for the removal or surmounting of these obstacles. In order to locate these barriers and ascertain the feasibility of such improvements on a cost-production basis it is necessary to first survey the situation from a biological as well as from an engineering viewpoint.

After making preliminary preparations for the field survey, Mr. S. J. Hutchinson was met in Ketchikan, October 1st, by a field staff aboard the F.W.S. BROWN BEAR consisting of Messrs. S. H. Bair, W. O. Brewington, R. E. Halverson, J. I. Hodges, W. M. Morton, and S. E. Pederson. During the next four weeks forty streams were surveyed starting in Dolomi Bay on Prince of Wales Island and ranging north along Etolin, Mitkof, Kosciusko, Baranof, and Admiralty Islands to Pavlof Harbor on Chichagof Island. Of these streams, 27 were surveyed from a biological standpoint, mapped, and photographs taken of their barriers. In addition, engineering topographical surveys were made of the falls in Navy Creek, Burnett Inlet, Etolin Island; Beauty Creek, Dolomi Bay, Prince of Wales Island; and Falls Creek on Wrangell Narrows, Mitkof Island. The field staff returned to Seattle November fourth. From that date until the first of April they were employed in analyzing these data. Preliminary reports were prepared on 15 of these streams and recommendations were made for the immediate improvement of 7 of them at an estimated cost of $400,000.

Field parties got underway again on April 3, 1947, when Messrs. Brewington, Halverson, Hutchinson and Morton left Seattle aboard the F.W.S. BROWN BEAR for Southeastern Alaska. Mr. E. Kenneth Stanton joined the survey party at Juneau. After discharging supplies and personnel at Juneau and Little Port Walter, Alaska, the survey party proceeded to Hunter Bay at the southern tip of Prince of Wales Island where the first stream survey was undertaken.

When surveying the streams a motor vessel the BROWN BEAR or BRANT was used as a base of operations. Ship to shore movement was by outboard-powered skiffs. A preliminary reconnaissance of each stream was made to determine what type of survey should be conducted. If the stream possessed no barriers to migrating salmon estimates were made of stream lengths, widths, and depths; azimuths were measured and the percentage of bottom usable as spawning area was estimated. A general description of the bottom and adjacent terrain was also made. If the spawning area lying above a barrier was found to have a potential value insufficient to justify the cost of making the barrier passable to migrating salmon a similar procedure was followed.

When a stream was found to possess a barrier which feasibly could be made passable, greater care was taken in making the survey. On such a stream it was necessary to traverse all the suitable spawning area, since the total potential area to be gained would need to be sufficient to offset, by increased salmon production, the cost of improvement. The procedure on a stream of this type was to obtain accurate measures of length, width, and depths from salt water to the upper limit of potential spawning area, indicating the location of prominent physical characteristics such as bars, pools, types of rubble, tributary rills, islands, rapids and cascades. Included on the drawing were recordings of the heights and nature of the banks and of the surrounding terrain.

The heights of barriers were measured when possible; if this proved impracticable they were calculated by triangulation. If the height was so great that an accurate measurement was not necessary an estimate was made. The flotation method was used in determining the amount of flow of streams.

During April and early May 1947 approximately 60 streams were surveyed in the west coast area of southeastern Alaska with operations ending in Port Beauclerc, Kuiu Island. At the completion of this survey in early May the F.W.S. BROWN BEAR returned to Seattle and the survey staff was transferred to the F. W. S. BRANT in Ketchikan for surveys in that district. Mr. James H. Drewry joined the field crew at this time. Approximately forty streams were surveyed from Portland Canal northward through Behm Canal to Caamano Point and Clover Pass. After June 1st intensive surveys were made from McLean Arm to Cholmondeley Sound on Prince of Wales Island.

Activities were terminated in Duncan Canal on Kupreanof Island where two days of aerial surveying proved its value in locating unreported falls, and for directing survey crews to such falls. The aerial survey conducted by Messrs. Hutchinson and Morton from an amphibious plane piloted by Mr. Delmar Freimuth covered the Duncan Canal - Petersburg area and the northwest section of Kupreanof Island. In 6 hours of flying time 74 streams were aerially surveyed. It was possible to determine in a few minutes whether or not a stream contained a barrier, and if so its location and the approximate length of potentially useful stream bed above the barrier. The work of the ground crews was facilitated by using information provided by the aerial survey. A number of streams which were observed from the air contained no barriers; thus, considerable time and effort was saved on the part of the ground crews in their search for barriers. The aerial survey required only a few hours whereas it would have taken the ground crew a month to cover the same area. This type of survey of all streams in southeastern Alaska is highly recommended and should precede any reconnaissance by ground crews.

This spring the survey parties were in the field 75 days. One-third of this time was spent in necessary travel and two-thirds in actual stream survey. A total of 120 streams were surveyed of which about 70 were considered useful as salmon-spawning streams, while the remaining 50 were classed as of doubtful or of no value to salmon because of the very steep gradient or small size. Twenty-three potentially productive streams surveyed were considered worthy of careful measuring and mapping. At present 19 of these appear to offer justification for improvement. If these 19 streams were improved at an estimated cost of $1,300,000 they would provide roughly 200,000 square yards of new spawning area for the salmon.

NORTH PACIFIC FISHERY INVESTIGATIONS, Joseph T. Barnaby, Chief

GENERAL

The studies carried on by the section North Pacific Fishery Investigations have, during the past fiscal year, been concerned primarily with (1) the effects of water use projects on the anadromous fish runs of the Columbia River, and (2) the probable effects that future projects may have on the resource.

Funds for the investigations were contributed in part by the Service, in part by the Corps of Engineers and in part by the Bureau of Reclamation. However, due to the uncertainty of the amount of funds that was to be available, which prevailed until quite late in the fiscal year, an orderly program of investigation could not be carried out. A number of studies that were being carried on at the beginning of the fiscal year had to be terminated or severely curtailed during the period because of lack of funds.

Late in the first half of the fiscal year it was decided by higher authority that preparation of reports on the effect on the fishery resources that might result from the construction of proposed water use projects would come under the jurisdiction of the Office of River Basin Studies. Pending the setting up of a staff to carry on this work, members of the section continued to prepare reports on the projects, with the Section Chief acting, in addition to his other duties, as District Coordinator of River Basin Studies.

Of particular interest during the year was Congressman Richard Welch's visit to the area in July, at which time the Section Chief accompanied the Congressman on a trip to Bonneville Dam to inspect the fish facilities at that project. Also of importance was the Congressional hearing of the Committee on Merchant Marine and Fisheries which was held in Portland on August 14. The Section Chief read a prepared statement on the effect that certain proposed dams in the Columbia River would have on the fish populations of the region.

During the last quarter (June 10-20) the Section Chief proceeded to California where he conferred with Drs. Rich, Moffett and Sette in regard to problems of mutual interest. A trip was made with a member of Dr. Moffett's staff to Shasta Dam, Coleman Hatchery, and the Deer Creek Station.

The Section Chief attended the meeting of the American Association for the Advancement of Science June 17-20 in San Diego and read a paper entitled "Dams and the Columbia River Salmon" before one of the meetings of the Society of Ichthyologists and Herpetologists.

While in California Mr. Barnaby also conferred with Messrs. Croker and Fry in regard to the degree of success they had experienced with electric fish screens, and with Mr. Hanson in regard to certain investigations he was carrying on at Bonneville in connection with the mortality of adult salmon.

During the previous three quarters, reports completed and submitted to the Regional Office were as follows:

Willapa River
Puyallup River
Umqua Harbor
Milton-Freewater
Charleston Slough
Columbia Slough
Smith River
Umqua River
Skipanon River
Westport Slough
Lake Crockett
Kennewick
Chehalis River
Purple Creek Water Power Project
Vale

During the past quarter the following reports were completed and submitted:

Yakima River Flood Control
Weise-Roberts Project
Tokotee Project
Wenatchee Project
Detroit Project
Meridian Project

PROJECT I. FLUCTUATIONS IN ANNUAL AND SEASONAL ABUNDANCE OF SALMON AND TROUT POPULATIONS.

The studies of abundance of Columbia River fish populations have two primary objectives: (1) estimation of the economic value of populations which may be affected by proposed water-use projects, in order that possible fish losses may be compared with claimed benefits; (2) determination of the relationships between fishing intensity and catch, so that recommendations may be made to state agencies and to the fishing industry regarding regulation of the fishery. At present the first of these is most important, since the Fish and Wildlife Service is charged by law with the review of all proposals for Federal water-use projects which may affect fisheries resources.

The studies were commenced by Mr. Silliman the beginning of the fiscal year, and with the exception of one quarter's help from Messrs. Johnson and Hodges, have been carried on solely by him. Progress reports on the individual subprojects follow.

Study of Catch-per-Unit-of-Effort of Columbia River Chinook Salmon.

Because of lack of clerical help this study has been restricted to the catch of a single species (chinooks) by a single type of gear (gill nets) in a single river zone. Even with these restrictions, however, the measure should provide a good sampling of the abundance of the chinook runs as they enter the river.

As an initial step performance records for 4,600 fishermen who fished during the period 1907-1940 were prepared; using these and considerable supplemental information preliminary analysis led to the setting up of a standardized procedure for calculating catch-per-unit. This procedure consists of four main steps: (1) a list is prepared of all fishermen who made landings in each month of each pair of seasons being compared; (2) the catches of each fisherman are summed and listed by standard weekly periods (whenever a fisherman made no catches during a given week he is listed as having made a zero catch if 10 percent or more of the other fishermen made only one delivery, and if he made one or more deliveries during the preceding and succeeding weeks); (3) catches of all fishermen on the list are summed by weeks for each of the two seasons being compared; (4) a final summation is made for selected parts of the season and the totals so secured are used in obtaining a ratio between catches-per-unit for the two seasons.

During the fiscal year catches per unit of fishing effort for selected periods of five fishing seasons have been calculated. These statistics represent the catch per fisherman week for the given periods (corrected for variations in fishing efficiency).

Year	May	June-July	August-Sept.	Season
1936	483	532	1307	751
1937	574	464	1806	903
1938	443	351	1418	701
1939	352	443	1725	823
1940	67	199	1812	673

These figures bring out even more strikingly than the total catch, the much greater decline of the spring and early summer runs as compared with the late summer and fall runs, At present the two most plausible explanations seem to be: (1) that the August 25 to September 10 closed season has afforded some measure of protection to the late runs, and (2) that the early runs, being composed mainly of up-river fish, have been exposed to more man-made hazards than the later runs.

Estimation of Troll catch of Columbia River Chinooks

Since the Columbia River stock of chinook salmon is known (from tagging experiments) to contribute significantly to the intensive oceanic troll fisheries, it is necessary to have some estimates of the size of this contribution in order to know the total catch of Columbia River chinooks. A tagging program to secure new direct evidence could not be undertaken due to a shortage of funds, so a statistical study was started during the fiscal year for the purpose of obtaining the best possible estimates from the available data.

The study has now been completed and a report has been prepared thereon. After some revisions suggested by Dr. Rich, it will be submitted for processing as a Special Scientific Report. The analysis indicates that the troll catch of Columbia River chinooks averaged about 8,000,000 pounds for the period 1936-40, and 7,000,000 pounds for the period 1941-45.

Study of Average Weights of Columbia River Chinooks.

In order that the catches of salmon may be compared with the counts at Bonneville and Rock Island dams, it is necessary to convert the former from the pounds in which they are reported to numbers of fish. To do so requires average weights of salmon caught, which fluctuate a great deal both within and between seasons as well as from point to point along the river. During the fiscal year an analysis was made of average weight statistics for 1939-42 gathered by Dr. Rich or his assistants and those for 1943-45 gathered by Mr. Bryant at Astoria. These statistics consist of total weights and number of fish for hundreds of loads aggregating over 350,000 individual salmon. Analysis of this mass of data has yielded weekly average weights for each of two river regions during each of the seven seasons involved, and has indicated the type of sampling needed to secure better data with less effort in the future.

The sampling system indicated was the securing of the weights and numbers of fish for at least one load of fish each week from each of three receiving stations ineach of the six river zones. Because of the shortage of available manpower (Mr. Bryant must do the average-weight sampling in whatever time he can spare from the collection of marked salmon at Astoria) this ideal sampling system is not being fully realized during the 1947 fishing season, but even so some improvement in the sampling of average weights has already been achieved.

A report on the subject, entitled "Intra-seasonal and Inter-seasonal Variations in Average Weight of Columbia River Chinook Salmon (Oncorhynchus tschawytscha)" by Ralph P. Silliman, Willis H. Rich and Floyd G. Bryant, has been prepared and is in the process of being submitted for processing as a Special Scientific Report.

PROJECT III. FISH PROTECTION AT DAMS AND DIVERSIONS

Fishways design

Plans submitted to the Federal Power Commission by the Idaho Power Company, for the proposed 50,000 k.w. power development at Lower Salmon Falls on the Snake River near Hagerman, Idaho, were referred to the Fish and Wildlife Service by the Federal Power Commission for approval of the project from the standpoint of fish protection. The proposed development designed for peak-load operation, will have a maximum difference between tailwater and forebay levels of 63 feet. A fish ladder, incorporated in the plans, was redesigned through the combined efforts of Messrs. Bair and Holmes. Of special significance was the automatic gate controls at the upper five weirs of the ladder, necessitated by a diurnal fluctuation of 6 feet in forebay elevation. At the lower end of the ladder, an automatic regulating gate was included in the redesign to maintain a normal drop in water surface of one foot at the entrance weir. Standard ladder pools were made 6 feet wide, 8 feet long, and with a minimum depth of 3 feet. Upon completion of a plan based on the recommended changes in ladder alignment and construction details, Messrs. Barnaby and Bair made a trip to Boise, Idaho, to discuss with various members of the Idaho Fish and Game Commission and the Idaho Power Company the redesigned features and the effect of peak-load operations on fisheries resources in the river both above and below the proposed development.

A trip was made by Mr. Bair to Oroville, Washington, in connection with the construction of two small timber fish ladders at the Zosel Mill Dam on the Okanogan River, and deviations of the constructed ladders from the plans were discussed with Mr. Zosel, the owner. These ladders were designed for a difference in operating level between tailwater and forebay levels of 3 to possibly slightly more than 4 feet. Each ladder consists of three pools, each pool being 6 feet in length and about 4 feet in width.

During the fiscal year 1947, fish screens were operated and maintained by this section at the following locations:

(1) Wapato Canal on Yakima River, near Parker, Wn.
(2) Sunnyside Canal on Yakima River, Near Wapato, Wn.
(3) Prosser Power Canal on Yakima River, near Prosser, Wn.
(4) Tieton Canal on Tieton River, west of Yakima, Wn.
(5) Ahtanum Canal on Ahtanum Creek, west of Yakima, Wn.
(6) Foghorn Ditch on Methow River, near Winthrop, Wn.
(7) Black Canyon Dam on Payette River, near Emmett, Idaho.
(8) Easton Dam on Yakima River, near Eason, Wn.
(9) Old Indian Canal on Yakima River, near Wapato, Wn.
(10) Pishkun Reservoir, near Choteau, Montana.

The Wapato, Sunnyside, Prosser, Tieton and Ahtanum screens are paddle-wheel operated rotary-drum screens; the Foghorn Ditch and Black Canyon screens are rotary-drum screens powered by electric gear-head motors; and the Easton (Kittitas), Old Indian, and Pishkun screens are of the parallel-bar type.

At the Wapato screen, four of the ten paddle-wheel shafts broke during the 1946 season of operation. All of the shafts broke at the point where the paddle-wheel hubs were keyed to the shafts. Since an analysis of the failures indicated that the remainder of the paddle-wheel shafts would suffer the same damage, the paddle-wheels were reconstructed, utilizing 5" D. extra-strong pipe for the shaft to avoid unnedessary weight of solid shafting and for economical reasons. Also, in an effort to avoid the expense of providing new bearings, the ends of the old paddle-wheel shafts were cut off and provided with collars to fit inside the ends of the pipe. These stub-shaft and collar units were then welded to the pipe. The original paddle wheels were constructed with two spiders (hub and spokes), spaced 5'-0" on centers, while in the reconstructed paddle wheels a third spider was added with the three being placed 4'-6" on centers. The paddle wheels at the Wapato fish screen are 12'-0" in diameter and are provided with paddle boards 10'-0" in length. The center to center distance of the supporting bearings on the paddle-wheel shafts is 13'-2".

In addition to time devoted to engineering activities, cooperation was given to the Bureau of Reclamation and various fish and game departments of Washington, Idaho, and Montana. Engineering assistance was also furnished to the Division of Game Fish and Hatcheries, in connection with the design of an aerator for well water at the Leavenworth hatchery and the preparation of a plan for a fish-food mixer.

Fish Screens

In connection with the operation of the Pishkun Reservoir fish screen near Fairfield, Montana, a crane barge has in past years been anchored in front of the fish-screen structure to provide a means of removing screen panels from the structure, in the event the fish screen should become clogged with debris. However, experience has indicated that it was unnecessary to have the barge launched each year, so it was decided to keep the barge on the skidway at all times, until an occasion should arise wherein it would be required that the barge be put in service. The original skidway was designed for accommodating the barge at the lower level maintained in the reservoir during the winter season and was nearly submerged at the normal reservoir level, so a skidway extension was designed by Messrs. Bair and Lambert to provide accommodations for the barge above the maximum reservoir water surface.

Each winter at the rotary-drum fish screen in the Prosser Power Canal, near Prosser, Washington, the lower half of each of the eight 12'-0" diameter paddle wheels has had to be dismantled to eliminate the possibility of damage due to ice. To obviate the laborious task and operational costs created by such a procedure, paddle-wheels storage racks 7 feet in height have been designed by Messrs. Bair and Lambert for installation on the walls between adjoining screen bays. As a means of removing the paddle wheels which weigh about 2400 pounds each,

a boom 15 feet in length has been designed for attachment to the existing gantry crane on the project.

A contract has been awarded for two new ring gears and pinions for the Prosser Power Canal fish screen to replace two existing ring-gear drives on the 11'-0" diameter fish-screen drums. The existing ring gears that will be replaced were originally installed before the 1943 season and, due to lubrication difficulties, did not give the service expected. At present there are two of the new type ring gears of the heavier construction, and, after a season of operation and provision of a satisfactory means of lubrication, it appears that the new ring gears should last the life of the project.

In the past, considerable difficulty has been encountered at the Prosser screen from the lack of proper transitions at the upstream and downstream ends of the south end wall. Material from the canal bank slides into the end screen bay, partially obstructing the flow of water and filling the by-pass trench in front of the screen with heavy deposits of sand and gravel. Transitions have been designed by Mr. Bair, utilizing sacked concrete riprap on a 1 on 1 slope.

Contracts were awarded for the furnishing of steel shafting and electrical equipment to be used in connection with the electrification of the Echo Feed Canal fish screen near Echo, Oregon. This fish screen, consisting of five 6'-0" diameter screen drums, was originally provided with paddle wheels, but, bue to extreme fluctuations of water surface in the canal, the paddle wheels were found to be impractical.

Steel reinforcement schedules were prepared for the proposed parallel-bar type of fish screen, designed for the south outlet of Nelson Reservoir located near Malta, Montana, in order that complete contract plans will be in readiness when construction funds become available. The detailed plans for the structure were prepared by Messrs. Bair and Burner during the fore part of 1942, but, due to the war and the situation regarding critical materials, the project was deferred indefinitely. The proposed fish screen is 23 feet in height, 40 feet in width at the bottom, 12 feet in width at the top, with screen panels placed on a slope of about 45 degrees. The individual screen panels are 4 feet wide by 10 feet long, and provision for their removal is included in the plans in the form of a stiff-leg derrick mounted on top of the structure.

The operation and maintenance of fish screens in the Yakima Valley has been continued by Mr. Holcomb, assisted by Mr. Argetsinger and temporary laborers, and has been more or less routine in nature for the past quarter. Mr. Holcomb has, however, developed and installed a device to give satisfactory lubrication of the ring gears at the Wapato and Prosser Fish screens. The device consists of a V-shaped metal plate with a notch cut out to give a fairly close fit over the pinion gear that drives the ring gear attached to the end rim of the screen drum. In the meshing of the pinion with the ring gear, the lubricant is squeezed out over the edge of the pinion, and the notched metal plate scrapes the lubricant off the sides of the gear and piles it back on the teeth of the pinion.

In addition to routine screen operation and the skidway extension work at Pishkun Reservoir, Mr. Holcomb, during the fiscal year, installed two 11'-6.5" P. D. segmental ring gears with 2 DP teeth at the Prosser fish screen, completely rehabilitated the four 8'-0" diameter screen drums at the Tieton project, and completely reconstructed the 12'-0" diameter paddle wheels at the Wapato fish screen. Rehabilitation of the Tieton screen drums consisted of adding two new end-rim assemblies on each drum, recovering the drums with 3-mesh/inch #12 wire galvanized wire cloth, and providing new side and bottom seal assemblies. In rebuilding the Wapato paddle wheels, a hollow shaft of 5-inch extra strong pipe was used, with solid steel stub shafts welded to each end. A third spider (hub and spoke) was also incorporated into the rebuilt paddle wheels.

Fish Weir Design

A new weir design was prepared by Messrs. Bair and Lambert, in cooperation with Mr. Kelez of the Alaska section, for the Chignik Weir on the Chignik River in Alaska. The new weir design consists of all-metal tripods, spanned by structural steel stringers, with pipe used as pickets. The plans call for a trial section about 30 feet in length to be used in the deeper part of the river, where the normal depth of water is about 6 feet. Consideration was given to the installation of the new type of weir with metal tripods, stringers, and pickets, as the existing weir is of wood construction, and considerable difficulty has been experienced in an effort to keep the weir of wood construction from floating out of place. This condition is accentuated by the fact that the weir is located in a section of the river affected by tidewater to the extent that the entire weir is submerged. The tripods are 9 feet in height and are submerged by approximately 2 feet at the higher tide levels. To prevent fish passing the weir at these times, a wire fence 4 feet high extends above the walkway level at the top of the tripods. One of the principal features of the metal tripods is that all three legs are adjustable. The front leg, which is on a slope of about 1 on 1-1/4, is composed of a 6" M 10¾ beam, with the adjustable part afforded by a 5" [6.7¼ bolted to either side of the beam at the lower end. Holes 6 inches on centers are drilled in the several pieces to provide for adjustment. The rear legs are 3" D. extra strong pipe inside of 3-1/2 D. standard pipe with holes drilled through both pipes 4 inches on centers to provide for adjustment of the leg length. Where the river bottom contour is somewhat irregular, the adjustable legs allow for installation of the tripods in such a manner that the tripods will not be tilted in any direction and the walkway supports for adjacent tripods will be at the same elevation. The weir was designed for the use of 3/4" D. standard pipe as pickets. The pickets are inserted from the walkway through 1-1/2" D. holes drilled in the web of 4" B 10¾ beams at 2 5/16 inches on centers.

Artificial outlets for reservoirs

Considerable time was spent during the 1947 fiscal year by Mr. Bair and Mrs. Barker on the design and preparation of complete detailed plans for facilities to be used in determining the feasibility of collecting seaward migrant fingerlings in reservoirs that have no surface outlet. The fingerling collector consists principally of a timber flume 10' -0" in width, 48'-4" in length, and 3'-6" in depth, with oil barrels secured to each side of the collector to provide buoyancy and stability. Near the center of the collector is a box trap provided with a hoist for lifting the trap from the water. As a means of producing an attraction flow at the entrance to the collector, the plans call for the installation of two 10 H.P. outboard motors at the rear of the box trap to provide a flow of 30 second-feet of water through the collector.

Passage of Fish at Bonneville Dam

As indicated by the following table computed from data furnished by the U. S. Engineers, the escapements of fish to spawning grounds above Bonneville Dam were unusually good during the quarter.

Number of Fish Counted Through Fishways at Bonneville Dam.
January through June

Year	Chinook Salmon	Blueback Salmon	Steelhead Salmon
1939	82,340	29,623	11,789
1940	73,406	59,845	11,401
1941	79,323	24,887	10,658
1942	52,287	12,637	9,636
1943	70,940	4,534	10,322
1944	35,228	3,115	10,764
1945	54,808	2,089	12,498
1946	97,571	7,881	22,239
Av.1939-46	68,238	18,076	12,420
1947	159,064	59,383	12,995

The count of spring chinook salmon was by far the greatest of the nine years of record. It was more than double the average of the earlier years of record and more than one and a half times the largest preceding year. The good escapement appears to be general throughout the upper spawning areas. This is shown by the fact that the count at Rock Island Dam, on the main Columbia, which was 7,584 chinooks by the end of June, was 2.8 times the average of the ten preceding years, and ten percent greater than the largest year of record. On the Yakima River, the count at Roza Dam was 2,557 chinooks at the end of June, which is more than 4 times the average of the preceding 7 years of record and 2-1/2 times the largest preceding count. Large escapements also are reported from the Snake River system in Idaho.

The count of blueback salmon at Bonneville Dam also has been exceptionally high. The run of this species starts in June and about reaches its peak by the end of that month. This year's count up to the end of June was more than 3 times the average and equaled the maximum of the eight preceding years.

The spring run of steelhead trout, which as usual was confined mainly to the months of March, April, and May, about equaled the average of previous records.

Mr. Holmes has devoted the greater part of his time during the quarter to analysis of data collected during the past seven years from a series of marking experiments that were designed to determine the extent of mortality of salmon fingerlings in passing Bonneville Dam. A report on this work will be completed soon and will be summarized in the next quarterly report.

Mr. Holmes also has been representing the Service in the consideration of fish protection at McNary Dam on the main Columbia River approximately 140 miles above Bonneville Dam. There have been several conferences for the exchange of views between representatives of the State fishery departments, the U. S. Engineers, and our Service. Observations also have been made of the hydraulic models of the dam that have been constructed by the U. S. Engineers at Bonneville. As a part of the McNary Dam study, Mr. Holmes is conducting a series of experiments to determine the effects of pressure, particularly the sudden release of pressure, upon salmon fingerlings. These experiments will furnish information regarding the danger of injury to the fish as a result of passing under lift-type spillway gates. The results of the experiments will be reported later.

Fingerling and adult studies at Bonneville Dam

One of the major problems in connection with the passage of anadromous fishes at a large dam such as Bonneville, is getting the downstream migrants safely past the structure. Although adequate data are not at hand from all experiments, it is established that considerable mortality occurs in the spillways and turbines. The Bonneville Fingerling Studies are directed toward determining the distribution of migrants from shore to shore and surface to bottom in the Bonneville forebay and then developing equipment to guide them away from the hazardous areas into safe routes for passing the dam.

During the early 1946 season a system of fyke netting was developed. These were operated at various distances from shore and at various depths in the forebay, but owing to delays in completing the nets and interference from spring floods, little information was obtained in 1946. A new type of fingerling trap, the inclined plane trap, was developed by Mr. Holmes and placed in operation in all the bypasses of the auxiliary water supply system at Bonneville Dam. They were raised every morning and evening, the fish identified as to species, measured and then released to proceed on their seaward migration.

Bypass trap catches of chinook salmon fingerlings at Bonneville Dam were as follows:

Date	Total No. Fingerlings Caught
July - 1946	480
August - 1946	104
September- 1946	18
October - 1946	144
November - 1946	155
December - 1946	133
January - 1947	3,026 *
February - 1947	12,116 *
March - 1947	5,700 *
April - 1947	7,391
May - 1947	7,625

* During January, February and March, 18,347,439 chinook fingerlings were released from hatcheries up river.

In January, February and March of 1947, funds again became available to continue the Bonneville studies. Fyke nets were operated under the direction of Messrs. Burner and Weber throughout the quarter in the power house channel. A preliminary analysis of the results of the data indicates that seaward migrating salmon fingerlings utilize the full width and full depth of the channel during their seaward migration. The greatest depth of the bottom channel of the forebay is 72 feet below normal pool level. The largest catches of the fyke nets were made at depths of from 25 to 50 feet. However, it appears that the fingerlings are fairly evenly distributed from the surface to virtually the bottom. This information fulfills the first requirement of the Bonneville studies in that it determines the type and placement of equipment used to guide fingerlings. It rules out, for example, the use of surface gear such as sheer screens, above surface lights, or shallow water equipment near shore.

During the quarter the fyke netting has been continued under high water conditions. Floating logs and debris have displaced rafts and anchors so that they cannot be kept in alignment but in spite of these difficulties at least four nets have been kept fishing at all times up until May 5th, when the forebay level was raised from 72 feet to 82 feet to maintain a 50 foot head at the power house. The resultant strain on anchors and lines as well as nets proved too much and fishing was stopped. During this and the preceding quarter over 6000 fingerling migrants were taken in the fyke nets. These were identified as to species, counted, a sample taken for comparative study and the remainder released. In comparison with samples of hatchery raised fish released upstream from Bonneville Dam it has been established that not all of the fingerlings caught in bypass traps and fyke nets are hatchery fish, in spite of the fact that 25,348,395 of the latter were released in a four and one-half months period. These upstream

releases are made known to the observers at Bonneville who can then estimate the time of arrival of the fingerlings in the traps and recognize the stock from samples submitted by the hatchery. At this time it was considered desirable to continue the fyke netting in order to obtain the seasonal distribution of migrants, to work out the age at migration and also to separate the various stocks on the basis of age and length measurement data, even though these are considered by-products of the fingerling studies.

In order to obtain additional information on the effect on fingerlings of passing through the turbines at Bonneville, a draft tube trap was designed to be operated at the turbine outlet. The trap is composed in part of a truss 40 feet long which spans one half of the draft tube of #2 turbine, and was installed just prior to the spring flood. The truss holds three fingerling box-trap units of orthodox design, but each differing slightly in that high velocity baffles are installed to catch fingerlings as they emerge from the draft tube. We have been unable to operate the draft tube trap because of the unusually high tailwater prevailing during June. Some damage to the bottom of the trap units has been caused by logs shot out from the trash sluiceway. Repairs will be made as soon as high water abates sufficiently so that a work crew can get under the truss which now is suspended one foot above the surface of the tailwater.

As part of the experiments to determine the possibility of diverting downstream salmon fingerlings into safe channels of migration studies have been under way in connection with the installation of a string of under-water lights which would, in effect, produce a traveling wave of light similar to that on a theater marquee. The experiment has been delayed due to the difficulty of obtaining the proper resistors, rheostats and other necessary equipment. However, much of the equipment is now at hand and is being assembled and installed.

As a further part of the investigations to determine methods of diverting fingerlings into safe channels of migration, data have been and are being assembled on supersonic waves. It has been ascertained that the frequencies used for the detection of fish and other objects in the water have little or no effect directly, on the movement of schools of fish. These frequencies are in the neighborhood of 20,000 to 30,000 cycles. It is apparent that if any sound frequencies would be effective they must be of either higher or lower frequency than the 20 to 30 k.c. band. While numerous inquiries have been made of firms dealing in supersonics, equipment suitable for our needs has not as yet been found available.

Ever since Bonneville Dam was constructed, there have been reports of dead and dying adult salmon in the river below the dam, presumably a result of fish being injured in attempting to pass the structure and not finding the fishways. The Service was pressed to carry on observations both above and below Bonneville to determine the extent and cause of mortality of salmon. A rough draft of a manuscript on

last season's observations has been completed and is being given a final revision by the authors, Messrs. Hanson and Zimmer, who carried on the work concurrently with the fingerling studies, assisted by Messrs. Bagwell and Jensen and the Corps of Engineers' resident biologist.

Mr. Burner attended a conference with Messrs. Holmes, Milo Bell, Morris Litt, Fred Abbott and Robert Moore at Portland regarding a proposed tunnel experiment to be conducted at Bonneville Dam to determine the reaction of adult migrating salmon to a dark passage such as may be built into the Washington shore ladder at McNary Dam. Little is known at the present time as to how fish will react in dark passages. Equipment is being installed in one of the fishways at Bonneville Dam so that the upstream migrating salmon may be counted below and above a darkened passage. The Corps of Engineers are providing and installing all of the necessary equipment and Mr. Burner will make the biological observations.

The study of seasonal fluctuations in temperature of the Columbia River and its tributaries was continued during the past four quarters. Data obtained were organized, i. e., classified, averaged, and analyzed, for progressive studies relating to the effects of water use projects on fishery resources. While these data have only slight value at the present time, they will become of increasingly greater importance when additional dams, which will affect the water temperature, are constructed in the Columbia Basin.

PROJECT VI. SALMON AND TROUT IN THE UPPER COLUMBIA RIVER

In May Mr. Hanavan completed extensive changes in a Report on the Grand Coulee Fish Maintenance Program and forwarded the report to Dr. Frederic Fish for further revision and early publication.

Preliminary analysis of returns from an extensive series of marking experiments conducted on the Grand Coulee Project were continued as time permitted. Returns from the 1939 and 1940 broods are now complete and will be reported upon in the near future. In the course of these experiments more than 1,000,000 fingerling fish were marked and, thus far, more than 5,000 marked adults have been recovered, mainly by Mr. Bryant, from the commercial fishery at the mouth of the Columbia River. Information provided by the experiments will be of value in any program designed to preserve the salmon and steelhead trout of the upper Columbia River from the effects of proposed power and navigation dams.

Aerial surveys of the spawning distribution of salmon in the main stems of the Columbia and Snake Rivers were initiated in the fall of 1946 and will be resumed during the spawning period in 1947. The initial survey served to emphasize the previously unrecognized importance of these main streams as spawning grounds for the fall chinook runs; which include nearly 80 percent of the chinook that pass Bonneville Dam. Nine hundred and nineteen nesting areas, many containing more than one redd, were counted on a single inspection of the Columbia

between the confluence of the Snake River and Grand Coulee Dam, a distance of 280 miles. Turbidity prevented inspection of the lower Snake River or of the Columbia below the Snake River confluence. Most, if not all, of the spawning grounds of these important runs will be destroyed by projected "lower river" dams.

PROJECT SPECIAL STUDIES ON EFFECT OF DDT.

Mr. Hanavan is conducting a study of the effects of DDT on trout streams in northern Idaho. In spraying 391,740 acres of forest land, at the rate of 1 pound of DDT per acre, the Bureau of Entomology and Plant Quarantine, has undertaken the most extensive aerial distribution of DDT yet attempted. The treatment area included several excellent trout streams that support populations of rainbow, cutthroat, and brook trout.

As the effects of the spraying may continue for several months, complete results are not now available. The direct effect upon trout, however, appears to be negligible. One trout, a rainbow, was found dying of DDT poisoning but this was a diseased and anemic individual. Other trout observed and examined have appeared to be normal. In several streams cottoids and suckers were killed, and in one stream impoundment there was a heavy loss of catfish. Bream and dace are widely distributed in the streams of the area and apparently were unaffected.

Frogs were occasional victims of DDT but the greatest upset in stream ecology resulted from the virtual elimination from many stream sections of all invertebrate life excepting annelids and a sparse population of molluscs.

Quantitative samples were obtained before and after treatment; aquatic forms by means of a square foot riffle sampler, and aerial forms by the use of flypaper. The decline in aerial forms was almost as great as the decline in aquatic life with caddis fly and the smaller deptera as principal victims. Trout stomachs obtained before and after treatment contained ants. As no change in the abundance of ants was discernible this food might be of importance in preventing starvation or the migration of trout to less suitable stream habitats.

The effects of DDT were most pronounced in stream sections receiving a direct application of spray. Stream sections three miles or more below treated areas were found to contain normal complements of riffle organisms and surface hemiptera.

Observations will be made later in the summer to appraise the recovery of trout food organisms and, so far as possible, the ultimate effects on the trout populations.

CENTRAL VALLEY FISHERIES INVESTIGATION, James W. Moffett, Chief

GENERAL

These investigations are concerned chiefly with the life history, behavior, and abundance of chinook salmon and striped bass populations in the Sacramento-San Joaquin River systems. Salmon populations were counted as they migrated upstream to spawn in Tuolumne and Feather Rivers and in Deer and Battle Creeks. Estimates of the numbers of adult salmon were made in Sacramento, Yuba, upper San Joaquin, Stanislaus, Tuolumne, and Merced Rivers. The spawning behavior, egg incubation, and subsequent downstream migrations of resulting salmon fingerlings were observed closely on the rivers and creeks mentioned. A salmon-tagging program sponsored by the State of California was aided materially by cooperative tagging and recovery activities. The movements, sizes and ecology of fishes inhabiting or passing through the Sacramento-San Joaquin Delta waters were brought under investigation preparatory to more detailed study relating to changes in delta dynamics resulting from the Delta Cross Channel and pumping plants. Sixteen major river basin reports were prepared and submitted to the Regional Office and several others were completed except for final arrangement into recommended form. Hearings, conferences, and discussions, too numerous to mention were held or attended relative to River Basin Studies and investigational programs. The research and supervision attendant to the Shasta Salmon Maintenance Program was continued. Daily water temperature records were maintained at thirteen stations throughout the Central Valley, and air temperature recordings were made at six key points in the network. Central Valley Investigations were drastically reduced in scope in anticipation of cutbacks in appropriations for fiscal year 1948. The Oroville and Modesto Districts were discontinued in June, and six employees were either terminated or transferred. One employee was detailed to special work in Alaska.

Reports completed:

The Chinook Salmon Potential of the Alternate Tributary Plan.

A Preliminary Report on the Fish and Wildlife Aspects of the Alternate Tributary Plan, Sacramento River Basin, California

A Report on Fish and Wildlife Resources in Relation to Minor Power Project No. 735 (Worni Creek) Federal Power Commission

Response to Public Notice from U. S. Engineer Office on Noyo River Harbor Improvement

A Preliminary Report on the Fish and Wildlife Aspects of the Prosser Creek Project (Truckee River) U. S. Engineer Office

A Report on the FWS Aspects of the North Fork Project Mokelumne River as Proposed for Construction by Pacific Gas and Electric Company, Major Power Project No. 137, Federal Power Commission

A Comprehensive Report on the F&W Resources of Lahontan Basin as They Relate to General Water Development Plans of the Bureau of Reclamation.

Revision of "A Preliminary Report on the Fish and Wildlife Aspects of the Upper Sacramento River Tributary Plan (Alternate to Iron Iron Canyon Dam)"

A Report on the F&W Aspects of Pine Flat Project, Kings River, California, U. S. Engineer Office and Bureau of Reclamation

Recommendations for Fish Protection on Minor Power Project No.1959 (Farley Creek) Federal Power Commission

Comments on Recommendations for Fish Protection Connected with Major Power Project No. 120 (Southern California Edison Company) Federal Power Commission

A Preliminary Report on the F&W Aspects of the Big Dry Creek Project, San Joaquin River Basin, California

A Report on F & W Resources in Relation to the Water Development Plan for the Proposed Kaweah Basin Terminus Project

A Report on F & W Resources in Relation to the Water development Plan for the Proposed Kern River Basin, Isabella Project

A Report of F & W Resources in Relation to the Water Development Plan for the Proposed Feather River Basin, Rock Creek and Cresta Projects, Pacific Gas and Electric Co., Federal Power Commission

A Report on the F & W Aspects of Boulder Creek in Relation to Constructed Minor Power Project No. 1348, Federal Power Commission

Upstream Migration of Adult Salmon

The 1946 catch of salmon, both chinook and silver, in California waters was the largest in 25 years of record. The total catch amounted to 13,649,673 pounds and the Sacramento-San Joaquin River catches were 6,462,050 pounds. Upriver escapement into Central Valley streams generally corresponds to the commercial take in the lower river and can be considered relatively large for the 1946 season.

Chinook salmon in Central Valley streams were counted at four locations during the fiscal year 1947. Fall runs were counted into Battle Creek, a tributary to Sacramento River; Feather River at Sutter-Butte Dam; and Tuolumne River, a tributary to San Joaquin River. The only spring run counted was that entering Deer Creek. Summaries of the counts obtained are presented on next page:

Counts of Spring and Fall-Run Salmon *
in Streams of Central Valley

Time Period	Counting Station and Salmon Counted			
	Battle Creek	Feather River	Deer Creek	Tuolumne River
4/9-13			5	
4/14-18			835	
4/19-23			647	
4/24-28			362	
4/29-5-3			559	
5/4-8			257	
5/9-13			2	
5/14-18			2	
9/11-15		19		
9/16-20		43		
9/21-25		116		
9/26-30		402		
10/1-5	421	647		
10/6-10	923	260		2
10/11-15	1,119	341		4,683
10/16-20	998	266		6,114
10/21/25	4,188	1,219		4,569
10/26-30	380	538		6,226
10/31-11/4	1,942	166		16,914
11/5-9	2,904	76		9,615
11/10-14	2,169	8		5,583
11/15-19	1,168	50		3,134
11/20-24	250	16		399
11/25-29	39			
11/30-12/4	1			
12/5-9				
12/10-14				
Totals	16,502	4,167	2,669	57,239

* The Deer Creek count was made in the spring of 1947. All others were made in the fall of 1946.

Because of the urgent need for accurate estimates of the salmon population, Sacramento River and its tributaries above Red Bluff, California, were under constant observation during the fall and winter migration, and spawning periods. No actual counting of salmon in Sacramento River was possible, but as a result of these observations, the following estimate was made: A. Spring run--

Trapped at Keswick Dam	2,391	
Battle Creek population	2,450	
Estimated number spawning in main river	25,000	
		29,841

B. Fall run--

Trapped at Keswick	7,560	
Battle Creek population count	16,502	
Estimated number in main river	40,000	
Estimated number in tributary streams	3,000	
		67,062
Total estimate		96,903

The use of available tributary streams other than Battle Creek and Clear Creek for spawning purposes was 10 percent in 1946 because of drought and late rains.

Fall-run salmon entering Battle Creek were counted as they entered the holding area of the old Battle Creek Station. During the period October 1 to December 3, 16, 502 of them passed that point. Floods affected counting after November 20, so therefore, the total given is minimal.

The spring salmon run into Deer Creek was first noted in early April but high water prohibited installation of the counting weir until April 12. Shortly after that date, irrigation demands on Deer Creek reduced stream flows drastically and the salmon had difficulty negotiating Stanford-Vina Dam. Despite low water and relatively high temperatures, the upstream migration followed the usual pattern throughout April and early May. However, conditions changed very rapidly and the count was discontinued May 16. Low and very warm stream-flows killed adult salmon below Stanford-Vina Dam and prohibited entrance of additional fish from Sacramento River. The maximum water temperature in Deer Creek rose above 80 degrees F. on May 19 and remained above that point until May 23. At the same time, volume of flow dwindled to practically nothing below Stanford-Vina Dam.

Observations made above the counting weir before it was installed and subsequent censuses in Deer Creek Canyon have furnished evidence to support the conclusion that, at least 1,000 salmon passed the counting site before facilities for control could be installed.

Facilities to count and trap fall-run salmon in Deer Creek were installed in the fish ladder over Stanford-Vina Dam. Low water conditions prohibited the entrance of the fall run into Deer Creek and none reached the traps.

Counting of adult salmon at Sutter-Butte Dam on Feather River began September 10, and continued until November 22, 1946, when high water stopped further observation. The Feather River run arrived at Sutter-Butte Dam in small numbers during the first two weeks in September, gradually increased to a minor peak in early October, declined throughout the first twenty days of October, increased to a seasonal peak on October 23, and dropped off abruptly to less than 100 fish per day for the remainder of the counting season. The total number of salmon counted was 4,167.

Sutter-Butte Dam is located upstream from what is now considered the main salmon spawning ground of the Feather River and many salmon entering the river stopped before they reached the counting station. Systematic surveys of the area below the dam provided reliable estimates of the salmon in that part of the river. Counts of live and dead salmon plus a conservative allowance for fish not seen totaled 6,927. The size of the Feather River fall-run salmon population in 1946 is estimated at 11,100. Two hundred and forty-six steelhead trout were seen during the counting period.

Salmon entering the Tuolumne River, a tributary to San Joaquin River were counted as they passed over the Modesto City Dam.

The early portion of this migration was delayed for about three weeks during September and October by industrial and domestic pollution. The dissolved oxygen content in the lower nine miles of Tuolumne River was below three parts per million for weeks and during critical periods it dropped to zero. Carp, suckers, and other fishes were killed in great numbers although some carp and mosquito fish managed to survive.

At the request of the State of California and this Service, additional water was released from La Grange Dam, far up on the Tuolumne, and the pollution was abated to the point where salmon could enter the stream. Counting began on October 10 and continued until November 20, when the Modesto Dam was removed from the river. A total of 57,239 salmon were counted, and while the dam was being dismantled an estimated 4,000 salmon passed upstream. The population estimate for the 1946 fall season was set at 61,200.

Compared with counts made in certain other years by the State of California, this run is not exceptionally large. During 1940, under circumstances similar to those now present in Tuolumne River, 122,448 salmon were counted over Modesto Dam. The run of 1941 was much smaller amounting to only 27,208. In 1944, the run into Tuolumne River approximated 144,000. Exact figures for that year are not yet published.

Average hourly counts during 29 days of the counting season demonstrated a bimodal frequency distribution for the day. The greatest period of abundance occurred between the hours of 6 and 11 a.m., and a secondary increase in movement was evident between 2 and 6 p.m. During the night hours numbers were comparatively low, but quite stable.

Observations and Studies of Natural Spawning and Egg Incubation in Central Valley Streams

Red Bluff District

The water flow situation in Sacramento River during spawning, egg incubation and subsequent emergence of fry was especially critical because of drought and the need to store all available water. In cooperation with Bureau of Reclamation officials, surveys of the spawning grounds were made to observe the behavior and relative safety of eggs and young under various schedule of water release from Shasta Dam.

During the entire spawning season, 5,200 to 5,700 second-feet of water had been released from the dam. Salmon utilized riffles at this flow which would not have been available at lower flows. Consequently, when the river was lowered, many nests were above water line.

The following flow schedules were maintained below the dam:

Jan. 1-24	- 5,700 to 5,200 second-feet
Jan. 24 -Feb. 1	- 5,200 second-feet for 18 hours 2,500 second-feet for 6 hours
Feb. 1-28	- 5,200 second-feet for 5 hours 2,500 second-feet for 19 hours
Feb. 28-Apr. 17	- 5,200 second-feet for 8 hours 2,000 second-feet for 16 hours
Apr. 17-21	- flow increased to 5,000 second-feet
Apr. 25-29	- flow increased to 5,500 second-feet
Apr. 29-June 5	- flow increased to 6,500 second-feet
June 5	- flow reduced to 6,000 second-feet
June 6	- flow reduced to 5,250 second-feet
June 11	- flow increased to 6,000 second-feet
June 14	- flow increased to 6,500 second-feet
June 23	- flow increased to 7,000 second-feet
June 27	- flow increased to 7,500 second-feet

Under the flow schedule established February 1, about 10 percent of the nests in Sacramento River were exposed sufficiently to endanger alevins and advanced fry. The recommendations of this office were for a minimum flow of 3,500 second-feet during the month of February if exposed nests were to be adequately covered with water. Two storms, one in mid-February and the other in early March, insured the completion of egg incubation and downstream migration.

Spring-run adult salmon displayed a marked tendency to remain in Sacramento River below Redding, California, during summer. Optimum water temperatures, clear water and abundant flow may account for the stilling of the migratory urge. Such behavior on the part of the salmon is in direct contrast to habits displayed before Shasta Dam was built. The same tendency was displayed last year. These salmon began spawning late in August but only scattered females occupied the beds until early September when the peak of egg deposition occurred. Spring-run salmon had virtually completed spawning by the end of September; a full six weeks before the fall-run spawning peak was reached.

Spawning of the fall-run population in Sacramento River began in late October, increased rapidly during the first two weeks in November and reached its period of maximum intensity immediately thereafter. Spawning was evident well into December although at a very much reduced rate.

Some concern has been felt for the safety of eggs deposited by spring-run fish in riffles heavily utilized by the fall run. This concern was somewhat relieved by stream observations and water temperature studies over the past season. It is quite evident that spring-run progeny were either hatched or in the eyed-egg stage before the fall run began to spawn. On the basis of seaward migration studies, practically all spring-run eggs had hatched and resulting fry had started downstream by December 20.

The spawning of spring-run salmon in Deer Creek was very successful. Practically no unspent females were found during inspections of the stream made on July 13, August 27, September 5, 6, 17, and 18. Use of the fish ladder over lower falls was extensive this year and the five-mile stream section above the ladder was adequately populated with spawning salmon.

A program to observe natural spawning under controlled conditions and to test the efficiency of the subsequent incubation of eggs in Deer Creek was disrupted by flood waters which removed all control structures. Operations were then transferred to natural conditions as found in Antelope Creek.

Eight salmon nests in this stream were marked for study. One nest was opened each week beginning December 11 and ending January 31. A random sample of eggs was recovered from each nest. The egg stratum in all nests was from 10-14 inches below the surface of the nests.

Results of this study indicate a high degree of survival among eggs deposited. The percentage of live eggs in the eight nests examined was found to be 92.3. (3,011 eggs in samples - 2,778 alive - 233 dead.)

Oroville District The spawning season of fall-run salmon in Feather and Yuba Rivers began during the last two weeks in October. Spawning did not reach a peak until about the third week in November and it was almost completed by the second week in December.

In both streams the best and most extensive spawning gravels are believed to be situated below the canyon-like portions of their drainage. It was estimated that over two-thirds of the Feather River salmon spawned below Oroville this season. It is known that practically all of the Yuba River fish used gravels below Daguerre Point Dam because of the inaccessibility of the fish ladder over that dam at stream flows which existed this year.

The amount of spawning gravel available to Feather River salmon is regulated to some extent by the operation schedules of two major canals which divert water from that stream; when these canals are shut down early much more gravel is made available by the increased stream flow.

Surveys of spawning beds of spring-run salmon in Middle Fork, Feather River resulted in counts of 89 redds and 174 salmon in 3-1/2 miles of stream. There are many miles of such spawning ground in Feather River available to spring-run fish, and if this 3-1/2 mile section is indicative of the concentration elsewhere, the spring-run must consist of thousands of salmon.

Modesto District

Spring-run chinook salmon in San Joaquin River below Friant Dam spawned while river-flow was maintained at about 1,450 second-feet by release from Friant Dam. After spawning was completed the Bureau of Reclamation found it necessary to reduce releases at Friant Dam to conserve water. Fishery interests were notified, and, by agreement, reductions were started October 29 and continued gradually to November 14, when they were held constant at 427 second-feet. During that time, biologists observed the effect of reduced flow on spawning beds. An aerial and ground study of San Joaquin River was made by the Modesto District staff and their recommendations were that the river should be maintained at a flow stage not lower than 750 second-feet. However, biologists of the State of California desired to follow the process of egg incubation in several exposed riffles and a request to the Bureau of Reclamation for more water was delayed until December 24. The flow was increased to 800 second-feet on that date.

The Service biologist in charge at Modesto recommended that for efficient production of young salmon, flows in the San Joaquin River should not be reduced more than one-half the flow at which adult salmon spawned.

The spawning beds of Stanislaus, Tuolumne, Merced, and San Joaquin Rivers were patrolled regularly. Power and other water demands combined with a rather dry winter militated against the effectiveness of spawning in all the streams.

In the Stanislaus scattered nests were observed along with dead and partially spent salmon. There was evidence of greatly fluctuating water flows which resulted from power demand releases from Malones Dam. During periods when power was not being generated the river flow was reduced to about 150 second-feet and many partially or wholly completed salmon nests were exposed for long periods of time. Poaching was quite general whenever the low river stages occurred. Utilization of available spawning gravel in this river was very light. Many more salmon could be accommodated there if water flows were stabilized and poaching reduced.

Few salmon were able to reach, enter and use Merced River. General water flows were low during the fall season and only enough water was being released from Exchequer Dam to satisfy downstream demands. The total flow was estimated at 100 second-feet near Merced Falls and at only a few second-feet below the Merced-Waterford Bridge, 18 miles downstream from there.

Observations of spawning behavior and riffle use in the Tuolumne River were impeded by turbid water

Seaward Migration of Young Salmon and Movements of Other Species in Central Valley

A rather extensive investigation into the downstream movement of young salmon and the movements of other fish and invertebrate species was undertaken this year. Fyke nets were operated at the following locations: Sacramento River at Balls Ferry, Squaw Hill Bridge, and Tolands Landing; Deer Creek near Vina, California; Feather River at Middle Fork, Oroville, and Yuba-Sutter Boat Club; Yuba River at Marysville; San Joaquin River near Antioch, at Livermore Yacht Club (Old River), San Joaquin City, and Herndon; Stanislaus River near Riverbank; Tuolumne River at Modesto; and Merced River at Shaffer Bridge.

Red Bluff District

Fyke-net catches of downstream migrant chinook salmon in Sacramento River at Balls Ferry, 35 miles below Shasta Dam, and at Squaw Hill Bridge, about 58 miles downstream from Balls Ferry, yielded some rather striking results.

The station at Balls Ferry was located in precisely the same place where sampling has been done since 1943-44. The pattern of seaward migration described by this year's catches (Table 1) bears very little resemblance to patterns obtained in previous years. In each of the seasons prior to the current one, netting did not begin until after January 1. In the current season netting began on December 11, 1946, to make sure that sampling had begun prior to seaward migration. However, catches on the first day demonstrated that young salmon were already in the river and in subsequent catches the numbers taken increased rapidly. A peak in abundance was reached in the last two weeks of December which was not approached throughout the remainder of the season. The migrants in these December catches were almost certainly progeny of spring-run adult salmon. Peculiarly enough, these young must have been spawned as eggs early in September or even in late August.

The distribution of the entire migration over time was definitely crowded toward the early part of the season. During the first 25 days of netting (December 11 to January 4) 47.0 percent of the total catch was taken. In the 1945-46 season it was March 1 before a similar percentage of the total catch had been taken. Previous seasons' catches described a rather uniform distribution curve over time. Catches were low in early January, increased gradually throughout that month to peak either in late January or early February. There is some indication of bimodality in curves for these seasons due to the appearance of a secondary peak in abundance in late March. The bimodality is assumed to reflect the maximum downstream movements of the spring and fall-run salmon progeny, respectively. It may be possible that the seaward migrant progeny of spring-run adults have never been adequately sampled because of the late dates when netting was begun. On the basis of water temperature the 1945-46 spring-run brood should have hatched earlier than the 1946-47 brood. River temperatures averaged about 4.5 degrees F. warmer in 1945 during the incubation period.

Uniform water temperatures below Shasta Dam may have accounted for the early and almost sporadic hatching of the spring-run progeny in 1946-47. The maximum daily water temperature during August 1946 was 56 degrees and the minimum daily temperature was 50 degrees F. A maximum temperature of 58 degrees and a minimum of 52 degrees F. were recorded in September. In October the recorder was out of service between the fourth and the twenty-first, but indications are that the maximum temperature was 57 degrees and the minimum 52 degrees F. November records demonstrate a gradual decline in water temperature from a maximum of 55 degrees early in the month to a minimum of 50 degrees F. toward the end of the month. Both maximum and minimum temperatures remained within a two degree range above or below 50 degrees F. throughout December.

Records of catches for the 1943-44 season are quite fragmentary as are those of the 1944-45 season. The catches in 1945-46, however, are practically complete and can be compared directly with the 1946-47 catches since all sampling factors were almost identical. If records for both seasons are adequate quantitative samples of the downstream migration, the number of migrants moving seaward this past season is greater than anything ever experienced since records were made. The catch per hour for the 1946-47 season to and including April 19, is 18.9 while that for the 1945-46 season, terminated on the same date, is only 4.5 fish. The only season which closely approaches the last one in terms of catch per hour is 1944-45 when a rate of 7.9 was obtained. When it is considered that the bulk of the 1946-47 season catch was made at a time when only spring-run migrants were moving, the size of the spring-run adult crop which entered the river in April, May and June of 1946 must have been very large or the reproductive process and subsequent hatching must have been remarkably efficient. Fyke-net sampling of the 1946-47 seaward migration at Squaw Hill Bridge, about 58 miles downstream from Balls Ferry and some 40 miles below Iron Canyon Dam site, was begun on December 19, and continued, whenever possible, throughout this quarter. High water and debris interfered with continued operation and direct comparison of the results presented in Table 2 (contained in our files) with those obtained at Balls Ferry is not wholly satisfactory. Judging from the early catches made, some downstream migration was occurring in late December, but in no measure comparable to that recorded at Balls Ferry. From January 21, on the catches increased until the period February 5-9, when, during 34 hours of fishing, 3,674 young salmon were caught. The rate of catch for this period was 108 fish per hour. This peak in abundance occurred six weeks later than the peak at Balls Ferry. If the same fish were involved at each station then six weeks were required for the salmon to move downstream about 60 miles. It is believed that the rate of downstream movement is influenced by floods, silt and other factors which exerted little or no influence on this segment of the migration. Therefore, the rate of movement as evidenced by this comparison should not be generally applied.

A check of fish releases from Coleman and Mill Creek Hatcheries eliminates these sources of abundance from consideration as an influence on the catch rate at Squaw Hill Bridge. No releases from either hatchery had been made prior to February 9.

Following the peak in abundance early in February, there ensued an abrupt decline in catch-per-hour rates. High water and floods in early March prohibited fishing, consequently records do not adequately portray the character of the downstream movement. There is an indication of increased downstream movement in mid-March when 56.5 salmon were caught per hour of fishing. This peak in abundance tapered off gradually toward the end of March. There is no consistent difference between length-frequency distributions for the two stations. Samples at both stations indicate a trend toward larger migrants as the season progresses. During the early season, salmon taken at Squaw Hill Bridge were consistently larger than those at Balls Ferry. The average lengths of salmon migrants taken at each station are: Balls Ferry 39.5 mm., and Squaw Hill 40.1 mm.

Fyke-net fishing at Deer Creek started January 1, and was completed May 20, 1947. During the period of net operation, 272 migrants were captured in 1773 hours of fishing, or at the rate of 0.15 migrant per hour. Toward the end of the fishing period, the net did not function efficiently because of extremely low water-flows in Deer Creek. Young salmon could be seen moving downstream, but they were not taken by the net

The migration was quite similar to those sampled in the past, as far as distribution over time is concerned. There was a gradual increase in numbers of migrants through January and early February. In the period February 15-19, a seasonal peak was reached which gave way very rapidly to almost nothing. A rain in late March caused a momentary rise in the catch rate, but it gradually declined to the zero point by May 20, when fishing was discontinued. Usually the net is fished until the middle of June, but a combination of low water flows and high temperatures practically eliminated all anadromous species in the lower portion of Deer Creek in Mid-May.

Because of low water which prohibited the use of Deer Creek by fall-run salmon, all influence of fall-run progeny on the length-frequency distribution of migrants was eliminated. In past years these fall-run progeny complicated the late season catch and confused analyses of the spring run seaward migration.

Oroville District:

Catches of seaward migrant salmon at the Feather River stations conform rather loosely to a general pattern. Fishing of the nets began during the last half of December 1946, and until the end of January practically no salmon were taken. With the exception of Oroville, the stations showed an increased catch-rate in mid-February which declined abruptly before the end of the month. There was a gradual rise in catch-rate at all stations from March 1 on, until a seasonal peak was reached .

at the Oroville and Yuba-Sutter stations during the period March 27-31. After a rather rapid decline a secondary peak was evidenced at all stations over the period April 10-20. The catch-rate declined gradually from that time on, until practically no catches were made in mid-May.

It is of interest to compare the catch rates of this season with those of last season at Yuba-Sutter Club. Fishing was not started until March 14, in the 1946 season and the catch-rate was lower except in the latter part of the season. Otherwise, seasonal and secondary peaks were concurrent with those of the 1947 season, and the pattern of migration was almost identical as regards distribution over time. This similarity between migrating seasons on Feather River contrasts greatly with the dissimilarity between the same seasons on Sacramento River at Balls Ferry.

The seasonal peak in catch-rate for the Bidwell Bar Station on Middle Fork occurred in the period February 10-14 and demonstrates the predominance of spring-run salmon in that stream as compared to fall run.

The productive potential of the 35 miles of spawning ground between Oroville and Yuba-Sutter Boat Club is clearly demonstrated by the differences between catch-rates at the two stations. The catch per hour of fishing at Yuba-Sutter Boat Club was, with few exceptions, much greater than that at Oroville, the uppermost of the two localities. The differences toward the end of the sampling season might be more pronounced were it not for the loss of many young salmon to irrigation diversions below Oroville. The magnitude of these losses was demonstrated by sampling carried on last year in the canals.

Sampling of the Yuba River seaward migrant salmon population yielded results which indicate little or no relationship to the pattern shown by the Feather River study. The catch per hour by the Yuba River net rose quite abruptly from February 5 until February 20 after which date it declined slightly but then continued to rise until a seasonal peak was reached during the period March 12-16; a full two weeks ahead of the peak in Feather River. There was no abrupt decline in catch rate following the seasonal peak. Catches declined gradually until the time period in which the seasonal peak occurred on Feather River and then dropped abruptly. The Yuba River migration was virtually completed by April 20.

Between the mouth of Yuba River and Daguerre Point Dam which forms a partial if not complete barrier to salmon migration, there are approximately 12 miles of broad, gravelly stream bed. When covered with water, this stream section is ideally suited for salmon spawning. It is quite possible that the remarkable production of young salmon demonstrated by the net catches occurred below Daguerre Point Dam. Water flows in Yuba River were too low during the upstream migration of adult salmon to activate the make-shift fish-ladder over that obstruction. There exists also the possibility that many of the young salmon caught were produced by spring-run fish which negotiated the dam during April, May, and June of 1946.

Delta District

One of the most important factors in the solution of fishery problems created by the Sacramento-San Joaquin Delta Cross Channel and the Delta-Mendota Canal to be constructed by the U. S. Bureau of Reclamation is a thorough knowledge of movements, locations, and seasonal abundance of the various fish species inhabiting the channels of the Delta. Fyke nets were placed at strategic locations in the Delta as follows: San Joaquin River near Antioch on August 15; Sacramento River near Tolands Landing on September 19, 1946; and in Old River near Livermore Yacht Club (site of the Delta-Mendota Pumping Plant) on January 21, 1947. The nets were rigged to fish both ebb and flow tides by suspending them to a buoy-supported cable by means of a swivel line.

Numerous species of fishes were taken during the year. The most important species were:

Striped bass - Roccus saxatilis
Chinook salmon - Oncorrhynchus tschawytscha
Smelt - Spirinchus thaleichthys
Smelt - Hypomesus olidus
Catfish - Ictalurus catus

Other species captured but for which records are not presented herewith are:

Shad - Alosa sapidissima
Starry flounder - Platichthys stellatus rugosus
Sacramento pike - Ptychocheilus grandis
Bluegills - Helioperca incisor
Cottus - Cottus asper
Stickleback
Lamprey - Entosphenus tridentatus
Green sunfish - Apomotis cyanellus
Crappie
Sacramento Perch - Hysterocarpus traski
Embiotocidae
Gobiidae

The catches of striped bass at Antioch and Tolands Landing demonstrate a definite movement seaward shortly after the young bass become free-swimming. The fyke nets used do not effectively catch fishes smaller than 20 mm. in length. Consequently, the early life history and abundance of the bass cannot be ascertained without tow net operations. Because of delays encountered in servicing the recently acquired launch "Roccus," it was impossible to make the tows necessary to describe the early stages. Sampling of eggs and larvae of striped bass by the State of California indicate a wide distribution through the channels of the Delta.

It is apparent that growth of the young bass is quite rapid. During the twenty-five day period, June 9 to July 4, the average length increased 10.0 mm. in Sacramento River and 10.1 mm. in San Joaquin River. If growth during the current season is similar to that of last year then the young bass will have reached an average length of 55.8 mm. by late August and 85.9 mm. by mid-October. Once the young bass approach 90 mm. in length, the sampling efficiency of fyke nets decreases. Therefore, the apparent disappearance of young bass during winter months may not actually occur.

The first striped bass taken in the Old River net at Livermore Yacht Club were captured June 13. On that date, two specimens, 145 and 175 mm. in length, were taken. These bass are probably yearlings. The first catches of bass fingerlings of the year were made June 25. Catches were continuing at the close of the fiscal year but in very small numbers.

Catches of the two species of smelt common in the Delta channels, were large especially in the San Joaquin River, during the winter months. However, by the end of April, adult smelt had practically disappeared. It is surmised that the disappearance may be coincidental with the spawning of these species. Many sexually mature individuals were captured in February, March and April, and larval smelts were taken in early May. Presumably many of the adult smelt die after spawning and the extent of this mortality should be explored.

The passage of chinook salmon through the Delta is reflected by the summaries of catches made at the fyke-net stations . This year's movement of salmon through the Delta began almost a month later than seasons of previous record. In 1899, the first downstream migrants were captured by Rutter from Georgiana Slough during the week of January 20-28. More recent studies by the State of California, at Hood, California, on Sacramento River record first arrivals of salmon during the weeks of February 4-10 in 1940 and January 14-20 in 1941. Salmon did not reach the Tolands Landing net or the Antioch net in any appreciable numbers until the period February 17-21. Operations by the State of California near Mossdale, California, at the head of the San Joaquin Delta showed migrants reaching that point February 4-10 in 1940 and January 14-20 in 1941. A comparison between the Antioch and Mossdale stations is not too appropriate because of the great difference in their locations. Seaward migrant salmon should pass Mossdale much earlier than the Antioch location since the two are at opposite ends of the Delta.

Although fishing began March 3, 1947, at the Livermore Yacht Club on Old River, a channel of San Joaquin River, no salmon were taken prior to April 21. After that date, salmon 66-76.5 mm. in length were taken until June 6. The period of greatest abundance occurred during May.

Physical conditions influencing the downstream migration are evidently several, but one of the principal elements seems to be the heavy rains necessary to increase run-off which moves the salmon oceanward at a more rapid and constant rate. Coincident with the start of this year's migration through the Delta, there was a marked increase in volume and turbidity of the river water.

Catfish were important components of fyke-net catches throughout the Delta during the winter and spring months. These catches are merely samples of the resident populations existing in the vicinity of the nets. Catches in the Antioch and Tolands Landing nets were much smaller in numbers and size of fish than those in Old River. Otherwise, the catch summaries do not reveal any wilfull movement or other phenomena associated with truly anadromous or migratory species.

Modesto District:

Downstream migrant salmon were sampled in Stanislaus, Tuolumne, and Merced Rivers and in the San Joaquin River at two locations; one at Herndon below Friant Dam about 20 miles, and another at San Joaquin City below the mouth of Stanislaus River.

Records for the San Joaquin River near Herndon are a good illustration of the migratory pattern of spring-run chinook salmon fingerlings in a stream where control over water-flow exists. Following a drastic reduction in river flow which was at its worst during the late stages of egg incubation, the discharge of the San Joaquin River was increased to 700 second-feet in late December and gradually increased from then until the end of April when the flow was about 1,500 second-feet.

The catch rate increased remarkably shortly after sampling was started and reached a seasonal peak on January 20. Thereafter, a decline in catch rate occurred until a more or less constant level was reached during the period January 27-February 18.

Catches after February 18 decreased rapidly until fishing was stopped on April 8. No fall-run salmon were able to utilize San Joaquin River above the mouth of Merced River in time to produce offspring prior to May 1. Consequently, the migratory pattern obtained at Herndon reflects movements of spring-run salmon progeny exclusively.

There is some resemblance between the migratory pattern obtained at Herndon and that recorded at Balls Ferry on Sacramento River. Both patterns display an initial bulk movement at the start of the migration and then a gradual tapering off in abundance. Further comparison based on the mid-and late-season catch rates are complicated by the presence in Sacramento River of a large fall-run population. There exists little relationship between the two patterns as regards time of migration. Salmon in Sacramento River left the gravels of that stream about a month earlier than salmon in the San Joaquin.

The seaward migration from Tuolumne River consists almost entirely of fall-run salmon progeny. From the beginning of the migration in mid-January there was a more or less gradual increase in catch rate per hour of fishing until the period April 1-5 when a very marked increase in the catch rate occurred and a seasonal peak was reached. A sharp decline in catch rate was recorded following that time and fishing was unsuccessful by April 30.

Two factors affected the migratory pattern of young salmon in Tuolumne River. River flows at the net site were almost uniform at an estimated 1,500 second-feet until March 31. After that date, requirements for irrigation storage reduced the river flow to about 150-200 second-feet for the remainder of the season. The maximum catch made April 1-5 was undoubtedly due to the flow reduction. Migrants were confined to a lesser volume of water, while the fyke net fished a greater proportion of the river volume and obviously caught more salmon per hour. Water temperatures increased abruptly in mid-April from 65.4 degrees to 71.5 degrees F. and undoubtedly hurried migration. The effect of the temperature change is reflected in the secondary peak in catch rate for the period April 15-19.

Downstream movement of Merced River salmon began rather abruptly in mid-February and increased with one major irregularity until a seasonal peak was reached on March 10. The migration decreased abruptly following that date and was practically over by April 14, when fishing was stopped.

Water flow in Merced River remained almost constant at 50 second-feet during the entire season of netting and nothing of a major character affected the stream.

Both spring and fall runs of salmon are known to use Merced River and it can be assumed that the migratory pattern described by catch rates reflects the emergence of progeny of the two runs. Catch rates show a rather marked bimodality with the first mode on February 24 and the second and larger on March 10. The first mode, presumably resulted from the movement of spring-run progeny while the second mode was formed by an overlap of the spring run with the seasonal peak of the fall-run progeny.

Water flows in the Stanislaus River fluctuated widely during the spawning, incubation periods, and seaward migration of the salmon. Many nests were alternately exposed and inundated and many young salmon were isolated by changes in flow. It is remarkable that any salmon were able to migrate seaward successfully under the very erratic water flow regime occasioned by operation of Melones Dam.

Fishing began on January 20 and the first salmon was taken January 24. The catch rate was very low during the first three weeks of sampling, but inthe following three weekly periods catches increased until a seasonal peak was reached during the period February 25 to March 1. This increase in catch rate occurred during a period of relatively constant river flow and it can be assumed that it was a normal downstream movement. A second peak occurred March 24-29 when the discharge from Melones Dam was suddenly increased from 100 second-feet to about 1,300 second-feet. As this peak flow was reduced, catches also declined. The river flow was increased markedly, April 14-19, but the increase was not reflected in the catch rates. It was concluded that practically all of the migrants had left the river by early May. Fishing subsequently thereto yielded no catches.

Catches of seaward migrant salmon in San Joaquin River at San Joaquin City downstream from all of the above-mentioned tributaries are summarized in Table 25 (see files in office). Sampling at this station began January 21, but no salmon were taken until March 10. Scattered individuals were taken after that date, but it was not until May 6-10 that significant catches were made and following that period, catches per hour declined to even lower rates. Fishing at this site was discontinued on May 23 because of the necessity to close the Modesto District. However, there was no indication that an increase was evident and river temperatures had risen to a point where migration through the lower part of the river was hazardous or even impossible.

There is some indication that many seaward migrants from San Joaquin River reach the Delta by routes other than the main river or are lost to the fishery completely. California State catch records for this season at Mendota, the major point of diversion for San Joaquin River water, show that at the peak of migration only about 16 percent of the daily catches in fyke nets were recovered in the main stream while the remainder were made in diversions. Mendota is about 37.5 miles downstream from Herndon and above the mouth of Merced River. When compared with records for past years, the seaward migration from San Joaquin River at Mendota this season was found by the State to be abnormally small.

To illustrate the losses in diversions of seaward migrant salmon, a summary of the State's records is given below:

Date	Catches in San Joaquin River	Percent of total	Catches in Helm Canal*	Percent of total	Catches in Main Canal**	Percent of total	Grand total
Feb. 22	189	15.84	1,004	84.16			1,193
26	14	6.57	199	93.43			213
Mar. 3	15	15.00	85	85.00			100
11	5	33.33	10	66.67			15
12	5	83.33	1	16.67			6
17	3	100.00	0	0.00			3
18	1	100.00	0	0.00			1
19	0	0.00	0	0.00	7	100.00	7
20***			0	0.00	8	100.00	8
21			0	0.00	5	100.00	5
22			0	0.00	9	100.00	9
27			0	0.00	5	100.00	5
28			0	0.00	7	100.00	7
29			0	0.00	10	100.00	10
31			1	20.00	4	80.00	5
Apr. 1			1	5.88	16	94.12	17
2			0	0.00	7	100.00	7
3			0	0.00	2	100.00	2
4			0	0.00	3	100.00	3
8			1	14.45	6	85.55	7
Totals	232		1,302		89		1,623

* Helm Canal opened February 17
** Main Canal opened March 19
*** Fyke netting in San Joaquin River terminated; too little current

Patterns of seaward migration as displayed at the various stations in the San Joaquin River system do not resemble each other even remotely. So many complicating factors were operative in each of the streams sampled, that the dissimilarity between migratory patterns is not surprising. Drought conditions in San Joaquin Valley during the past winter certainly altered the seaward migration and rendered the records obtained very much atypical of any average year. High water temperatures probably restricted the free movement of young salmon once they reached the main San Joaquin River. It is believed by some that a large portion of the salmon production in San Joaquin Valley was lost before it reached the lower reaches of that stream.

Central Valley Water Temperature Studies

Central Valley streams are generally quite warm during the hot arid summers especially in their lower reaches. The temperature problem in Central Valley waters is further aggravated by major stream diversions for irrigation and power production. Studies designed to explore the suitability of such streams for anadromous fishes must consider the thermal cycles existing there.

Recording thermometers were obtained after much delay due to shortages, and stations were established at the following points: Balls Ferry, Squaw Hill Bridge, Knights Landing and Walnut Grove on Sacramento River; Coleman Hatchery on Battle Creek; Deer Creek Station on Deer Creek; West of Orland on Stony Creek; Daguerre Point Dam on Yuba River; mouth of West Branch of Feather River; above junction with Yuba River on Feather River; Nicolaus on Feather River; west of Stockton on San Joaquin River; Modesto on Tuolumne River. Hand thermometer records were made at Oroville on Feather River. Thermographs were set up to record the temperature of Anderson-Cottonwood Irrigation District Canal at its beginning and end to learn of temperature gradients in canals.

Thermometer stations were established by the State of California at strategic locations in San Joaquin Valley and on American River. These records have not been included in this report, but, between the State and the Service all important streams were brought under observation.

Water temperature records at Balls Ferry, Squaw Hill Bridge, Knights Landing and Walnut Grove on Sacramento River are practically complete for the first six months of 1947. Balls Ferry is 35.5 miles, Squaw Hill Bridge 93.5 miles, Knights Landing 226 miles, and Walnut Grove 259 miles below Shasta Dam. Comparison of daily records at these stations yields an interesting portrayal of the heat uptake or loss in Sacramento River.

In order to more clearly portray the temperature differences existing at these stations, the daily records have been summarized and are presented as monthly averages in the next table.

Temperatures at Balls Ferry, the station nearest Shasta Dam, are practically as high or higher during January and February as those down river; beginning in March a divergence between the temperature at Balls Ferry and the recordings at Knights Landing and Walnut Grove becomes apparent. It increases throughout April, May, and June. The temperature at Balls Ferry is 2.5 degrees higher in January than at Squaw Hill. Temperatures at both stations are almost identical in February, diverge 4 degrees in March and April, 6.5 degrees in May and 5 degrees in June. Squaw Hill average temperatures are higher than those at Balls Ferry after February.

Extreme variation in seasonal and daily temperatures characterizes the waters in Deer Creek. The temperature extremes were 34 degrees and 56 degrees in January, 40 degrees and 56 degrees in February, 44 degrees and 61 degrees in March; 43 degrees and 74 degrees in April, 55 degrees and 84 degrees in May and 57 degrees and 82 degrees F. in June.

Monthly Average Temperatures - Sacramento River

Station location	JANUARY Avg. Max.	JANUARY Avg. Min.	JANUARY Range	FEBRUARY Avg. Max.	FEBRUARY Avg. Min.	FEBRUARY Range	MARCH Avg. Max.	MARCH Avg. Min.	MARCH Range
Balls Ferry	48.5	46.6	41 -51	50.1	48.0	46-52.5	52.6	49.7	47.5-57
Squaw Hill	45.7	43.2	41.5-48.5	49.9	47.1	43-55	56.7	51.9	49 -60
Knights Landing	49.1	43.6	35 -52.5	53.7	51.7	50-57	56.8	54.2	42.5-62
Walnut Grove	48.5	46.3	43.5-52	52.3	49.8	47.57	55.9	53.6	50 -60

Station location	APRIL Avg. Max.	APRIL Avg. Min.	APRIL Range	MAY Avg. Max.	MAY Avg. Min.	MAY Range	JUNE Avg. Max.	JUNE Avg. Min.	JUNE Range
Balls Ferry	55.5	49.8	49-60	55.2	50.9	50-57	58.1	52.5	51 -62
Squaw Hill	59.4	53.8	46-66	62.0	57.0	52-65	62.9	58.6	53 -67
Knights Landing	62.5	57.3	51-67	68.8	65.8	61-74	70.4	67.8	65.5-74
Walnut Grove	62.5	59.8	55-65	68.9	66.0	62-73	71.1	69.2	65 -75

The maximum stream temperature of 84 degrees F. was recorded May 21. It culminated a period of rapidly rising temperature and followed after the daily maximum had reached 80 degrees or over for two days. The daily maximum temperature reached 78 degrees or over for four consecutive days after May 21. This period of high water temperature was sufficiently extended to stop all upstream as well as downstream migration and to kill anadromous salmonoids in that seven-mile portion of Deer Creek between its mouth and the beginning of Deer Creek Canyon. Previous records show a water temperature increase of over one degree per mile between Deer Creek Canyon and the mouth of that stream.

It is of interest to note that there was an average temperature differential of 2.3 degrees to 13.5 degrees F. in April and May between the colder Sacramento River and Deer Creek. During these months spring-run adults entered Deer Creek even though they entered water 13.5 degrees F. or more warmer than that in which they found themselves.

Feather River, at Yuba City, became too warm for trout and salmon in the latter part of May. On May 21, the maximum temperature was 83.5 degrees and on May 29 it was 84.5 degrees F. In mid-June the river temperature reached 85 degrees F. after having been at 70 degrees or below through the first 10 days of that month. At Nicolaus downstream and below the mouth of Yuba River the Feather did not become as warm in either May or June except on June 25 when the maximum was 87.5 degrees F. The maximum temperature at Nicolaus was 78.5 degrees F. in May. The effect of the lower temperatures in Yuba River during May and June as recorded at Daguerre Point Dam probably accounts for the lower Feather River temperatures at Nicolaus. Yuba River temperatures did not exceed 65 degrees F. in May and 75 degrees F. in June. It is not unreasonable to assume that Yuba River cooled Feather River when it is borne in mind that less than 200 second-feet of water was escaping the lowermost Feather River diversion at Sutter-Butte Dam.

Air and water temperatures in Stony Creek, a west side tributary to Sacramento River, were recorded by thermograph October 17, 1946 to April 30, 1947. The recording station is located west of Orland, California, and below Stony Gorge Dam operated by the U. S. Bureau of Reclamation. Failure of the thermograph necessitated temporary suspension of recording until repairs could be effected. The water temperature record shows a much greater range between daily maxima and minima than was observed for any other stream over the same period. It is quite unusual that differences of about 10 degrees F. should be displayed in winter when the general tendency is toward similarity between maxima and minima. An explanation might be derived from the relationship between volume of flow and physical character of the stream bed on the one hand and constancy of temperature on the other. Small streams spread over broad stream beds reflect air temperatures more directly than do large rivers confined to deep channels.

West Branch of Feather River appeared to be a favorable stream into which salmon and steelhead trout could be moved when the dams were built on Feather River as planned by the Bureau of Reclamation and U. S. Engineer Office. However, water temperatures virtually eliminate that stream from further consideration as a spring-run holding area unless means are found whereby the stream flow can be stabilized and temperature held below 65 degrees F. The stream reached 74 degrees F. or higher during seven days, out of the last ten in May. Minimum temperatures during the same period were 70 degrees F. or better. Both minimum and maximum temperatures rose above 70 degrees F. on June 15 and remained above that figure for the remainder of the month. From June 24 on, the maximum reached was 80 degrees F. or higher each day and the minimum temperature ranged between 73 degrees and 78 degrees F.

It is of interest to compare the San Joaquin River temperatures with those recorded at Walnut Grove on Sacramento River since both stations are at the head of the Delta area. The Walnut Grove temperatures have been discussed in connection with thermal gradients in Sacramento River. Summer temperatures in the Sacramento River at this point are remarkably low as compared with San Joaquin River. At no time since operation began has the river temperature at Walnut Grove risen above 75 degrees F.

The San Joaquin River temperatures at Stockton reached 71 degrees in April, 78.5 degrees in May, and 81 degrees F. in June. Irrigation demands along the San Joaquin reduce river volumes materially by the time the Delta is reached. During the spring months of 1947 the river was reduced to a 100-second-foot flow above the mouth of Merced River and practically all water reaching the Delta came from tributary streams below that point. The low volumes of flow in San Joaquin River are reflected in the much greater range between daily minimum and maximum temperatures. The usual range amounts to about 10 degrees while in Sacramento River the range seldom exceeds 4 degrees.

The thermograph installed at Modesto on Tuolumne River was somewhat erratic in its operation. It was mounted on a pier of a railroad bridge and excessive vibration caused occasional loss of calibration. Frequent checks of the thermometer with a standard instrument, especially used for that purpose, kept the record comparatively accurate.

Maximum daily temperatures in Tuolumne River increased gradually through February, March and early April, in about the same measure as would be expected considering the onset of spring. However, beginning on April 10, a very marked rise in river temperature occurred and maxima of 80 degrees F. were recorded on April 14 and 15. The maximum daily temperature remains high, between 73 degrees and 82 degrees F. throughout the remainder of the period of record. The increase in river temperature coincided with reductions in river volume due to storage requirements at Exchequer Reservoir.

Fecundity of Female Salmon and Length-Weight Relationships of Salmon Measured on Feather and Tuolumne Rivers

During the counting activities at Sutter-Butte Dam on Feather River, 62 salmon were weighed and measured. Of this number, 30 were females which averaged 87.8 centimeters (34.5 inches) in length and 20.09 pounds in weight; and 32 were males which averaged 74.0 centimeters (29.1 inches) in length and 12.97 pounds in weight.

Eleven female salmon were taken from Feather River during the fall migration of 1946. The average number of eggs per female as determined from this sample is 6,525 which resembles the average of 7,000 derived from a larger series of egg counts obtained from Sacramento River salmon.

The eggs contained in 14 sets of ovaries, taken from tagged salmon recovered from Tuolumne River during counting operations in the fall of 1946 were counted. In the 14 cases the number of eggs per female ranged from 4,698 to 7,524 and averaged 6,438. The number of eggs per pound of salmon averaged 394.

Salmon from which these eggs were taken cannot be considered random samples of the Tuolumne River population since all specimens were previously taken by gill nets such as are used by the commercial fishery. These nets select for medium and large-sized salmon and do not adequately fish the smaller size groups. Females in the sample were between 30.5 and 35.5 inches and averaged 33.5 inches in length and were between 13.5 to 19.25 pounds (average equals 16.32 pounds) in weight.

Scale samples were taken from 75 tagged salmon trapped at Modesto Dam on Tuolumne River. The outer edges of the scales were badly eroded and it was impossible to determine the age of the fish. However, the scale nuclei were classified as to type, either ocean or stream. Twenty-three specimens or 30.6 percent were found to have spent their first year in fresh water.

The average length of the salmon collected was 34.75 inches and the average weight was 18.6 pounds.

Shasta Salmon Maintenance Program

Installation of a coffer dam across the fishway at Keswick Dam by the Bureau of Reclamation stopped the summer activity of the Shasta Salmon Maintenance Program. The hauling of spring and summer salmon was resumed on July 10, when a flume leading to the fishway and a second coffer dam were placed. As of September 30, only 2,119 salmon had been hauled to Coleman since that time and 1,467 of these were hauled in September. There is some indication that the increase in numbers of salmon taken in September is the result of a prespawning migration of spring-run fish. Flows in the river were gradually reduced beginning August 23 and may have accounted for some of the migration. Flow reductions were made as follows: August 23, to 8,000 second-feet; August 30, to 7,500 second-feet; September 4, to 7,000 second-feet; September 9, to 6,500 second-feet; and in September 16, to power demand with a 5,000 second-foot minimum. Over the same period the temperature of water released from Shasta rose from 50 degrees F. to 53.6 Degrees F.

Plans for the fall season operations in the Shasta Plan were laid during conferences at Coleman Station. On August 20-21, 1946, it was agreed to: (1) postpone repair of Balls Ferry rack, (2) seek permission to use Anderson-Cottonwood Irrigation District Dam as a stop rack and counting station, (3) operate Keswick fish traps (4) count all adult salmon into Battle Creek (5) release fingerlings at Coleman Station October 1-15, (6) mark 200,000 fingerlings from the 1946 brood year.

These plans had to be changed. The ultimate operation included: (1) Maintenance of Keswick trapping facilities in operation and trapping of fall run there, since the Anderson-Cottonwood Irrigation District Dam could not be used as a stop rack; (2) Counting 2,000 salmon past Anderson-Cottonwood Irrigation District Dam beginning November 1 (count made in 2 days); (3) Trapping these fish at Keswick to determine speed and completeness of upstream movement; (4) Trapping and spawning Battle Creek fall run for eggs at Coleman.

Since Anderson-Cottonwood Irrigation District dam could not be used as a block after November 4, 7,560 salmon were hauled from Keswick between November 4 and 26.

Summary of Coleman Operations, 1946

	Battle Creek Native Spring Run	Keswick Spring Run	Battle Creek Fall Run	Keswick Fall Run
Males killed for fish food	768	1,106	4,100	3,838
Females used for fish food	78	22	216	0
Females spawned	328	236	1,801	2,379
Males spawned	145	85	501	523
Spent fish recovered (females)	67	57	100	6
Dead from other causes (males)	570	434	383	408
Dead from other causes (females)	481	260	179	69
Fish unaccounted for	13	0	0	0
Hauled to Deer Creek	--	167	--	--
Released to spawn naturally	--	24	3,551	337
Totals	2,450	2,391	10,831	7,560
Eggs obtained	1,476,000	1,287,000	11,131,000	14,403,100
Total eggs				28,297,100

The small loss of females in the lot hauled from Keswick is remarkable. Only 2.8 percent of females available died before spawning. The lowest previous loss on a lot of fall run salmon was 25.2 percent.

The sex ratio as established from 19,116 salmon handled at the hatchery in 1946 was 2.1 males to 1 female.

Twenty-nine 2-year-old grilse salmon from lots of marked fish (brood year 1944) released at Coleman Station in 1945, were recovered as they entered Battle Creek during the 1946 fall migration period. Fourteen of the marked salmon were fish released in the spring (April) and the remainder were from the lot released in the fall (October). Spring released specimens averaged 6.47 pounds in weight and 23.8 inches in length. Fall released salmon averaged only 3.83 pounds in weight and 20.0 inches in length. Differences between the two lots would indicate that holding in the hatchery is not economically sound. However, conclusions should not be made from this observation since it is likely that the differences will be overcome in future years.

General Activities

Evaluation was made of salmon spawning and nursery grounds in Clear Creek; North, Middle and South Forks of Cottonwood Creek; Little Cow, Stillwater, South Cow, Bear, Elder, Thomas, Paynes, Antelope, and Mill Creeks, all tributary to Sacramento River. All of these streams are likely units to be developed in the Alternate Tributary Plan as proposed by the Bureau of Reclamation. There are approximately 20,400 salmon nesting sites in these streams which, if provided with dependable water supplies, would accommodate 61,200 salmon where practically none are accommodated under present conditions. This new salmon crop would be worth, conservatively speaking, $186,200.00 in direct revenue annually to commercial and sports fishermen.

In cooperation with the State of California, personnel of the Delta district tagged adult salmon taken in the Delta area with gill nets. Tagging expeditions were made on July 2, 12, 24, August 10, 29, 30, and September 14. Following the close of the fishing season on September 26, daily tagging expeditions were made until October 11. Three hundred and ninety-one salmon and 26 striped bass were tagged during that period. Recoveries from the tagging program have not been summarized by the State.

Many of the tags were recovered by the Service. In the Tuolumne River salmon population were 86 individuals which had been tagged in the Delta. Of this number, 79 tagged fish were recovered, 4 were seen, and 3 were taken with tag scars. Three tagged salmon were taken on the last day of counting, and it is very likely that additional tagged individuals moved upstream after the dam was removed. A superficial check of the numbers on recovered tags revealed that practically all of the fish taken in Tuolumne River were tagged in the Delta after the close of the commercial fishing season. These results demonstrate that virtually all of the Tuolumne River run passed through the fishing grounds after the season had closed and contributed little or nothing to the salmon catch. There is indicated a need for revision of present legislation so that all runs to Central Valley streams might be equally utilized.

Oroville District personnel undertook the location of, and made plans for, the construction of a counting weir on Feather River early in this fiscal year. The objective of the search was to find a weir location as near to the mouth of that river as physical conditions would permit. A site was located but difficulties in obtaining materials and land leases forced abandonment of plans for a weir. Permission was obtained to count salmon over Sutter-Butte Dam; a less desirable site because of its location above most of the good spawning grounds used by fall-run salmon.

A rather intensive survey of the lower Feather River drainage was made in March, 1947, to determine when the first spring-run adult salmon arrive in that stream. Up to March 17, no salmon were seen although numerous steelhead trout were observed migrating upstream to spawn.

The Oroville District staff worked over Feather River flow data and made observations throughout the North Fork of that stream to fix a schedule of minimum flows which will be required below diversions to power plants now being planned by the Pacific Gas and Electric Company. On the basis of data obtained a report was prepared which recommended stipulations for protection of fish and recreation to the Federal Power Commission to be included in the license for the projects.

Conferences with the Bureau of Reclamation to discuss fishery problems related to the Delta Cross Channel and the Delta-Mendota Canal were held on several occasions during the year. Fishery interests went on record as recommending as their first choice of plans to solve the fishery problems the construction of the closed-channel version of the cross delta scheme. The closed channel, in brief, consists of an artificial waterway from a diversion point on Sacramento River near Walnut Grove, around the Delta to the Delta-Mendota pumping plant.

As a second choice, screening of the Delta-Mendota pumping plant and the Delta Cross Channel (open version) intake and construction of a by-pass canal for fish from San Joaquin River to Dutch Slough were recommended. This by-pass canal would originate in the vicinity of Mossdale crossing on San Joaquin River and would describe a course around the southwest side of the Delta past the Delta-Mendota pumping plant and thence to Dutch Slough, somewhat upstream from the city of Antioch and sufficiently removed from the Delta to avoid influence of pump drafts. This canal would have a capacity of 500 second-feet of water which would be diverted from San Joaquin River. It would not only carry the majority of San Joaquin River anadromous fishes but would also receive fish screened from the Delta-Mendota canal intake.

A 26-foot Higgins built launch was procured from U. S. Army surplus in April. She was put on the ways for a major overhaul and first became available for use in July, 1947. She is to be used for making net tows, doing experimental fishing and collecting other scientific data in the Delta Investigations

During July, 1946, a series of preliminary tests was conducted at Convict Creek in an effort to determine the effects of certain commercial weed killers on trouts. The experiments were set up in hatchery troughs, with various concentrations of chemicals flowing into the pools containing fish. Observations were made on the lengths of time required to produce distress and death in the different species and size groups, and notes were taken on the actions of the fish on exposure to the various herbicides. The fishes tested were: Six-inch rainbow trout, three-inch rainbow trout, two-inch brook trout, two-inch lake chubs. The chemicals used were: Dow Contact Herbicides and Dow Selective Herbicide, both derivatives of dinitro-O-secondary butyl phenol; 2, 4-Dow Herbicide, 2, 4-Dow Weed Killer, Dow G 654, and the sodium salt of 2, 4-D, all derivatives of 2, 4 dichlorophenoxyacetic acid. During the course of these tests, certain plant and aquatic insect material were also treated with chemicals.

The results of the experiments are shown in the following table:

Concentrations Required to Kill Fishes
in p. p. m.)

	6-inch Rainbow Trout	3-inch Rainbow Trout	2-inch Eastern Brook Trout	2-inch Lake Chubs
Dow Selective Herbicide	12	12	12	12
Dow Contact Herbicide	100	100	100	1,000
2,4 Dow Herbicide	No kill at 1017	101	1,017	Not tested
2,4 Dow Weed Killer	990	990	No kill at 990	Not tested
Dow G 654	204	204	204	100
Sodium salt of 2,4-D	990	990	Not tested	Not tested

Additional studies should be made to determine the effects of these chemicals on other fishes, on submerged aquatic plants, and on aquatic invertebrates.

SOUTH PACIFIC FISHERY INVESTIGATIONS, Oscar E. Sette, Chief of Section

GENERAL

Pilchard Studies

The marked decrease in pilchard landings which occurred in 1944-45 was followed by a more disastrous decline during 1945-46. The following table showing the catches in 1000's of tons by ports during the last ten seasons illustrates this:

	San Pedro	Monte-rey	San Fran-cisco	Calif-ornia	Wash. & Oregon	British Columbia	Total
1937-8	109	104	200	417	34	48	499
1938-9	145	180	244	575	43	52	671
1939-40	93	227	211	532	50	6	577
1940-1	170	165	118	455	4	29	488
1941-2	146	250	186	583	33	60	676
1942-3	200	183	116	501	2	66	560
1943-4	132	212	126	474	12	89	575
1944-5	175	235	136	548	--	59	607
1945-6	169	142	83	396	2	34	432
1946-7	191	27	3	221	10	4	235

These statistics illustrate the fact that the fishery at San Francisco was a complete failure and that at Monterey only slightly less so. The resulting heavy concentration of vessels in the San Pedro fishery caused an actual increase in the catch there, although the abundance was apparently no higher than before.

This decrease in the catches may be attributed to two factors. First, there are, as a result of a succession of poor year classes since 1940, less pilchards in the sea to be caught. Whether this low recruitment is the result of a series of unfavorable hydrographic circumstances or whether it may be also partly attributed to the fishery is a moot question and stands in need of much further study than it has been possible to give it so far. In addition, it appears that, particularly at the northern California ports, the fish have not been available to the fishermen to the usual degree. Whether this indicates that the fish are not present in northern waters, or are present and not showing up on the fishing grounds there, the effect is the same; the catches in northern waters have shown a marked decline in relation to those in the south during the past two seasons.

This unsatisfactory condition of the fishery and the equally unsatisfactory condition of scientific knowledge regarding the dynamics of this fishery, particularly with regard to the causes of fluctuations in recruitment and availability, has caused the industry to become greatly concerned. As the result of a series of conferences held with members of this staff, and with representatives of the California Bureau of Marine Fisheries and Scripps Institutions of Oceanography, the industry people have determined to promote vigorously a program of oceanic research designed to supply answers to the vexing questions confronting

this fishery. To that end two bills have been introduced in the California State Legislature, one to provide $300,000 a year for Scripps Institution to carry on oceanographical studies and another to tax the catch an extra 50 cents a ton to enable the necessary concomitant biological studies to be carried on. This latter fund would be expended by a committee of industry and State representatives, advised by a technical committee of which a representative of this staff is a member. The industry and State people expect to be able to allot some of these funds to be expended under our supervision.

A good deal of time of various members of our staff has been spent during the past year in preparing estimates requested by the industry in connection with the above program and in conferring with industry and State representatives in regard thereto.

A conference of Pacific pilchard biologists was held in San Francisco on May 28, 29, and 30, and was also attended by Dr. Hubbs of Scripps Institution because of the prospective participation of that organization in future work. The work of the various organizations during the past year was reviewed, and it was agreed that the routine work of sampling the catch and compiling routine vital statistics therefrom should be continued as before, with some modifications in the sampling at San Francisco in anticipation of a possible repetition of last season's poor catches. It was especially urged that the various organizations do whatever they could within their regular budgets toward getting ready to undertake the expanded program, funds for which are being considered by the California State Legislature. To this end, Scripps Institution expects to carry out work on the methods of collecting late larvae and juveniles, on rearing young fish from eggs, and possible on methods of plankton analysis. The State of California expects to conduct a trial run of log-books in the San Pedro fishery. For our part, we expect to continue work on high speed plankton collecting gear to that extent which our funds will permit.

Following the conference of pilchard biologists, a conference on oceanography along the Pacific Coast in relation to the fisheries was held on June 2, attended by Dr. Barnes of the U. S. Hydrographic Office, by Dr. Sverdrup of the Scripps Institution, by representatives of the fisheries agencies of the Pacific Coast States and British Columbia, and by scientists of this staff. The needs for oceanographical work off the Pacific Coast were reviewed. It was brought out that there is a particularly great necessity for carrying on repeated surveys in waters up to 300 miles offshore in order to determine the short period fluctuations which are of great importance to the fisheries. The Hydrographic Office will probably be unable to participate directly in such work because of limitations of personnel and lack of equipment, but it can assist in instrumentation and in obtaining the cooperation of the Navy and Coast Guard so far as practicable. The cooperation of the Coast Guard in obtaining regular bathythermograph sections off San Francisco and Cape Flattery has already been obtained through the initiative of this section and with the cooperation of Scripps and the Hydrographic Office.

The extensive oceanographical program, funds for which are being considered in the California Legislature, would give excellent coverage of waters from lower California to Oregon. The Canadian Government is in the process of instituting a program of detailed oceanographical work off the Canadian Pacific Coast, which will provide comparable data in those waters. No means seems to be at hand for obtaining such data off the Washington and Oregon Coasts except as the two projects above-mentioned can be stretched to cover parts of this area.

COLLATERAL DUTIES

In addition to the duties reported on above and under specific projects below, there have been a number of miscellaneous activities during the past year which have occupied a good deal of time of various staff members. Conferences and trips of vessel inspection undertaken to assist the Philippine Fisheries Program in getting under way have required several man-weeks. Mr. Sette has spent a considerable share of his time in revising for publication data on the Atlantic mackerel. The report on the work of the office of the Coordinator of Fisheries has been completed and is undergoing final revision. One Inter-American Fellow, Mr. Francisco Lara, from Brazil, was supervised during the last 2 quarters.

These projects, involving a good deal of clerical work, place on our clerical staff a work-load too great to be accommodated. As a result it is necessary for our scientific staff to perform many clerical duties not commensurate with their professional grades.

PROJECT 1. PILCHARD FISHERY DYNAMICS

Sub-project 1--Size and age composition of the stock

a. Results of sampling of the commercial catch in 1946-47

Estimates of age of pilchards sampled from the commercial catch during the 1946-47 season were made jointly by two members of the staff of California State Fisheries Laboratory and one of our staff. The estimated percentage age composition weighted to the total numbers of fish taken in each port gives the following estimates in millions of fish of each age caught in Pacific Coast ports:

Year class	Age *	San Diego	San Pedro	Monterey	San Francisco	California	Washington	Brit. Col.	Pac. N.W.	TOTAL+ 1946-47	TOTAL+ 1945-46	TOTAL+ 1944-45
1946	0	0.04	2	10	--	12	--	--	--	12	--	--
1945	1	16	668	84	4	772	--	--	--	772	249	471
1944	2	12	476	22	3	513	--	--	--	512	929	1227
1943	3	8	313	32	2	355	1	1	2	358	869	721
1942	4	2	99	19	4	124	3	2	5	128	454	642
1941	5	1	44	10	1	56	3	1	4	60	231	676
1940	6	0.2	7	5	1	13	13	5	18	31	170	246
1939	7	0.04	2	4	2	8	6	6	12	20	61	73
1938	8	0.04	2	0.2	0.4	3	1	1	2	4	16	17
1937	9	--	--	--	1	1	1	0.2	1	2	3	2

*Applicable to 1946-47.

Fish of older year classes were notably less abundant than formerly. There was marked departure from the mortality trend of the five preceding seasons. There was unusual abundance of 1-ring fish in California, and, for the first time in five seasons of sampling the commercial catch for ages, fish of the year, or 0-ring were present.

The region of catches may account in part for peculiarities in age composition. More than 80 percent of California's total was landed in San Pedro, and sampling of the "available" pilchard population was thus primarily in a region normally productive of younger age groups. In the previous 5-year period the 2-ring fish have usually predominated in San Pedro, and the dominance of 1-ring fish has not occurred. There is some promise that the 1945 year class is stronger than the incoming year groups since 1939. The older age groups are usually less abundant in southern California so that this may partially explain the striking departure from the norm for the whole coast and apparent under-availability of older ages in the catch.

Evidence from the growth rates of the past five seasons shows that there has been a rather consistent increase in rate of growth of the more recent year classes. There are indications of this also in the size composition of this season's age groups.

Summaries for publication of size and age data collected since 1941 are near completion.

b. Study of determination of age by means of otoliths In order to extend our age analysis of the pilchard fishery back to the period prior to the adoption of our present routine age analysis through scale samples, and gain thereby extremely valuable data on mortality and recruitment rates in earlier years, under less intense fishing, 10,000 otoliths from fish sampled at California ports during the seasons from 1932-33 to 1936-37 by the California State Fisheries Laboratory, and a substantial number collected in British Columbia during the same period by the Fisheries Research Board of Canada, were made available to us for age determinations by the above agencies.

Comparative studies of the readings obtained from otoliths and from scales of young pilchards had been quite completely studied previously; however, it was realized that similar studies should be made on the adults before undertaking the complete study of the otoliths from previous seasons. Consequently special collections were made of approximately 500 otoliths and scales from the same fish for these comparisons, and a detailed study of them has been made by Mr. Mosher.

b. continued.-

Readings were made of the scales in the usual manner without reference to the fish length or the otolith. Readings of the otoliths were then made independently without reference to the fish length or the scale reading. Comparisons were made by matching up the scale and otolith readings of the same fish and noting the fish length.

Among the results obtained were:

1) Age classes one to seven were found in these samples, the fish ranging in size from 166 to 252 mm. in standard length.

2) In approximately 68 percent of the total readings the otolith and scale determination agreed perfectly as to the age indicated. Approximately 88 percent of the disagreements were in doubt only as between one of two adjacent ages such as between a three or a four. Less than 12 percent were in doubt as to ages two or more years apart such as between a two or a four, or as between three or more ages such as between a three, four, or a five.

3) The percentage age composition of the sample as computed from the otoliths agreed quite well with that obtained from the scales, and when tested statistically gave a reasonably high probability of representing the same population.

4) Average sizes at each age as computed from otoliths gave at least as reasonable values as those computed from the scales, and possibly better ones in some respects.

5) The age determinations by both methods were examined by various methods, the results of which indicate that the otolith presents a satisfactory means of estimating the age of individual adult pilchards.

This preliminary study of the comparison of scale and otolith readings of the same fish is nearly completed, needing only a few final computations and the writing up.

Reading of the otoliths of the early seasons' collections can now be undertaken with assurance that the data obtained will represent with substantial accuracy the age composition of the fish sampled. Further tests of otoliths and scales from the same fish of large size are anticipated from time to time, however, in order to maintain as accurate a check as possible on the future scale and otolith readings.

Sub-project 2--Abundance off California

Based on the studies of relations of boat-catch to vessel characteristics reported on below (sub-project 4), two statistics of success of fishing were devised, each measuring a different aspect of the apparent abundance. The average catch per boat per night's fishing during a given lunar period was taken as a measurement of the success the fishermen met with in finding schools of pilchards. The size of the schools when found is reflected in the average size of landings made. The first of these factors is independent of vessel size and the statistic used is simply the average catch per night's fishing for all the boats fishing during a given lunar period. The second, the average landing size depends on the hold capacity of the vessel which in turn is related to its gross tonnage. The statistic used is, therefore, the average size of landing for a vessel of standard size (85 gross tons) estimated from the regression of landing size on gross tonnage for the given lunar period. These two statistics may be employed separately or combined into a single statistic of "success of fishing."

Employing the above statistics, the prewar season of 1940-41 has been compared with the war season of 1943-44 for the fisheries at San Francisco and San Pedro. It has been found that the average number of landings and average size of landing do not vary together, probably indicating variations in schooling habits or behavior of the fish in different years. Rather significant discrepancies between the results of this method of boat-catch analysis from those of the chain-link system are evident, particularly at San Francisco. The reasons for these differences are being sought in a more detailed comparison of the elements making up the two different measurements.

Sub-project 3--Boat Catch Analysis of the Oregon-Washington Pilchard Fishery, 1935-1943

This analysis has been completed and it is expected that a terminal report will be submitted in the early part of next quarter. Due to the nature of the fishery, the method of comparing the performance of identical boats between successive seasons could not be used. Use was made, therefore, of the relationship between boat size and catch size and a boat's performance was rated in terms of its potential performance, as estimated from this relationship. Levels of abundance (including the effects of varying availability) as measured by catch per-unit-of-effort are presented for the seasons involved. The catch per-unit-of-effort fluctuates around a level of about 140 tons per boat-week. Continuation of the series would be difficult or impossible due to the disruption of the fishery by conditions obtaining during the war.

Sub-project 4--Correlation of Boat Characteristics with Catching Ability

The statistic at present used to measure the apparent abundance of pilchards in the California fishery is derived from a comparison of the catches of those boats which fish during comparable lunar periods of both of two successive seasons. During periods when the composition of the fleet is undergoing rapid transition, as during the war period, this "linkage" method does not utilize the catches of a large fraction of

the fleet. Any alternative method, however, must of necessity contain corrections for changes in catching ability of the vessels of the fleet as they change in size and design. For these reasons there have been undertaken analyses of data on boat characteristics and their relationship to the success of fishing. The success of fishing is reflected in two fashions, the success in locating and catching any fish, and the sizes of the catches when catches are made. In order to lay a foundation for possible future analysis of each of these factors, the relationship of vessel characteristics to each of these was studied.

The hold capacity of the fishing vessels was selected as the characteristic most directly related to the size of deliveries on the basis of a preliminary study. Since the hold capacity is not available for all years, it was necessary to use some other characteristic which appears in the ship register. During the war years when each vessel was required to obtain a government permit the hold capacity figure was available for all vessels and a study was made of the relationship between hold capacity and gross and net tonnage for the seasons 1943-44 and 1944-45. It was found that hold capacity can best be predicted from gross tonnage and further analyses, therefore, used gross tonnage as a measurement of hold capacity.

It was found that the number of landings made in a given period, the measurement of success of catching any fish at all, is independent of the gross tonnage of the vessel. It was found that the average size of the landings during a given period, however, increases with the gross tonnage of the vessel and that the regression is roughly linear over the range of vessel sizes and levels of abundance studied. Lampara boats and purse seiners have, as might be expected, different relationships of boat size to catching ability and must, therefore, be treated separately.

Deviations from the regression of size of catch on gross tonnage are not correlated with deviations from the average power of the propulsion machinery for vessels of a given size; from this we infer that the speed of the vessel is not an important factor in determining the size of its catch, within the range of speeds in the present fleet.

PROJECT II. AVAILABILITY OF PILCHARDS

Sub-project 1--Experimental Fishing

A draft report has been prepared on the results from the Pearl Harbor surveys, carried out in the spring of 1946, covering sonar scouting and analyses of oceanographic and plankton data. This report will be submitted in the near future.

Study of the bathythermograph data has shown that, in general, the coldest water was inshore and temperature increased in the seaward direction. Assuming that temperatures approximate densities, isothermal charts for the middle of May indicate a southerly drift about 50 miles off the coast between San Francisco and Ano Nuevo Point, turning

somewhat south of Ano Nuevo and going sharply eastward toward Monterey Bay. There was also an eddy in this current bending shoreward southeast of the Farallon Islands. BT's taken during the following six weeks indicate that this latter eddy shifted in and out so that the water between the Farallon Islands and Point Montara shifted from warm to colder then warm, and then colder again. By the middle of June a relatively strong southeasterly current had developed just west and south of the Farallon Islands.

Pilchard eggs were taken in three plankton collections, and pilchard larvae in three hauls also. The eggs were collected during June at water temperatures above 57 degrees F. The usual temperature encountered was much lower than this. Anchovy eggs were taken throughout the period of sampling; they were present in about a third of all samples collected, and occurred in considerable numbers in some samples.

The volume of plankton collected in individual samples near shore was found to be considerably larger on the average than those collected further seaward. The average volume of samples collected at night was considerably larger than that collected during daylight hours. However, in both these aspects and in other ways as well, the major groups of plankton animals differed markedly. On the longest seaward cruise, a rich zone of plankton was encountered on both the outward and inward lines at some distance from shore. The volume of plankton taken in this zone was several times as large as in hauls taken on either side.

Experimental fish scouting

At the request of the San Francisco sardine industry a Navy blimp made flights off the coast of central California, on October 14, 16, 17, 18 and 28. Mr. J. J. Dorsey acted as observer for the industry; Mr. Aplin of the California Fish and Game, went as biological observer on the first three; and Dr. Osgood Smith, of this laboratory, on the last two flights.

Schools of fish were sighted on the 14th, northwest of the Farallones, and on the 28th near Bodega Bay and southeast of the Farallones. Following the first occasion fishing boats reported the schools to be anchovies, and following the second, the fishermen could not find any fish schools.

Sub-project 2--Pilchard populations

The meaning of differences in rates of growth, as evidenced from the study of scale patterns of pilchard caught in different parts of the range of the species, has not progressed appreciably owing to primary effort toward publication as soon as possible of all age analysis data so far accumulated.

Analysis and write-up of growth data obtained from experimental rearing of two sets of genetically similar Platypoecilus under different temperature conditions is similarly held in abeyance.

PROJECT III. RECRUITMENT OF PILCHARDS

Sub-project 1--Spawning surveys of 1939, 1940, and 1941

A manuscript dealing with "A record of pilchard eggs and larvae collected during surveys made in 1939 to 1941" has been prepared, and will be submitted as soon as it can be typed and circulated among the cooperating State agencies for comments and criticism. The paper contains a series of tables giving data on the individual hauls, and on the number of eggs and larvae collected at each station. The data on pilchard eggs and larvae are given in terms of "standard hauls." The egg data is broken down into the several days of spawning present in each sample. The larvae data is summarized by 1 mm. size classes. The paper includes a short account of each survey, a description of the gear and methods of operating the gear, methods employed for determining the volume of water strained and for standardized hauls, data on vertical distribution of pilchard eggs and larvae, and a discussion of identification and separation of pilchard eggs and larvae. It will afford the basis for further analytical reports on growth, drift and mortality of young stages.

Sub-project 2--Correlation of year class strength with meteorological and oceanic conditions.

A study of the numbers of fish caught in each year from each year-class had led to a method of estimating year class size from the age composition data and statistics of the catch. It may be briefly described as follows: During a period when the intensity of the fishery is roughly constant, the total mortality rate of each year class should be the same at comparable ages. The selectivity of the fishery at younger ages is also expected to remain constant under such conditions. This makes it possible to establish a normal curve of change of abundance in a year-class as it passes through the fishery. The deviation of the average abundance, throughout its life, of a year-class from this normal curve may be taken as a measurement of the abundance of the year-class relative to other year-classes.

Applying this method to the catch and age analysis data of the fishery from 1941-42 to 1945-46 it has been found that the year-classes from 1933 to 1936 were subnormal. The years 1936, 1937, and 1940 were about average, while 1938 and 1939 were outstandingly good, the latter being some 210 percent of "normal." Year-classes 1941 to 1944 have been subnormal.

It has been found that a good correlation exists between summer salinity at La Jolla and year-class strength, perhaps connected with amount of upwelling off the California coast.

The summer salinity at La Jolla, in turn, has a very high correlation with the amount of the winds from the north during the preceding winter, as inferred from the average monthly pressure gradient off central California. The pressure gradient data have been made available by the

Navy weather Central in San Francisco for the war years.

In order to establish a basis for future study of the short time fluctuations in the current systems which seem to have an important influence on the recruitment of the pilchard stock, arrangements have been consummated for Coast Guard weather vessels operating from San Francisco and Seattle to take bathythermograph sections to a distance of 300 miles from the coast on their way to and from their assigned duty stations. These trips are made at approximagely 20-day intervals and follow the same track each trip. Thus over a period of time it is expected that data of considerable value on the variations in the current systems may be amassed. The B. T. slides from these sections are processed by Scripps Institution whence enlarged photographic copies of the slides are sent to us routinely.

Sub-project 3--Experiment with plankton catching devices

Preliminary plans and designs for three types of plankton collectors, operable at ordinary cruising speeds of nine or ten knots, have been drawn. They have been derived partly from the "high speed net" used on the Pearl Harbor, combined with current meters, etc. One of these, combining some features of a bathythermograph and a current meter, has been referred to the Woods Hole Oceanographic Institute and the Scripps Institute of Oceanography for suggestions and possibly final engineering.
A simplified version, embodying a current meter, weighted head, and diving vanes, is now being constructed and will soon be given sea trials, through the courtesy of Scripps Institution of Oceanography. Further developments will await the outcome of these trials.

PROJECT IV. EFFECTS ON FISHES OF THE ATOMIC EXPLOSIONS

Sub-project 3--Pelagic fishes

Routine trolling operations carried out by three YMS'S were continued in the vicinity of Bikini, Rongelap, andRongerik Atolls through 17 August, 1946. During the entire period 251 boat-days of fishing were amassed in all areas. The total catch was 4825 fishes distributed among 23 species. The bulk of this catch, plus several hundreds of preserved fishes taken under a light at night, in plankton net hauls, etc., records, and gear, left Bikini on August 19, aboard the USSYP636. This ship went aground about 32 miles south of San Francisco on September 13 and the cargo was virtually a complete loss; roughly 15 percent or less of the preserved fishes were recovered and only 119 troll-caught fishes were salvaged. The proposed comparison

of tunas of commercial importance from the northern Marshalls with samples from other areas is thus prevented. This comparison was of considerable importance. The loss of the preserved material leaves a considereble gap in the systematic collections, since the fishes lost were largely from habitats not worked by others.

Fortunately the boat-catch records were all saved. A considerable portion of this fiscal year has been devoted to a catch per unit-of-effort analysis of these records. A manuscript embodying the results of this analysis has been prepared and will be submitted in the early part of next quarter in its final form.

PROJECT V. PRELIMINARY INVESTIGATION OF PACIFIC TUNAS

Early in January Mr. Schaefer proceeded to Costa Rica aboard the Pacific Explorer. Mr. Marr relieved him on March 6 and continued field observations until May 12. During this period observations were made on the bait fishery in the Golfo de Nicoya and on the live bait and purse seine tuna fishery off Costa Rica and Panama. Preliminary data were obtained on the biology of the yellowfin tuna and, to a lesser extent, on the oceanic skipjack including size composition of the stock, feeding habits, aggregation habits, morphometric characters, and maturation of gonads. Condition of yellowfin gonads indicated that spawning must take place in the late winter or spring months in the area visited or in some nearby area. Collections of bait fishes were made, as well as collections of small pelagic fishes. Among the latter is a good series of a young scombroid not yet specifically identified. Primary emphasis was placed on obtaining information which will be useful in planning future tuna investigations and on gathering data not obtainable ashore.

GULF OF MEXICO FISHERY INVESTIGATIONS, William W. Anderson, Chief of Section

PROJECT I. CONDUCT OF SHRIMP TAGGING EXPERIMENTS ALONG THE NORTHERN MEXICAN COAST

During the month of March 1947 a program of shrimp tagging was conducted along the northern Mexican Coast. The purpose of this experiment was to determine whether or not a suspected migration of shrimp was occurring between Texas and Mexican waters. Since there is no established fishery on the upper Mexican Coast, the shrimp were tagged during the early spring so that if a northward migration was occurring the tagged individuals would be recovered in the Texas fishery. Such a movement would follow the pattern found to exist on the South Atlantic Coast.

In all, 1,000 tagged individuals were released along the Mexican Coast from a distance of approximately ten miles below the Rio Grande River to approximately one hundred miles below the border in the vicinity of Hut's Bayou.

By the latter part of May, approximately two months after completion of the tagging, returns had reached a total of 130 or 13 percent of the releases. These returns were scattered from below the border in Mexican waters to a distance of approximately 75 miles north of the border in Texas waters. By far the greatest percentage of returns were made in Texas waters in the vicinity of Brazos Santiago Pass just north of the Rio Grande River. During April tagged individuals were secured a maximum distance of 25 miles north of the border and in June a maximum distance of 75 miles north of the border. Several individuals had traveled a minimum distance of between 80 and 100 miles from the point of release. With the exception of one shrimp, which was recovered a few miles south from the point of release, the tagged individuals all displayed a northward migration.

Returns from this experiment to date are extremely encouraging, and since the tagged individuals are rapidly moving northward along the Texas coast we have hopes that the next month or two will yield some very valuable recoveries.

PROJECT II. WATER HYACINTH STUDIES

Early in June, due to the need for immediate work on the Service's part of the water hyacinth program, Mr. King was detailed to work with Mr. Lynch and Dr. Mottley on that project. His activities in this work covered the following subjects:

A. Effects of the water hyacinth on various types of water in Louisiana

1. Lakes
2. Rivers

3. Waters on Federal refuges
4. Bayous
5. Borrow pits

B. Special studies on ponds of the Bonnet Carre Spillway
C. An investigation of certain Florida waters.
D. Bottom fauna studies
E. The water hyacinth as a food producer
F. Plankton studies
G. Effects of control methods on fish
H. Evaluation of damage to fresh-water fisheries by the water hyacinth.

In addition, Mr. King assisted in the preparation of the final report on the water hyacinth studies which was published by the Service under the title "Effects of Aquatic Weed-Infestations on the Fish and Wildlife of the Gulf States," by J. J. Lynch, J. E. King, T. K. Chamberlain and Arthur L. Smith, Jr.

PROJECT III. FISHES OF THE SOUTH ATLANTIC AND GULF COASTS

During the course of operations with the vessel "Pelican" on shrimp studies an attempt was made to keep records of all fish taken in the hundreds of trawl hauls made along the South Atlantic and Gulf Coasts. It was thought that very valuable information on the bottom fish could be thus obtained incidental to the shrimp studies. In the course of this work it was necessary to collect and preserve large numbers of fish, since the identification of other than the common species was impossible aboard the vessel. In order to make the fish records usable the identification of the preserved specimens is necessary, as they are a key to the records taken. Arrangements were made for Mr. Isaac Ginsburg of the Ichthyological Laboratory to spend some time in New Orleans to examine the collection. As a result, Mr. Ginsburg was in New Orleans during the month of May at which time the collection was gone over and tentative identifications made on most of the specimens with the assistance of Mr. Anderson and Mr. King as other duties permitted. It will be necessary for the collection to be shipped to Mr. Ginsburg at the U. S. National Museum for further study and comparison before final determinations can be made.

NORTH AND MIDDLE ATLANTIC FISHERY INVESTIGATIONS, Lionel A. Walford, Chief of Section.

PROJECT I. THE HADDOCK AND HADDOCK FISHERY, Howard Schuck, Project Leader

New England Landings of Haddock during the calendar year 1946 amounted to 18,737,880 pounds of scrod and 108,113,555 pounds of large, or 126,901,435 pounds of all sizes, as compared with 127,449,599 pounds in 1945.

A more complete understanding of the factors affecting the abundance of haddock on Georges Bank, and also on the Nova Scotian Banks, must be obtained as rapidly as possible. This necessitates evaluating recruitment, and an accurate index of recruitment is difficult to obtain without the age composition of the population throughout the years considered.

As the first step in this direction, an analysis of extensive length frequencies (about 600,000 measurements) has produced the size frequency of the total catch of large, scrod, and all sizes of haddock taken from Georges Bank in each of the four seasons of the years 1931-1946. The analysis of this large quantity of data was carried out under Mr. Schuck's direction by Miss Monahan and Mr. Phillips, at times assisted by Mr. Stringer and Mr. Arnold of the Salmon Investigation.

The total number of haddock caught on Georges Bank during recent years were computed from these studies to be as follows:

Year	Total catch in numbers of fish
1931	34,980,894
1932	32,348,089
1933	20,526,333
1934	15,616,600
1935	28,564,758
1936	31,422,843
1937	32,527,625
1938	33,570,343
1939	38,639,192
1940	31,346,203
1941	47,484,367
1942	41,299,358
1943	32,936,899
1944	28,702,381
1945	21,422,229
1946	32,678,770
16 years	504,066,884
Average per year	31,504,180

Age determinations of all available scale collections taken from Georges Bank populations from 1931-1946 were made concomitantly by Mr. Schuck and Mr. Arnold. The summarization of these data is at present being completed by Messrs. Phillips and Arnold. Such readings will be applied to the size compositions in order to obtain the ages of all fish in the total catch during these years and seasons, and thus the contribution of the various year classes, etc., on Georges Bank.

It is important that the accumulated data for the major Nova Scotian Banks be analyzed also, and it is planned to initiate this work if adequate personnel are available for the next fiscal year.

The calculation of length of fish from a knowledge of the fish length-scale radius relationship was carried out for samples of Georges Bank fish caught in Season A of various years. Previously, the relationship between fishlength and scale radius was studied at some length by Mr. Schuck and was reported upon in a paper presented at the A. A. A. S. meetings and in a manuscript submitted for publication.

It is planned to complete the studies on Georges Bank growth over the 1931-1946 period during the next fiscal year. To speed up the analysis of these data, key punch cards have been ordered for their tabulation and summarization.

The abundance of haddock on Georges Bank has progressively dropped in the past three years due to a scarcity of scrod haddock which has resulted from the relative failure of the 1941, 1942, and 1943 year classes.

In 1944, 1945, and 1946, scrod haddock on Georges Bank were less abundant than at any time since 1929, 1930, and 1931. Figures on catch-per-boat-per-day for recent years are:

Year	Scrod catch-per-boat-per-day in pounds
1932	4,102
1933	2,840
1934	3,049
1935	4,512
1936	5,018
1937	4,528
1938	5,760
1939	5,254
1940	4,627
1941	6,525
1942	8,616
1943	7,000
1944	2,727
1945	2,560
1946	2,982

This scarcity of scrod is also shown by an approximate measure of the relative catch of fish spawned in various years.

Year spawned	Year caught	Relative number caught as three-year-old fish
1934	1937	2,215,000
1935	1938	4,101,000
1936	1939	1,717,000
1937	1940	2,949,000
1938	1941	8,967,000
1939	1942	8,159,000
1940	1943	5,001,000
1941	1944	1,386,000
1942	1945	947,000
1943	1946	444,000

As can be seen, very few of the haddock spawned in 1941, 1942, and 1943 were caught as three-year-old fish. This caused the catch of scrod in 1944, 1945, and 1946 to be very low (most scrod are 2-3 years old).

The extreme scarcity of scrod in the past three years makes it seem that large haddock will be even more scarce in 1947 and 1948 than they have been recently. The failure of three successive spawnings makes it very important that those fish spawned in 1944, 1945 and 1946 survive in good numbers.

Concern of the fish industry and of the general public over the scarcity of haddock has increased greatly during the past year, as reflected in several magazine and newspaper articles and in the discussions of a meeting of the North Atlantic Section of the Atlantic States Marine Fisheries Commission on May 2. At this time, Dr. Walford, and Mr. Schuck presented a summary of the haddock situation and outlined possible methods of conserving baby haddock, which at the present time are landed and destroyed in large numbers by otter trawlers comprising almost the total offshore haddock fleet.

It is important that the baby scrod that are now on the bank should survive to an age of at least three years in order that:

1. The small numbers of mature spawning haddock now on the bank be increased.

2. The maximum marketable poundage from these year classes be obtained.

The average weight of a haddock at the end of two years, .80 pounds, is five times its weight at the end of one year, .16 pounds; and a two-year-old fish nearly doubles in weight if left on the bank one more year (grows from .80 to 1.56 pounds).

In regard to the size to which baby haddock on Georges Bank should be protected, it is possible to compute the benefits, in terms of poundages available and value in dollars to the fishery, of leaving one-year-old baby scrod on the Bank to the ages of 2, 3, 4, 5, and 6 years. The figures in the following table assume an initial stock of 50,000,000 one-year-old haddock and a ten percent natural mortality of haddock annually. The values in dollars are based on the 1945 values to the fishermen at the ports of Boston, Gloucester, Portland, and New Bedford of:

3.14 cents a pound for round scrod haddock (1-and 2-year olds)
7.33 " " " " " " " (3-year-olds)
7.91 " " " " " large " (4-, 5-, and 6-year olds)

Age	Length	Average weight	Quantity of fish		Value of fish	Annual increase in value
			By number	By weight		
Years	Inches	Pounds		Pounds	Dollars	Percent
1	7.6	0.16	50,000,000	9,500,000	298,300	- - - -
2	13.0	0.80	45,000,000	42,300,000	1,328,220	345
3	16.6	1.56	40,500,000	63,180,000	4,631,094	249
4	20.2	2.66	36,450,000	96,957,000	7,669,299	66
5	21.7	3.34	32,805,000	109,568,700	8,666,884	13
6	23.3	4.10	29,524,500	121,050,450	9,575,091	10

Considering the total and percent increase in value, it can be seen that the protection of baby scrod from 1 to 2 years of age may result in an increase of 345 percent; protection from 2 to 3 years of age may result in an increase of 249 percent; and protection from three to four years of age may result in an increase of 66 percent. There appears to be good reason to protect baby haddock until the end of their third year but relatively little advantage to protect them until the end of their fourth year.

Although the cull of haddock, as recognized by the New England Fish Exchange lists scrod (the smallest recognized category of haddock) as from 1-1/2 to 2-1/2 pounds (gutted weight) at the present time numbers of baby haddock as small as 1/2 pounds are landed.

If 1/2 pound (round weight) baby scrod were protected until they had reached a weight of 1.56 pounds (age 3 years), the result would be about 63,180,000 pounds of scrod at the value of 7.33 cents a pound rather than about 24 million pounds of low-priced (3.14 cents a pound) round scrod, or an overall increase of about 39,180,000 pounds or about $3,900,000, an increase of 515 percent in value.

It appears efficient to protect haddock until they have attained an average weight of 1.5 pounds which corresponds to a length of about 16-1/2 inches or 42 centimeters (fork length). This size is usually attained by the average Georges Bank haddock at the completion of its third year of life, which occurs in the spring (March). Such protection would, in addition to producing a much greater poundage from any year class, result in many more of the year class spawning at least once (most Georges Bank haddock spawn at the end of their third year).

The adoption of (1) minimum mesh size for offshore otter trawls and (2) a minimum market size for haddock was recommended to the Atlantic States Marine Fisheries Commission at the May meeting. Exact recommendations are being prepared at the present time. The papers of W. C. Herrington published in 1935, 1936, and 1941, which called attention to the destruction of baby haddock and reported upon experiments with larger meshed trawls, are the basis for these determinations. Recommendations by the Service as to minimum sizes for other offshore species taken on the same grounds as haddock have also been requested and data are being assembled on this subject.

PROJECT II. THE ABUNDANCE AND YIELD OF GROUNDFISH, Miss Stone, Project Leader

In March 1947, summary statistical tables, based on "Current Fishery Statistics" and groundfish abundance data, were furnished the Washington Office, indicating the annual catch-per-day trend for haddock, cod, and rosefish for the New England and Nova Scotian Banks. The data for haddock and cod covered the period 1930-1945, while those for roesfish were for 1935-1946. These data show that a proportionately increasing amount of the total catch has come from the more distant banks during recent years.

Sub-project 1--Abundance of groundfish

During the last six months, the methods used in the abundance analysis have been reviewed by Miss Stone with a view to their simplification. During the reviewing process, certain inaccuracies in the data were corrected. Routine computations have continued, yielding a monthly catch-per-day's fishing effort for each of the species of groundfish for the New England and Nova Scotian Banks.

The method of the abundance analysis was explained at the June seminar in Cambridge. The abundance analysis is based upon the catch-per-day's fishing effort of a selected group of Boston otter trawlers classified as to efficiency. Current data are secured through the daily interviews with a representative of each vessel and the weigh-out sheets of the Boston Fish Exchange. The catch for the "Study Boats" is assigned according to the areas and subareas fished and the depth zones. Sailing date and arrival date are secured from the interview sheets and actual fishing time calculated with "lost time" as well as sailing time to and from the banks deducted. From this information, a catch-per-day for each species for each month is computed by dividing the aggregate catch in pounds for the area under consideration by the number of calculated days' fishing effort in that area.

The abundance index is based upon the aggregate catch of two boat groups. The relative efficience of the two boat groups selected was determined by an analysis of their relative catching ability. This was done to make possible the pooling of their catches so that one curve of abundance could be obtained for each area. The days fishing are, therefore, corrected according to the relative efficiency of the two boat groups before the catch-per-day is calculated. The monthly aggregate catch data for each species for a selected area and depth (or combination of areas and depth) divided by the number of corrected days fishing in that area furnishes the unit of measurement "catch-per-day."

The fundamental question which arises in the construction of an index of abundance from catch-per-day data revolves around the method of combination of the data. Statistical procedures must be chosen, which are pertinent to the biology of the fishery. The catch-per-day data for successive months are grouped in four seasons of three months each. The first quarter, Season A, includes February, March and April; Season B, May, June and July; Season C, August, September, and October; Season D, November, December and January. The present method of averaging the catch-per-day data involves the use of a base period and the calculation of a geometric mean ratio weighted by the number of days fishing effort for each season. That is, the seasonal index for each quarter is obtained by calculating the weighted geometric mean of the catch-per-day ratios for each month of the quarter to the corresponding base period. The mean ratio thus found for a given season is applied to the base catch-per-day for that season resulting in a quarterly catch-per-day index expressed in pounds. The annual index is obtained from a simple aritimetic mean of the catch-per-day index for the four seasons.

The method of averaging chosen for the groundfish abundance analysis, that of averaging ratios, follows in general pattern which is used often in the construction of index numbers of business activity and changes in price level. The method of ratios implies that the index numbers are developed on a relative basis, that is, as the ratio of the actual occurrence to the expected or "base." The ratio for each month is weighted by the number of days fishing effort during the month. Weighting was introduced because of the variation in the number of days fishing effort upon which the averages are based. The use of a base period which deviations are measured from has several advantages from the point of view of both biology and statistics. It makes possible the construction of a seasonal curve of abundance for each species, and it is from this curve that relative changes are measured. Use of a base period provides a ready means of estimating the level of abundance for a season for which data are insufficient or missing. The seasonal ratios for three seasons prior and three seasons following the quarter for which data are missing or insufficient may be averaged, and this average ratio then applied to the base for the season, resulting in a reasonable estimate of the level of abundance for the "missing season."

The geometric mean rather than arithmetic mean average of ratios was chosen originally in preference to an arithmetic average, inasmuch as the geometric mean is not in danger of distortion from the asymmetrical distribution of percentage deviations. Theoretically, there is no limit to the possible percentage of rise, while the possible percentage of fall cannot exceed 100. The cases of extraordinary advance, therefore, tend to raise the arithmetic mean of a series more than cases of extraordinary decline tend to depress it. In the calculation of the geometric mean of ratios, an increase in one of the items is exactly offset by a proportionate decrease in another item.

A review of the data already analyzed according to the above method indicates the possibility of using a more simplified procedure to yield substantially the same results with much less work. Also, because the final results may be considered no more accurate than the original data, refinements of method which are time-consuming, but which tend not to change any significant figures in the result are unnecessary. What is fundamental is that the index for each season be based upon sufficient days fishing to furnish a reliable average. Whenever data are sparse, it would seem preferable to estimate the index for that season by the method described above for filling in a missing season, rather than to calculate it from possibly erratic information. If this procedure is followed, weighting by days fishing may be eliminated without substantially changing results. An arithmetic mean may be substituted for the geometric mean in averaging ratios inasmuch as review of the data indicates no wide variability during months in the same season.

Still another suggestion involves the use of the aggregate catch for each three-month period for a given species, without reference to a base period, except for the purpose of filling in missing data. The catch-per-day for any season may be found merely by dividing the season's aggregate catch of a species by the number of days fishing for the season. This provides, in effect, a weighted arithmetic average of the three-month period. The annual index is a simple arithmetic mean of the four seasonal indices. The method of ratios would be used only when data for a season were missing or insufficient to provide a reliable average.

There is some difference of opinion concerning the use of calculated as against interview fishing time for the purposes of computing fishing effort. Calculated time, in preference to interview time, was chosen originally because it was felt that calculated time, in the long run, would be subject to less variation from the "personal equation" than interview time. Calculated time, however, is subject to variation because of weather conditions affecting running time in the different seasons and is affected by the "personal equation" to some extent also, inasmuch as "lost time" is deducted on the basis of interview data. The use of interview instead of calculated fishing time would simplify the procedure considerably. When calculated fishing time is used, it is necessary to check computations carefully because errors at this point may seriously affect the catch-per-day.

The results obtained by simplified procedures will be explored further during the next few months.

Sub-project 2--Abundance of Rosefish

Dr. Perlmutter, assisted by Miss Dee, investigated various methods of evaluating the trends of abundance of rosefish, using the Gloucester fleet for the purpose. Interview data was available since April 1942. A random sample of 33 vessels which had fished for rosefish at least six months in 1943 and 1944 respectively was studied. The total catch and days fished in each biological area (determined by various criteria which will be discussed elsewhere) by each boat were obtained, and these data were analyzed by four different methods: Method 1, Original Data-The original total catch of all boats was divided by the total number of days fished by all boats to obtain an unadjusted catch-per-day. Method 2, Cigar Ridge-Cashes Adjustment--The relative efficiency of each boat was determined from a comparison of its catch-per-day in the Cigar Ridge-Cashes biological area in July through September 1943. From this, factors were derived which when multiplied by the total catch of each vessel would bring it up to a relative efficiency of 50,000 pounds per day, thus equalizing any differences in the efficiency of the vessels comprising the sample fleet. Method 3, Mt. Desert-Matinicus Adjustment--This method was substantially the same as Method 2 except that the factors used were derived from the catch-per-day of the sample fleet in the Mt. Desert-Matinicus biological area in July through September 1943. Method 4, Cambridge Approach--The procedure as outlined by Miss Stone in the preceding sub-project was used.

All biological areas were studied by means of Methods 1 through 3 while Method 4 was applied only to the Cigar Ridge-Cashes Area and the Mt. Desert-Matinicus Area which comprise the two most important fishing grounds in the Gulf of Maine. The data for all methods have been summarized by eight-month periods, March through October. The period November through February was excluded since the catch-per-day information is subject to considerable fluctuation due to weather and is less reflective of actual abundance of fish on the grounds than during the other eight months of the year.

Summarized below are the catch-per-day for the period March through October, 1943-1946. The catch-per-day for each year is in terms of a percentage of the four-year average.

Cigar Ridge--Cashes Area

Year	Method 1 Unadjusted Data	Method 2 Cigar Ridge-Cashes Adjustment	Method 3 Mt.Desert-Mat. Adjustment	Method 4 Cambridge Appr
1943	128	125	126	120
1944	104	97	107	108
1945	84	79	81	89
1946	83	99	86	83

Mt. Desert-Matinicus Area

Year	Method 1 Unadjusted Data	Method 2 Cigar Ridge-Cashes Adjustment	Method 3 Mt.Desert-Mat. Adjustment	Method 4 Cambridge Appr.
1943	124	120	125	117
1944	94	105	101	102
1945	85	86	82	78
1946	97	89	92	103

The same general trend is shown in all four methods with the catch-per-day in 1946 below the 1943 level. The trend of the catch-per-day for the entire Gulf of Maine for the years 1942 through 1946 was also in close agreement using Methods 1, 2, and 3. These results plus information obtained in sub-project 4 of the rosefish investigation are now being incorporated in a report on trends in the abundance of rosefish.

PROJECT III. FLOUNDERS AND THE FLOUNDER FISHERY. Dr. Royce. Project Leader

Routine collections of market news data, statistics on landings, and port interviews at New Bedford for the Division of Commercial Fisheries, as well as scale samples and length-measurements of the commercial catch of yellowtail flounder, were interrupted but once during the fiscal year. This interruption was brought about due to a dispute between fishermen and local buyers. After one month of waterfront idleness, during which time the activities of the flounder investigation personnel were directed towards summarizing and compiling masses of data that had been previously collected, the dispute was settled and routine collections were once more made.

A manuscript, "The Stocks and Migrations of the Yellowtail Flounder" has been completed by Messrs. Royce and Buller, indicating that:

1. The principal yellowtail stock exists between Nantucket Shoals and Long Island and mixes very little with other stocks.
2. Lesser stocks occur in Cape Cod Bay and off Cape Cod, in the northern Gulf of Maine, on Georges Bank, and on the Nova Scotian Banks.
3. Off southern Massachusetts there is a seasonal migration to the westward in the late fall and an easterly movement in the late spring.
4. Most of the catch is taken along the 20-fathom curve from off Montauk Point to Nantucket Shoals.

To determine fishing mortality by tagging studies, abundance trends, and age composition, 2 tagging experiments were completed during the fiscal year. In July, 158 fish were tagged southeast of No Man's Land from the Fish and Wildlife Service vessel SKIMMER. In August, 228 fish were tagged at the "Corner" from a commercial dragger, the SKIMMER having been abandoned for further tagging work due to its inadequacy and badly needed repairs. It had been hoped that a

replacement, a former fishing boat, was to be secured from the Navy, but the original owners chose to buy back the vessel, thereby leaving the flounder investigation without an adequate vessel for tagging and experimental fishing operations. A preliminary analysis of the last tagging experiments conducted with the SKIMMER, at which time a live box with running sea water was used to hold the fish prior to tagging, indicated better returns and that there is possibly a tagging mortality brought about by rough handling through makeshift tubs or none at all aboard commercial draggers. All tagging operations have been suspended until a replacement for the SKIMMER has been secured, or the research vessel, ALBATROSS III is put into operation.

Routine collections of scale samples and length frequencies of the commercial catch from the main stock and from the lesser stocks, when they have been landed in New Bedford, have been made by Mr. Buller. Further work on age analysis from scale reading has been suspended pending the delivery of a new microscope. When scale reading is resumed, the age, length, sex, date, etc., of each fish will be entered on a punch card.

Dr. Royce has completed a manuscript, "The Spawning Season of the Yellowtail Flounder," indicating that spawning commences about April 1, off southern Massachusetts and is almost 100 percent completed by July 1.

Dr. Perlmutter published a paper entitled "The Distribution of the Winter Flounder, Pseudopleuronectes americanus, and its bearing on Management Possibilities," and has now in press a summary paper entitled "The Winter Flounder, Pseudopleuronectes americanus, and its Fishery."

Results obtained are as follows:

1. A decline in the abundance of blackback flounders together with the withdrawal of vessels from this fishery has resulted in a lowered catch in recent years, compared to the peak period, 1928 through 1931.

2. Data obtained from Fish and Wildlife Service hatchery catch records and fishermen's log book records show a drop in abundance from the early 1930's to the present, of 63 percent in the Boothbay Harbor region and of 31 to 40 percent in the area south of Cape Cod.

3. Information on the early life history and distribution of young blackback flounders and the size and age composition and distribution of fish subject to the commercial and sport fisheries, indicates that the young are the product of local spawning and that the sport and commercial fisheries draw on a resident stock of primarily adult fish.

4. Since young blackback flounders are the product of local spawning and the stocks of adult fish drawn upon by the sport and commercial fisheries remain highly localized, it follows that each of these resident stocks offers the same management possibilities to nearby communities as do their clam, oyster, and scallop resources.

Dr. Perlmutter partly revised a manuscript titled "Effectiveness of Hatchery Plants in Maintaining the Supply of Winter Flounder, Pseudopleuronectes americanus," which summarizes a preliminary study to evaluate artificial propagation of blackback flounders.

PROJECT IV. THE LOBSTER AND LOBSTER FISHERY, Mr. Scattergood, Project Leader.

The cause of heavy losses in some Maine lobster pounds during the fall of 1946 was discovered to be a bacterial infection, the name, Gaffkya homarii being proposed as the causative agent.

Reliable interpretation of length-frequencies has been impossible in the past because it appeared impossible to separate length-frequency data into growth classes, and experimental results gave serious discrepancies when applied to length frequencies. Using 1939-1941 data, a method of determining the growth per annual shed of lobsters within the legal-size range from length-frequency samples was devised. The method depends on known characteristics of the lobster and the lobster population such as non-migration, absence of selective fishing by size, as shown by tagging returns, and a relatively short period of shedding. Under these conditions, it is possible to assume various growth rates and compare ratios of successive growth classes from year to year. The criterion for selecting the proper growth rate is taken as the correlation coefficient between the values of successive ratios. It is found that an assumed growth of 7/16 inches per annual shed gives a correlation coefficient of .431; an assumed growth of 8/16 inches a correlation of .974; and an assumed growth of 9/16 inches, a correlation of .651. The annual growth per shed of lobsters through the legal-size range is, therefore, considered to be very close to 8/16 inches.

Analysis was restricted to the 1939-1941 data to avoid complications arising from a change in size limit in 1942 and a rapidly increasing catch from 1943 to 1946. Final calculation of correlation coefficients, however, is based on all length-frequency data from 1939 to 1946. A paper outlining the method has been submitted for criticism. If the method proves valid, it will be of tremendous value in determining such basic information as annual recruitment, annual mortality, survival to maturity, and escapement beyond the maximum legal-size.

The relationship between water temperature and days required for development to the fourth stage of larval lobsters was found to be a logarithmic straight line with the equation:

$$\text{Log } Y = 3.6605 - 1.9207 \text{ Log } X$$

where y is time in days, x is temperature in degrees Centigrade. The bearing of this relationship on costs of heating water in the rearing of lobsters is examined, and it is shown that the temperature of maximum heating cost is nw/n-1 where w is starting sea temperature and n is 1.9207. It is further shown that in the typical hatchery situation where production depends on the number of lots of larvae which can be put through the station within a limited hatching season the maximum cost of production is 2nw/2n-1 and that this maximum lies sufficiently close to w so that it is possible to exceed it with great advantage at the

beginning of the season when water temperatures are low. The nature of these relationships are such that there are no points of minimum cost.

Experiments in delaying the development of lobster eggs to facilitate uniform hatchery output were completed and showed that the hatching period can be approximately doubled by holding egg-bearing females in sunken cars to take advantage of lower bottom temperatures.

Experiments to determine factors necessary to the survival of lobsters beyond the fourth stage indicate that these factors are still undetermined.

An explanation of the increase in the Maine lobster catch during recent years is given in a paper by Mr. Herrington. The probable factors causing the increase are found to be an increase in the size of spawning stock in 1936, 1937, and 1938, which would determine the recruitment seven years later and a reduction in intraspecies competition extending from 1936 to 1939. These changes apparently were brought about by a reduction in the minimum legal size from 3-1/2 inches to 3-1/16 inches in 1935.

PROJECT V. NEW ENGLAND SALMON RESTORATION, Mr. Stringer, Project Leader

During the 1947 fiscal year, the salmon program made the most progress of any year since its inception in 1940. The pressures of other work incident to the war were removed, and more time could be devoted to the biological problems. The shortage of help, however, still reduced the amount of effective work. Mr. Edgar L. Arnold, Jr. was hired and reported for duty on November 12, 1946. This was too late for field work during the 1946 season.

However, despite the advances that were made, the severe cut in appropriations made by the Congress during the spring of 1947 caused the complete closing of the project for an indefinite period. This is unfortunate in several respects, the foremost of which is the large plants of marked fish which were expected to return in 1947. More fish were planted which are due to return in 1947 than of all previous stocking. Much of the data which should be obtained from any returns must now be abandoned. A second point which makes the termination of the program unfortunate is the discovery of a small stream bordering on the Moosehorn Wildlife Refuge which appears ideal for experiments on salmon. A third feature is the increased efficiency of the hatchery in rearing salmon. Many new techniques have been introduced, and studies of diet and disease have been inaugurated.

Stream surveys of the St. George, Pemaquid, and Ducktrap rivers were carried on in 1946. These surveys, although complete in themselves, were only preliminary in purpose. At its present stage of development, the program does not need the more extensive stream surveys. The information collected was concerned mainly with the stocking experiments or problems related to them. Temperature, stream flow, spawning and nursery areas, dams, and fishways were the main features considered.

The most important problems of the salmon program during 1946 were the population evaluations necessary for accurate information on mortality of young fish in the stream, the escapement of smolts to the sea, and the number of mature salmon which return to the river. These data would determine the stream conditions which were limiting restoration. Evaluation of these data made necessary the installation of fish-tight barriers at selected points in the stream. Construction of these barriers is difficult. They must be fish-tight, easily cleaned, strong enough to withstand high water, easily installed, and relatively cheap. Preliminary work with screens of hardware cloth and examination of reports of this type of screen, as well as the rotary screens and bar racks used elsewhere, showed them to be unsatisfactory for our purpose. Preliminary ideas and drawings were made and from these a small scale model was constructed of a new type of bar rack. Tests with the model proved the idea feasible, and a full-size fence was constructed in early 1946. The fence consists of flexible sections linked together through supporting posts and held in place by wire rope fastened to anchors on the stream bank. The sections consist of three redwood beams, one close to the stream bottom, one about 4-1/2 feet above this, and the third midway between the other two. To the forward edge of these beams are fastened brass rack plates or spacers, similar to the teeth of a comb. Into the slots formed by these teeth and at right angles to the beam are placed bars of 1/8 x 1-inch steel. The spacing between the bars is 1/4 inch. These bars form the rack or screen. The bars slide freely in the slots and can be driven into the bottom so that no base or bed log is necessary.

The full-size fence was tested in the Pemaquid River from August to November 1946 and proved very satisfactory. Leaves and debris were allowed to accumulate on the fence during the latter part of the period until there was a 23-inch difference in water levels above and below. With this difference, no leaks or undercutting appeared and no blowing under took place. After fabrication of the parts, the fence was installed in two days by four men and removed in one day. The 35 feet of fence constructed cost approximately $800.

A paper giving more detailed construction notes, diagrams, and pictures has been submitted to the Central Office for publication.

The fence was installed in May 1947 on Little Falls Stream which borders the Moosehorn Wildlife Refuge. This stream was also planted with Atlantic salmon in May. Little or no follow-up of this project will be possible, however, because of the termination of the program.

Information concerning the life history of the Atlantic salmon was collected whenever possible during the year. Twenty adult salmon were tagged last fall after the fish had been stripped for spawning. They were released in the Machias River from which they were taken. This tagging was to trace time of second spawning and homing instinct.

All samples of fish taken from the marked planting were measured and weighed during December. The arithmetic mean length in millimeters for the various ages is as follows: 1/2-year old - 38.6; 1-year old - 61.7; 1-1/2 years old - 79.5; 2 years old - 103.1; and 2-1/2 years old - 153.0.

Improvement in growth and condition of fish held in the hatchery over the winter was obtained. The addition of more meat, principally liver, to the diet seemed to relieve the critical anemic condition. The introduction of sorting and prophylactic measures to the hatchery methods also contributed to the improved condition of fish. This is the first winter in which gain in weight has been obtained. Experiments are being designed and set up under the direction of Dr. Arthur Phillips to study further the diet requirements.

The marking by fin clipping of fish to be planted to test the best age, size, time of year, and locality in the stream was continued. Approximately 25,000 Atlantic salmon were planted in the Penobscot River during 1946. The Pemaquid and Ducktrap Rivers received plants of 19,766 and 16,133 silver salmon respectively. These plantings bring the total number of fish planted by the Investigation to 584,296; of which, 387,236 were Atlantics and 197,060 silvers.

Although returns were expected in approximately 66,000 Atlantics and 96,000 silvers in 1944, 1945, and 1946, none appeared. Because of this lack of returns, it was decided to change the objectives of the program somewhat. A small stream was picked and plans were made to stock this with sea-run salmon. Stream improvements and predator control would be started to make the stream as suitable as possible. Counting fences would be installed to count down-stream migrants and returning adults. These operations would be directed toward the establishment of a run of salmon. However, the decision to drop the program came before this was started.

Approximately 181,000 Atlantic salmon were planted in May and June 1947 as follows: - Penobscot River - 90,500; Machias River - 45,250; and Little Falls Stream - 45,250.

Four silver salmon grilse were caught by smelt fishermen in Pemaquid Harbor in November 1946. These fish weighed about 2 pounds and were probably from the plants made the previous spring. Four marked Atlantic salmon have been caught this spring. Three fish with both ventrals removed have been taken on the Penobscot, and one fish with the adipose and right ventral missing caught on the St. George. These fish were from the 1942 brood year and were planted in May 1944.

Tests of two types of Denil fishways were carried out during 1946. These were to find an internal design which would be better suited to conditions in New England. The tests were run on models in a small stream. Hydraulic data were collected and small trout were used to test suitability. The Denil type, from experiments conducted at the University of Iowa and from our own tests, seemed the best for the low water conditions in New England. Experiments with full-scale models using adult salmon were planned for 1947 but have been dropped.

A manuscript summarizing the work of the program since its foundation is being prepared. A news release on the return of marked salmon has been forwarded to the Central office.

PROJECT VI. THE ROSEFISH AND ROSEFISH FISHERY, Mr. Perlmutter, Project Leader

A detailed history of the fishery is necessary to understand many of the changes in the catch and abundance of rosefish on the various grounds. From the inception of the fishery at Boston in 1935 through its shift to Gloucester about 1938 and to the present, changes have occurred in the nets, engines, and fleet composition as well as in the fishing grounds. Information on these various aspects of the history of the fishery has been obtained for the past and is being recorded currently.

Based on information on past and present total catch by biological areas and abundance studies, an article titled "The Future of the Redfish Fishery," was prepared for the Gloucester Master Mariners' Association Year Book for 1947. In the period 1942 through 1944, 10 percent of the rosefish landed at Gloucester was taken on Nova Scotian Banks. By 1945, 32 percent came from there. In 1946, 54 percent of the fish was from Nova Scotian Banks. Decreased abundance of rosefish in the adjacent Gulf of Maine waters and failure to discover new grounds within that region are the principal reasons for the sharp rise in the catch of rosefish in Nova Scotian waters. Gloucester redfish landings will continue as large as in the past several years only if new, highly productive grounds are discovered and fished.

A revised and expanded manuscript titled "Biology of the Rosefish (Sebastes marinus): Age and Growth of Immature Fish in the Gulf of Maine and off Western Nova Scotia," prepared by Perlmutter and Clarke, is near completion. A brief abstract of the paper is as follows:

1. Examination of opercular bones, otoliths, and scales indicated that scales would be the best material to study in determining the age of rosefish.

2. By a comparative study of scales from different body areas, it was determined that scale samples should be taken from beneath the pectoral fin in a region defined as the "pectoral patch."

3. The annulus was defined and the time of annulus formation determined by a study of the scale margins throughout a year's growth.

4. Independent readings of a random sample of the scales by the two investigators showed 84 percent agreement. The remaining 16 percent disagreement was in the order of one annulus.

5. Fragmentary data on the size of fish before scale formation indicates the possibility that the scale does not form until the spring of the year following the birth of the fish. Since it has been determined in our studies that young rosefish are liberated in the Gulf of Maine from mid-May through early September, the first annulus of the scale represents more than the first year's growth.

6. Annuli could be readily distinguished in fish less than approximately 235 mm. but were more difficult in the larger fish. Size-at-maturity studies carried on in 1943 and 1944 in the Gulf of Maine showed that 92 percent of the males and 99 percent of the females less than 235 millimeters in fork length were immature, and in the western Nova Scotian Area, 88 percent of the males and 98 percent of the females under 235 millimeters were immature. Consequently, because of time limitations, the preliminary study of the age and growth of rosefish was limited to fish in this size range which constitutes primarily immature fish.

7. Age and growth of the rosefish in the Gulf of Maine was calculated using both a modified Lee Method developed at the Cambridge laboratory and the Hile Method, which were found to give identical results.

8. No great difference could be found in the calculated lengths at each annulus between different biological areas within the Gulf of Maine or for data collected at different times of the year.

9. The calculated length at each annulus in the Gulf of Maine and the Western Nova Scotian Area is as follows:

Gulf of Maine				Western Nova Scotian Area			
Annulus	Fork Length	Standard Deviation	Number of Fish	Annulus	Fork Length	Standard Deviation	Number of Fish
1	52	7.92	308	1	47	8.20	104
2	76	10.53	297	2	69	10.40	104
3	99	14.62	251	3	92	12.90	103
4	121	17.37	203	4	112	14.10	95
5	139	16.89	139	5	132	15.50	92
6	154	16.72	90	6	150	17.30	82
7	169	19.47	38	7	167	19.50	74
8	189	16.51	12	8	181	18.60	62
9	218	.....	3	9	193	17.00	42
.	...	.....	...	10	208	15.00	12
.	...	.....	...	11	225	.....	1

10. The calculated growth to each annulus and between annuli for the Gulf of Maine and the Western Nova Scotian Area is as follows:

Gulf of Maine					
Annulus	Aver. growth in mm. to each annulus	Growth period	Average growth in mm.	Standard Deviation	Number of fish
		Birth to			
1	52	1	52	7.92	308
2	76	1-2	23	8.91	297
3	100	2-3	24	8.79	251
4	122	3-4	22	7.24	203
5	141	4-5	19	6.01	139
6	160	5-6	19	6.01	90
7	176	6-7	16	4.42	38
8	192	7-8	16	6.78	12
9	209	8-9	16	....	3
10	...	...	..	....	..
11	...	...	..	....	..

Western Nova Scotian Area

Annulus	Aver. growth in mm. to each annulus	Growth period	Average growth in mm.	Standard Deviation	Number of fish
		Birth to			
1	47	1	47	8.50	104
2	69	1-2	22	7.06	104
3	92	2-3	23	6.80	103
4	113	3-4	21	5.62	95
5	134	4-5	20	5.33	92
6	153	5-6	19	5.75	82
7	170	6-7	17	5.15	74
8	187	7-8	17	5.05	62
9	203	8-9	17	4.69	42
10	220	9-10	16	4.72	12
11	242	10-11	22	....	1

11. Compared to other Atlantic species of great commercial importance such as haddock, cod, and mackerel, the rosefish is extremely slow growing. Similar results have been obtained by Russian fisheries' workers at Murmansk investigating the species in the Barents Sea. Preliminary unpublished data collected by Templeman on rosefish in Newfoundland waters also are in agreement with our findings. The implications of these findings are being studied in relationship to results obtained from other phases of the general rosefish investigation.

The same random fleet of vessels which was used in the abundance analysis reported under Project II was also used to determine fishing concentrations both in the Gulf of Maine and off Nova Scotian Banks. Based on interviewed fishing effort for the years 1942 through 1946, six virtually distinct fishing concentrations were located within the Gulf of Maine as follows: in the Mt. Desert-Matinicus Area to the north; in the Monhegan-Jeffreys-Platts Area to the west; the East of Gloucester-Highlands Area in the southwest; the Cigar Ridge-Cashes Area in the center of the Gulf; the Grand Manan Area from Mr. Desert eastward to the tip of Nova Scotia.

The distinctive differences in the size composition and the percentage parasite infection (with the copepod Sphyrion lumpi) of the fish contained in each fishing concentration area would indicate little interchange of fish between these areas. Information on this aspect of the problem has been summarized and a report is now being prepared by Dr. Perlmutter.

It has been stated above that the size composition of the stocks in the various biological areas over the period 1942-1946 indicates little interchange of fish among areas. The size composition has also been useful in explaining what is happening to the rosefish population.

Independent tabulations of male and female length frequencies by four-month periods (March-June, July-October, November-February) for each year from 1942 through 1946 for each biological area show a progressive decrease in the number of males over 250 mm. in length and females over 280 mm. in length and a corresponding increase in the number of fish under these sizes. "Size-at-maturity" studies carried on in 1943 and 1944 show that these smaller fish are mostly immatures and the larger ones matures. Considering the length frequencies alone, one of two things has happened to the rosefish population in the Gulf of Maine. Either there has been a reduction in the total number of mature fish or the number of mature fish has remained the same and progressively larger numbers of immature fish have entered the fishery in the past few years.

To determine which of these two hypotheses applies, by means of length-weight data which was collected during 1943, the catch-per-day information obtained in Project II was broken down into two categories; namely, the catch-per-day of primarily immature fish, males less than 250 millimeters in length and females less than 280 millimeters in length, and primarily mature fish, males and females larger than these sizes. This was done independently for each biological area by four-month periods and then combined by the eight-month interval March-October from 1942 through 1946, using: Method 1, Unadjusted Data; Method 2, Cigar-Ridge-Cashes Adjustment; Method 3, Mt. Desert-Matinicus Adjustment.

The results obtained for the Gulf of Maine as a whole shown in the table below are summarized by the following method. The average catch-per-day for the five-year period 1942 through 1946 was obtained separately for the immature and mature fish. Then the catch-per-day value for each of these size categories for the individual years was calculated as a percentage of the five-year average. This was done so that results obtained by the use of Methods 1, 2, and 3 could be directly compared.

Gulf of Maine

	Immatures			Matures		
	METHOD			METHOD		
	1	2	3	1	2	3
Year	No. adj.	Cigar Ridge-Cashes Adj.	Mt. Des. Mat. Adjustment	No. adj.	Cigar Ridge-Cashes Adj.	Mt. Des. Mat. Adjustment
1942	88	85	89	122	121	123
1943	108	104	106	120	119	119
1944	101	96	103	98	95	99
1945	94	93	91	85	82	81
1946	108	120	111	75	82	78

All three methods gave very similar results. It is evident that the catch-per-day of the immature fish has been more or less the same over the five-year period 1942 through 1946, fluctuating up and down at random. However, the catch-per-day of the mature fish has been declining steadily. Since the age and growth studies show an extremely slow rate of growth in the rosefish, the decline in the catch-per-day of the mature fish can be attributed to their removal by the fishery at a faster rate than they can be replaced by the growth of the small fish. These findings are being summarized in greater detail in a report now being prepared by Dr. Perlmutter.

PROJECT VII. SPECIAL INVESTIGATIONS RELATED TO WAR WORK.

Dr. Royce completed a manuscript on this subject in January 1947 and forwarded it to Washington. A brief summary is as follows:

Data on the total sales of fish from vessels to the primary wholesalers in Boston, Gloucester, and New Bedford, were available covering a period before and after the establishment of price ceilings. The price ceilings allowed an abnormally high margin for the primary wholesaler. Firms controlling vessels generally increased their volume of business, and many new dealer-vessel owner combinations were formed. Despite large reductions in the volume of fish handled by some firms, no firms went out of business. Black markets caused the greatest changes in the distribution of whiting and sea scallops. It was concluded that because of the diversity of business practices within the industry, it was impossible to impose price ceilings without causing changes in the distribution.

PROJECT VIII. THE ALBATROSS III. Dr. Royce, Project Leader

Reconversion for fishery research of the ALBATROSS III is now underway. It will involve changing the entire superstructure of the ship and rearranging the space on the lower decks midships for scientists' quarters and a fish hold. The engine room will be left almost intact. Dr. Royce reports the following:

"Basic lines of the ALBATROSS III will be very similar to those of the large Boston otter trawlers. She will have a high head with a Maierform bow. Laboratory and officers' staterooms will be located on the main deck aft. The main deck midships will be left clear for the handling of fishing gear. Length over-all will be about 179 feet. Gross tonnage will be about 400.

"A crew of 21 plus 6 scientists will be the regular operating complement. Extra quarters will be available so that the ship can carry a total personnel of 33.

"The research program for the ship has not yet been outlined in detail. The present knowledge of the New England fisheries has been reviewed at length and the most urgent problems have been stated. Rating immediate consideration is the need for more knowledge of the selectivity of nets and the proper construction of an otter trawl of larger mesh for the protection of small fish. A second urgent requirement is the need for information of the effect of otter trawling on the bottom. It is planned to study this with submarine photographic equipment.

"Numerous lesser problems such as tagging for the study of the migration of haddock as well as the collection of the young stages of yellowtail flounder and lobster are being considered. These and several others are small but important links in the chain of information which has been assembled ashore.

"The availability of a research vessel such as the ALBATROSS III which is equipped for efficient handling of otter trawl nets presents an unequalled opportunity to attack fishery research on a new basis. It presents the opportunity for the development of a sampling technique which will permit the direct estimation of the actual numbers of many kinds of fish of all catchable sizes on the bank. It will permit, at the same time, the measurement of several hydrographic features which are thought to influence fish populations. Heretofore, this complete program has been impossible. The problem has been attacked in roundabout ways such as by estimating the abundance of fish and by tagging. Development of a standard sampling technique with an otter trawl net and the use of such a technique throughout the range of a fish population could answer many of the urgent problems in determining the effect of fishing on the haddock, redfish, and other fish populations.

The operation of the ALBATROSS III at first would be confined mostly to the New England banks which include Georges Bank, Gulf of Maine, and the vicinity of Nantucket Shoals. It is from these banks that New England catches a major part of its fish and in turn supplies the country with the major part of its fresh and frozen fillets. Our fleet fishes the Nova Scotian Banks too, but these fish populations are fished by the people of several other nations. Research and conservation here must be a cooperative enterprise among nations."

MIDDLE ATLANTIC FISHERY INVESTIGATIONS.

PROJECT I. SHAD INVESTIGATIONS, Louella E. Cable, Project Leader.

Sub-project 1--Trends of abundance

Connecticut River: The catch of shad in the Connecticut River has continued to increase the past three years in contrast to a serious drop that has occurred in the catch of the nearby Hudson River. In the Connecticut, the catch in 1946 of 1,084,000 pounds is approximately 30 percent greater than the last previous peak catches of 1903 and 1904, and 15 times the catches of 1931 and 1932. The larger catches, since 1931, do not represent overfishing but an actual increase in the population. The study of some 7,000 scale samples shows that the percentage of old fish in the population has continued to rise during the same period.

Hudson River: In the Hudson River the increase in production of the shad fishery has been halted, at least temporarily. The spectacular comeback staged by the fishery in recent years came after 30 years during which the fishery remained at near-depletion levels. The catch suddenly rose from 438,000 pounds in 1934 to 5,000,000 pounds in 1944. But now, we find those gains dwindling much as similar gains were lost nearly 50 years ago. Each time the decline has been much more rapid than the building-up process. In 1945, 4 million pounds were taken from the Hudson population, in 1946, only 3 million pounds could be obtained and some increases in gear had been made. This year the catch dropped again, barely totalling 2 million pounds. The study of several thousand scale samples shows there have been two recent years in which there was a partial failure in reproduction. In 1943, the increment of young shad making their first spawning migration (virgins) was less than one half normal size, and again, in 1946, the increment of virgins was extremely low. The accumulated effect of two small year classes has materially reduced the size of the Hudson River population. A large collection of scale samples was made this spring by the New York Conservation Department. These scales will be studied to learn whether the 1947 slump in the catch was due to still more reduction in the size of the population by a third small increment of virgins.

The price of shad held up well through the peak of the run this year, bringing an average of 15 cents per pound to the fishermen.

Chesapeake Bay: As determined from the study of 4,000 to 5,000 scale samples collected each year the percentage of old shad, in the populations of some Maryland rivers, has risen from less than 10 percent of the runs in 1940-1942 to approximately 30 percent in 1946. In these rivers reproduction has been good and the fishing rate somewhat reduced by license reduction. In other rivers, where the fishing effort has not been reduced but maintained at the level established before the Management Plan became effective, the populations appear to be holding their own.

According to catch records collected by the State of Maryland as reported daily, weekly or monthly by the fishermen as part of their obligations as license holders, the 1947 catch of shad was one million pounds larger than that taken in 1946.

In Virginia, there are, at present, no restrictions on the catching of shad other than those of the U. S. Engineer Corps requiring that prescribed channels be left clear of nets and regulations regarding the spacing of nets. The older fish, there, make up 20 percent (1947) of the run in the James, 15 percent (1947) in the Rappahannock, 20 percent (1943) in the Mattaponi and York Rivers, 12 percent (1946) in the Pamunkey and 12 percent (1943) in the Chickahominy.

This spring, the Virginia Fisheries Commission requested a Survey of the shad fisheries of the State to determine the value of prohibiting fishing on the spawning grounds. (A partial report of this work is contained under Sub-project 2). The State provided a boat on the Rappahannock River for a survey of the spawning grounds there. Several years ago a similar survey was made on the Pamunkey River. As the spawning grounds of that river extend into the Pamunkey Indian Reservation and those of the Mattaponi are in a similar reservation, it would be difficult, if not impossible, to close those areas. Such action would be opposed to treaty rights of the Indians. Since the Mattaponi and the Pamunkey rivers are tributaries to the York River and provide the spawning grounds for the shad that pass up the York, it is apparent that nothing can be done for these populations by the method proposed.

The survey shows, further that little would be accomplished from the closure of the spawning grounds without additional protections.

Sub-project 2--Migrations and mortality of shad

Tagging experiments conducted during this fiscal year have been limited to the marking of juvenile shad pond-reared at the Harrison Lake Hatchery and released in the James River, Virginia in December 1946 and an experiment conducted in cooperation with the Bureau of Marine Fisheries, New York Department of Conservation in the marking of down-run adult shad in the Atlantic Ocean off Fire Island, New York during June of 1946.

The feasibility of marking juvenile shad was demonstrated in 1941 with subsequent recaptures from this experiment in 1944, 1945, and 1946. It was found that for the marked fish to survive the tagging operation, they must be held in a physiological saline solution until their wounds healed. Tests conducted during the tagging of juvenile shad in this fiscal year indicated the further importance of accurately controlling the pH of the holding medium. When the pH of the medium was adjusted to 7.4, survival was materially improved.

One of the difficulties encountered in rearing juvenile shad to a size large enough to tag, has been the accidental inclusion of predator and competitor species of fish in the rearing ponds. The undesirable fish probably have gained access to the ponds in the egg or larval stages by passing through the screens on the inlet pipes and by being trapped in the hatching jars where the shad eggs are hatched. This year new procedures for rearing the shad were innovated. Ponds were filled with water which had been screened as usual, and then the ponds were chlorinated heavily using calcium hypochlorite. Following the dissipation of the chlorine, the ponds were fertilized and innoculated with daphnia. Newly fertilized shad eggs were then placed in wire bottom floats suspended in the ponds. After the eggs were hatched, the floats were tipped to allow the fry to escape. Survival of the shad so far has been good. These shad should attain a length of about 3 inches by October at which time they will be marked with internal tags to determine ocean mortality, time of ocean stay and maturity. The return of scale samples with the report of recaptured tagged shad will aid materially in the interpretation of scale markings not now fully understood. These scale samples from shad of known age will help in determining which of many indistinct scale markings, on scales collected from the catch for spawning mark analyses, indicate year marks. Ponds where the juvenile shad are being reared are located at the Harrison Lake Hatchery near Charles City, Virginia and at Fairlee, Maryland. At Fairlee the work is a cooperative project with the Maryland Department of Research and Education.

Early fisheries for shad were limited to estuarine waters but with the increased demand for shad and the development of improved boats and gear, the fishery for shad has extended to the ocean. This extension has not only prolonged the season when shad may be taken, but has contributed to the overfishing to which most stocks of shad are subject on the Atlantic Coast. The extent to which these ocean fisheries draw on individual spawning streams is not known, nor is it known which ocean fisheries draw on which spawning streams.

As a basis for any management program administered by the States for building up and maintaining a high level of productivity, the total catch for each stream's stock must be known. Because all tagging data and morphometric studies indicate that shad on the Atlantic Coast return to their parent stream on reaching maturity, that part of the catch taken within the river may be determined from catch record material. However, until shad caught in ocean fisheries are traced by tagging, to their streams of origin, there is no way to determine on which stocks these ocean fisheries are drawing and the extent of their withdrawal. The biggest impediment to tracing these shad to their stream of origin has been the lack of a suitable tag-one which will be retained for at least one year. During this fiscal year the cheek tag developed by L. E. Cable has been tested on trout held in tanks and gives every indication of having a long retention. Plans

are now underway to mark ocean caught shad this fall using this cheek tag to trace the streams of origin for ocean caught shad off the coast of Maine. This experiment should also give information on rate of travel and the migratory behavior of the shad prior to entering their spawning stream. Previous experiments have not given this information as the shad have not been tagged until they enter estuarine waters.

The final quarter of this fiscal year has been largely devoted to a survey of the shad fisheries of Virginia, which was requested by the Virginia Commission of Fisheries. All river fishermen of the State, numbering nearly 1500 were circularized asking for information on catch in the last two years, their method of fishing, and the number and location of their nets. A large number of fishermen were interviewed personally. Salinities were determined for a number of stations in the spawning streams.

The data obtained from this survey have not been summarized as yet. The survey does show that the following conditions exist in the fishery for shad in Virginia waters:

1. A very large number of fishermen participate in the fishery.
2. Very few of these fishermen keep any accurate record of their catch.
3. The fisheries in the rivers vary widely in their catch from season to season, and from time to time during the season. In some sections of the river, shad are not available to existing fisheries because of the configuration of the river bed.
4. Dams and pollution are menacing the perpetuation of shad stocks.

Sub-project 3--Interdependence of stocks of shad along the Atlantic Coast.

Considerable time was spent during the year in the application of the discriminant function to racial data in preparation for a report on that phase of the shad studies.

Sub-project 4--Effects of Pollution on Shad

Study of the shad population of the Delaware River was given special emphasis in the program of this fiscal year. This fishery, which produced from 15 to 20 million pounds annually at the turn of the century, by 1946 was reduced to 69,000 pounds. The 1947 figures are not in yet, but from reports of individual fishermen, it seems probable that the total catch will be even lower than in 1946.

Pollution was found to be the major factor causing the decline and preventing recovery of the fishery in the Delaware, also a limiting factor in the production of some other rivers. In the Delaware, abatement of pollution is a prerequisite for restoration of the fishery. Public opinion is demanding abatement of pollution on many grounds and it seems rather certain that some progress will be made within the next few years. To what extent abatement must be carried for the benefit of shad is not yet known.

In Washington last September at a meeting of the Technical Planning and Coordination Committee of the Division, attended by members of the Water Quality Section, the Middle Atlantic Section and the Oyster Investigation, a program for the study of pollution as it affects the shad fishery in the Delaware River was discussed. The program later was stated in definite terms at a meeting in Burlington, N. J., attended by Dr. George Rounsefell, representing the Chief of the Division, by Mr. Wm. C. Neville, Middle Atlantic Section Chief, by Miss Louella E. Cable, In Charge Shad Investigations, and by Dr. R. A. Westfall, In Charge, Water Quality Section and three of his assistants. It was agreed that not only should information be obtained on the extent and type of pollution in the Delaware, but especially experiments should be made to learn the ranges of tolerance of shad, or other experimental fish, to different amounts of specific pollutants in order to determine the standards of water quality required by shad and whether the standards proposed by Incodel are sufficient.

Because of the pollution in the Delaware the only portion of the shad spawning grounds in that river, where shad may spawn successfully, is a stretch above Milford, Pennsylvania, which begins approximately 130 miles above Philadelphia. Although in 1944 and 1945 shad eggs were taken in the plankton at several apparently suitable locations between Philadelphia and Equinunk, all but one of the eggs taken below Milford were dead eggs. After making a survey of the pollution in the Delaware, the Water Quality Section expressed the opinion (Water Quality studies of the Delaware River with reference to Shad Migration, by Ellis, M. M., R. A. Westfall, D. K. Meyer and W. S. Platner) that "The major disturbing characteristic" was low dissolved oxygen, during the period of the spring migration of adult shad to the spawning grounds and of the fall migration of young shad from the nursery grounds to the sea. The area of gross pollution was found in the 40 miles from Pennsville to Trenton. In this area the dissolved oxygen content of the water is often less than 2 p.p.m. Experiments of the Water Quality Section involving studies of the effect of water of low oxygen content on young shad showed that they commence to die in waters containing 5 p.p.m. Catch records and the plankton samples show that some shad pass through the polluted Pennsville-Trenton area in spite of the low oxygen content of the water. This spring the up-river fishermen had the best season in several years. The fish were probably aided by flood waters improving the general condition of the water.

Pollution abatement, if confined to the Pennsville-Trenton area, will permit more adult shad to pass up the river but will not open up the extensive potential spawning grounds from Philadelphia to Milford. Reports have been received that such hardy fish as carp are killed, at times by pollution in this stretch of the river.

The dissolved oxygen content of the water here was tested by the Water Quality Section and was found to be well within the limits of tolerance of shad. The tolerance of shad eggs, larvae and adults for chemical constituents of the water will require further study to determine the cause of these up-river deaths of shad in all stages of development from the egg to the adult, and even of more hardy fishes.

Before the shad fishery in the Delaware River may be restored, it will be necessary to render usable again their spawning grounds in their entirety. In addition to pollution, there is another grave threat to the achievement of this goal. It looms in the form of a proposed 115 foot dam at Wallpack Bend. The changes in the river that would result from the erection of the dam would destroy both the present and potential spawning areas so completely that restoration of the fishery would be impossible.

Restoration of the shad fishery of the Delaware would add millions of pounds of fine fishery products to the national diet and from two to three million dollars to the annual income of the Delaware River fishermen from a 60 to 75 million dollar industry.

Reports in preparation

Louella E. Cable has been working on analysis of data for a report on the shad population of the Hudson River as observed since 1880. Also in preparation are, a report on the method of scale analysis for determining age composition of the fishery and total mortality rates, and a paper on the "Races of Shad occurring on the Atlantic Coast of the United States."

Edgar H. Hollis has a manuscript on the "Migrations of Shad in Chesapeake Bay as Determined from Returns of Tags." He also has spent some time tabulating and analyzing the data from tagging experiments in the Hudson River and along the New Jersey Coast.

A third manuscript in preparation concerns the results of an experiment in which juvenile shad were tagged for the first time.

GREAT LAKES FISHERY INVESTIGATIONS, John Van Oosten, Chief of Section

GENERAL

The two matters of paramount interest to the Great Lakes Section during the fiscal year 1947 were the treaty with Canada for the establishment of international control of the Great Lakes fisheries and the program for the control of the sea lamprey in the upper Great Lakes. Unfortunately, completely satisfactory progress cannot be reported in either.

Since April 22, 1946, when President Truman forwarded the "Convention between the United States of America and Canada for the Development, Protection, and Conservation of the Fisheries of the Great Lakes to the Senate for advice and consent on ratification, no further action has taken place. The treaty is, however, on the agenda of the Senate Foreign Relations Committee, and the opening of hearings is anticipated soon. In the meantime members of the Great Lakes staff have devoted considerable time to the preparation of materials that will be needed when the hearings are held.

Lack of funds has prevented all but small-scale participation in the sea lamprey program, a cooperative project of this Service, the Great Lakes States, and the Province of Ontario. Money for this work was authorized when the President signed H. J. Res. 566 on August 8, 1946, but no appropriation was made for the past fiscal year. Detailed plans of operation have been drawn up, however, so that activities can be started with a minimum of delay once funds do become available.

During the past year the Great Lakes staff made substantial progress in the completion of reports on various projects some of which were initiated not a few years ago. At the present time three papers are in proof, three are completed and in the hands of the editor, and one, nearly complete, has been accepted for publication. Work has been resumed on other projects that were largely suspended during the war; reports on some of these should be completed during the coming fiscal year.

The few continuing projects that it is possible to carry with the limited staff and facilities of the Great Lakes have been maintained with a minimum of interruption. Among these projects are: cooperative lake trout investigations (with the States of Minnesota, Wisconsin, Illinois, Indiana, and Michigan, and the Province of Ontario); the annual sampling of the principal commercial species of Lake Erie to determine size, age, and year-class composition; the collection of scales for the study of fluctuations of age and growth in the yellow perch and lake herring of Saginaw Bay; the accumulation of data on the age and growth of the smelt in various Great Lakes waters; the compilation of the pounds and value of the commercial production in the United States waters of the Great Lakes (project in cooperation with the Division of Commercial Fisheries); analysis of local fluctuations in production, fishing intensity, and the availability of fish in the State of Michigan waters of the Great Lakes.

Two fishery fellows have been assigned to the Great Lakes laboratories for training: Mr. Wagner Terrazas of Bolivia arrived in Ann Arbor on January 16, 1947, and Mr. Mario Barreda of Peru on June 9, 1947.

As in previous years the work of our Great Lakes section has been characterized by active cooperation with other Federal and State agencies, educational institutions, conservation groups, and other organizations.

The University of Michigan continues to provide the Great Lakes section with office and laboratory space and storage facilities for a car and for equipment. This considerate treatment is all the more to be appreciated at the present time when the University's facilities are so badly overtaxed.

Review of Reports in Press or Accepted for Publication

"Mortality of Smelt (Osmerus mordax, Mitchill) in Lakes Huron and Michigan, during the fall and winter of 1942-1943," by John Van Oosten, in proof, to appear in Transactions of the American Fisheries Society, Volume 74. A careful analysis of circumstances relating to and a detailed consideration of all possible causes of the phenomenal mortality which destroyed all but a few stragglers in the vast smelt populations of Lakes Huron and Michigan led to the conclusion that death was the result of disease(bacteria or virus). Although direct evidence of disease is lacking, all other causes can be ruled out as inconsistent with the facts--the manner in which the mortality spread, the death of smelt under a wide variety of conditions, the failure of the mortality to reach inland lakes to which passage of fish from the Great Lakes was blocked, and so on.

The smelt mortality dealt a severe blow to the nation's wartime food-production program. The total loss of yield from 1943 through 1946 was estimated as about 50 million pounds.

Some recovery from the mortality was observed as early as 1945. It was estimated that barring recurrence of the epidemic complete or nearly complete recovery might be possible by 1948 or 1949.

In Green Bay the mortality was followed by a significant increase in the growth rate of smelt.

"Distribution, abundance, and spawning season and grounds of the kiyi, Leucichthys kiyi Koelz, in Lake Michigan," by Ralph Hile and Hilary J. Deason, is now in proof and will appear in Transactions of the American Fisheries Society, Volume 74. From May through November Lake Michigan kiyis characteristically inhabit depths of 40 to 50 fathoms or greater. There is evidence that the occasional penetration of relatively large numbers of kiyis into shallower water is the result of exceptional hydrographic conditions involving the disturbance of considerable masses of water. Temperatures (in the neighborhood of 4 degrees C.) cannot explain the concentration of kiyis in deep water as readings only a fraction of a degree higher extended up to depths of less than 30 fathoms. Possibly the distribution of food organisms or a preference for greater pressure, darkness and quiet water may account for the kiyi's distribution.

The abundance of the kiyi, except as related to depth of water, was more or less uniform throughout the great central basins of Lake Michigan. They were scarce, however, in the northeastern island region where the currents of a hydrographically complex area may create unsuitable conditions.

In a chart showing the geographical distribution of the kiyi in Lake Michigan, 89 new locality records were added to the 22 previously reported.

Spawning begins in late September and continues through at least the first week or two of November. The peak of activities is in the latter half of October. Spawning grounds are widespread and at the same depths occupied by kiyis during the summer.

"Age and growth of the kiyi, Leucichthys kiyi Koelz, in Lake Michigan," by Hilary J. Deason and Ralph Hile is in proof and will appear in Transactions of the American Fisheries Society, Volume 74. With the exception of the bloater (L. hoyi) the kiyi is the smallest and most slowly-growing of the chubs. Females do not attain a total length of 10 inches until the fifth year of life or males until the sixth. Aside from the somewhat slower growth in weight of the Fox Islands kiyis (which are relatively light for their length), no regional differences of growth rate could be demonstrated. The season's growth probably begins some time in May and most or all of the growth is completed by the end of August. Younger Lake Michigan kiyis averaged smaller and older kiyis larger than Lake Ontario fish of corresponding age.

Age-group IV dominated the 1931 samples from southern Lake Michigan and age-group V the 1932 collections from northern Lake Michigan. A trend was noticeable toward an increase in average age from south to north.

Measurements of thousands of kiyis revealed that chub gillnets were much more selective with respect to numbers of fish than with respect to size. To give one example, in 1930-1931 the 2-3/4-inch mesh nets took kiyis that were only 0.1 inch longer than those in 2-1/2-inch meshes but captured less than one-fourth as many. On the other hand, the size distribution of fish on the grounds must affect considerably the size of fish taken, for gill nets fished in northern Lake Michigan in 1932 captured kiyis that averaged 0.2 to 0.4 inch longer than those taken in the same meshes in southern Lake Michigan in 1930-1931.

In both the central basins of Lake Michigan and in the northeastern island region (where kiyis were light for their length) the weight increased to a power slightly greater than the cube of the length. Condition ($\overline{K}$) increased during the summer to a peak in August and early September and then declined up to the time of most active spawning (October and early November). Spawning itself was accompanied by an additional loss of about 12 percent of the body weight of females and of somewhat less than 2 percent of the weight of males.

Females were strongly predominant in all collections but were relatively more plentiful in the summer (90 percent) than during the spawning period (75 percent). Of more than 6,000 kiyis examined, only 11 were immature.

Little exploited in the early fishery, the kiyi has become increasingly important in the commercial catch as the larger chubs have declined in abundance and mesh sizes in chub gill nets have been decreased. Present regulations on mesh size and closed seasons afford the kiyi good protection but offer no guarantee against depletion from overfishing.

"Turbidity as a factor in the decline of Great Lakes fishes with special reference to Lake Erie," by John Van Oosten, was submitted to editor and accepted for publication; to appear in Transactions of the American Fisheries Society, Volume 75. This paper was prepared as a refutation of the widely publicized turbidity theory of Langlois which holds: that turbidity is the major factor in the abundance of Great Lakes fishes, especially in Lake Erie; that turbidities have risen as the result of increased soil erosion in agricultural regions draining into Lake Erie thus rendering it an unsuitable habitat for first-choice species; and hence that materials carried into the lake by tributary streams and not destructive fishing practices must be held responsible for the decline of the fisheries. Demonstration of the invalidity of Langlois' views is essential to the future welfare of the fisheries, since acceptance of his theory would entail the abandonment of the vitally important struggle being waged by conservationists to correct fishing abuses on the Great Lakes and bring the fisheries under scientific management.

Refutation of the Langlois turbidity theory was made along the following major lines of argument:

(1) Fishes are far more tolerant of turbidity than is commonly believed. Turbidity values in the Great Lakes are far too low to affect adversely the production of fish. Even in Lake Erie, the most roily of the lakes, the mean annual value for inshore waters is only 37 p.p.m. For April-May, months in which many fishes spawn, the mean is somewhat greater (57 p.p.m.) but still relatively low.

(2) Contrary to Langlois' repeated assertion, turbidity in Lake Erie is decreasing rather than increasing. Comparisons of values before 1930 with those of 1930 and later reveal a drop in the annual mean from 42 p.p.m. in the former period to 32 p.p.m. in the latter. For April-May the change was from 72 p.p.m. in the earlier to 46 p.p.m. in the later period. Increasing turbidity, therefore, cannot possibly account for the declining abundance of fishes.

(3) Evidence that stream-borne suspensoids from agricultural regions cause the turbidity of western Lake Erie is weak and inconclusive. Much more consistent with the facts is the belief that wind action is the major cause of turbidity and that bank erosion on the lake itself is the principal source of suspensoids.

(4) There is every indication that Lake Erie offers an excellent not an unsuitable, habitat for fish. Plankton production is rich, the growth of fish compares most favorably with that in other waters, and despite severe declines the output of the fishes themselves is still reasonably high. Furthermore, fish production is greatest in the more turbid westerly region.

(5) Extensive data on age composition and the strength of year classes failed to reveal any correlation between turbidity and the success of reproduction of the principal commercial species. Of particular interest here is the complete failure of Langlois' much publicized prognostication that exceptionally strong year classes would be produced in 1941, a year with unusually clear water during the spring.

(6) The proof of invalidity of Langlois' turbidity theory together with repeated associations of increasing fishing pressure and declining abundance lead inevitably to the conclusion that overfishing is the major cause of depletion of the Great Lakes fisheries.

"Standardization of methods of expressing lengths and weights of fish," by Ralph Hile was submitted to editor and accepted for publication in Transactions of the American Fisheries Society, Volume 75. Variations in the method of measuring the lengths of fish and in the units employed to express both lengths and weights are a major source of inconvenience to United States and Canadian fishery workers in the use of current literatures. Inability to think readily in terms of the metric system of weights and measures is especially troublesome. After a review of the general problem of standardization and a consideration of arguments for and against various procedures, it was recommended that in most of our fishery work we (1) employ the total length (defined as the distance from the tip of the head, mouth closed, to the tip of the tail with the lobes compressed to give the maximum possible measurement) and (2) use the English system of weights and measurements to express length and weight. The publication of at least the key information in both English and metric units also was recommended for our more formal papers, and the desirability of using the metric system only in certain highly technical articles or in special situations was recognized.

Greater uniformity is needed also in the expression of ages, in the presentation of morphometric and other data on lakes and streams, and in the classification of the products of fish-cultural establishments.

"The age, growth, and bathymetric distribution of the bloater, Leucichthys hoyi (Gill) in Lake Michigan," by Frank W. Jobes, was submitted to the editor and accepted for publication in the Papers of the Michigan Academy of Sciences, Arts and Letters, Volume 33. The bloater is the smallest and most slow-growing of the Lake Michigan chubs. As an illustration of this slow growth the average calculated length at the end of 6 years of life was only 8.9 inches for the males and 9.2 inches for the females. The corresponding calculated weights were but 2.9 and 3.2 ounces. Since all fish aged were captured off Grand Haven, Michigan, the matter of regional differences of growth

rate was not investigated. Fish captured in 1928, however, had grown more rapidly than had those taken in 1919.

Age-group IV dominated the 1919 sample (41.1 percent). In 1928 age-groups II to VI each contained from 20.9 to 16.2 percent of the collection.

The circumstance that the gill nets customarily took considerable numbers of bloaters both in the customary manner and by the entanglement of mouth parts in the twine led to an unusual relationship between mesh size and the length of fish captured. In 1930-1931 the average length of bloaters from southern Lake Michigan decreased consistently with increase in mesh size (five sizes fished) with from 9.2 inches in the 2 3/8-inch mesh to 7.9 in the 3-inch mesh. The frequency distributions were bimodal for both the 2 3/8- and 2 1/2-inch meshes. The three mesh sizes fished in northern Lake Michigan in 1932 all took fish that were of about the same size (range of average length, 10.6 to 10.8 inches) but which averaged 2.3 to 2.7 inches longer than those captured in the same meshes in 1930-1931.

The weight of the Lake Michigan bloater increased as the 3.168 power of the length. Condition (K) improved from May to June and remained at a high level or increased in subsequent months.

No distinct trends could be determined in changes of sex ratio with age or during the fishing season.

Bloaters were captured at depths as shallow as 12 fathoms and as deep as 97 fathoms, but were most plentiful at 20 to 59 fathoms where the temperature was 3.8 degrees to 7.0 degrees C. In some months the larger fish seem to inhabit the deeper water.

The bloater was about 3 times as abundant along the east shore as along the west shore of the lower lake. Abundance on the east shore was about 2 1/3 times that in northern Lake Michigan, and that in the northern region was about 1 1/2 times that on the west shore. The greater exploitation with smaller meshes on the west shore probably accounts for the relative scarcity of bloaters in those waters whereas less favorable environmental conditions are assumed as the reasons for the relative scarcity of the species in the northern region.

"Age and growth of the whitefish, Coregonus clupeaformis (Mitchill) in Lake Erie," by John Van Oosten and Ralph Hile was accepted for publication to appear in Transactions of the American Fisheries Society, Volume 76. Although the whitefish has by no means ranked first from the standpoint of production, it has always been an important commercial species in Lake Erie. The general level of productivity declined at a relatively early date. Despite certain noteworthy but temporary recoveries, the 1893-1945 annual yield in United States waters (1,212,000 pounds) has been only 39 percent of the 1879-1890 mean (3,133,000 pounds).

Age-group III was typically dominant in random samples from commercial gear (trap nets, pound nets, and large-mesh gill nets). The same age group also dominated most samples of the commercial catch (that is, whitefish that equalled or exceeded the legal minimum weight of 1 3/4 pounds) taken in late summer, fall and early winter, but IV-group fish were the more plentiful in July when many members of the III group were still undersized. Apparently the members of a year class normally dominate the commercial take about one year but this year extends over parts of two years of life (latter part of the fourth and early part of the fifth).

The year classes of 1922 and 1926 were much stronger than average whereas the 1923 year class was exceptionally weak. No correlation was detected between limnological-meteorological conditions and the strength of year classes.

Although female whitefish averaged longer and heavier than males, the difference was sufficiently small (length advantage of females relatively steady at about 1/2 inch in the third and later years) that growth can be described reasonably well for the sexes combined. The Lake Erie whitefish was a foot long in less than 2 years, 18 inches in about 4 years, and 2 feet in slightly under 12 years. The legal weight of 1 3/4 pounds was attained toward the middle of the fourth growing season, 4 pounds in between 7 and 8 years, and 6 pounds in about 13 years. Growth in Lake Erie was much superior to that reported for Lake Ontario. Lake Erie whitefish were also longer than Lake Huron whitefish during the first 5 years of life and heavier during the first six. In later years the Lake Huron fish were the larger.

The growth in length of Lake Erie whitefish ranged from 15.0 percent above the 1924-1930 mean in 1927 to 25.0 percent below average in 1930. There is good evidence that the annual fluctuations in growth rate were correlated negatively with fluctuations in the turbidity of water off Erie, Pennsylvania, in certain months (especially May-June) and/or correlated positively with the amount of rainfall during July and August at the same locality.

The weight of the Lake Erie whitefish increased to the 3.1523 power of the length. The total length corresponding to the legal weight of 1 3/4 was 16.9 inches. Available data on condition indicated that K declined continuously from August to December. At spawning in November and December female whitefish lost 11 percent of their weight, but no loss could be demonstrated for males.

Apparently most or all males are mature as age-group III, but there is evidence that many females (possibly a majority) are first mature as members of the IV group (end of fifth year). The sexes were about equally represented in collections of summer and early autumn. Males were strongly predominant (79 percent) in spawning-run collections.

Spawning commenced during the second week of November and was continuing actively when the last samples were collected at the end of the first week in December.

Progress in Current Projects - Biological

Age, growth, and distribution of the longjaw chub, Leucichthys alpenae Koelz in Lake Michigan. The present study is the fourth of its type for species of chubs in Lake Michigan. Dr. Jobes has completed all of the original tabulations and analyses in this investigation and is currently preparing the formal report.

The longjaw is one of the more rapidly growing chubs. At the end of 4 years of life, for example, it averages a little above 11 inches in total length and more than 6 ounces in weight (cf. data on kiyis and bloaters earlier in this report). The growing season must begin early, for in 1923 the major part of the annual growth had taken place by June 15.

Age-group IV dominated the 1923 sample (53.8 percent) and age-group III the 1928 collection (55.2 percent). The oldest fish was a member of the IX group.

Data on length failed to reveal any annual difference, or a difference between the east and west shore with respect to the average lengths of longjaws captured in southern Lake Michigan in 1930-1931. Longjaws taken in northern Lake Michigan in 1932 were larger than in the preceding years, averaging 1.0 to 1.3 inches longer than fish from corresponding mesh size in 1930-1931.

The weight of the Lake Michigan longjaw increased to the 3.0606 power of the length. The calculated length-weight curve fitted the empirical data rather poorly. Condition (K) was best in 1931 and poorest in 1932. The individuals of both sexes were in poorest condition in some month preceding August each year.

Females made up 76 percent of all collections but were more plentiful in 1932 (81 percent) than in 1930 (72 percent) or 1931 (68 percent). The percentage of females increased with increase in age. Data on monthly trends in the sex ratio were inconclusive.

The present study will add 129 locality records for the longjaw in Lake Michigan proper and Green Bay to the 35 previously reported. Longjaws were most abundant in 20 to 69 fathoms but were taken as deep as 97 fathoms. Abundance was approximately the same along the east shore of southern Lake Michigan in 1930-1931 as in northern Lake Michigan in 1932. In both of these regions, however, longjaws were

about three times as plentiful as along the west shore of the lower lake. The relative scarcity of longjaws along the west shore is believed to have been the result of more intensive fishing with nets of smaller sizes of mesh.

Age and size composition of the commercial catch in Lake Erie. The annual sampling of the commercial catch of Lake Erie, instituted in 1943, was continued in the fall of 1946 when scale samples of 1,586 fish (including blue pike, ciscoes, saugers, sheepshead, walleyes, white bass, whitefish, and yellow perch) were collected from Sandusky, Lorain, and Conneaut, Ohio, and Dunkirk, New York, on the south shore and Wheatley, Ontario, on the north shore. Dr. Jobas made age determinations for these fish during the past winter.

These annual studies of the age and size composition of Lake Erie fish will in time provide a valuable background for a better understanding of the population dynamics of the lake. The data have had also a great immediate usefulness in that they constituted an important part of the information employed to refute the Langlois turbidity theory. (See review earlier in this report of Dr. Van Oosten's paper on turbidity as a factor in the abundance of fish.)

Age and growth of the walleye Stizostedion vitreum vitreum (Mitchill) in Saginaw Bay, and the walleye fishery of Lake Huron. After a nearly complete suspension of activities during the war years, Dr. Hile has resumed work on this extensive study of the walleye. During the past year the last of the scale collections were read and nearly all of the tabulations prepared for such phases of the investigation as: long-term trends of production; annual and seasonal trends, beginning with 1929, in abundance, production, and fishing intensity; age composition, including annual and seasonal variations; growth rate (length and weight at capture, calculated lengths and weights, annual fluctuations in growth rate); length-weight relationship; sex ratio; age and size at maturity.

Since much of the analytic work remains to be completed, only limited and necessarily tentative conclusions can be offered at this time. Comments will be limited here to the rather striking information uncovered to date on annual fluctuations in growth rate. The more than 3,000 fish collected from 1926 to 1930, inclusive, yielded extensive data on growth fluctuations in the period 1916-1929, and a small collection of 288 walleyes gave information on more recent growth (especially for 1939-1942). During the earlier of the periods fluctuations in growth of males and females and of fish in the first and in the later years of life followed the same general trend. For the sexes combined and for all years of life the range of fluctuations was from 12.8 percent above the 1919-1928 average in 1916 to 14.2 percent below average in 1924.

Walleyes collected in 1943 had grown much more rapidly than had fish taken in 1926-1930. As illustrations, males captured at the end of 3 and 4 years of life in 1926-1930 had average total lengths of 12.6 and 14.4 inches, respectively, as compared with averages of 16.4 and 17.5 inches for males of corresponding age in the 1943 sample. The average weights for these same age groups were 0.59 and 0.89 pound in

1926-1930 as against 1.41 and 1.69 pounds in 1943.

Calculated lengths of the 1943 walleyes indicated that a high level of growth rate extended back well into the 1930's. This fact in turn invites the assumption that the recent high level of production that began in 1932 may have been to a considerable extent the result of faster growth rather than of more successful reproduction.

Age and growth of the smelt. Although it has not yet been possible to set up an organized program of investigation of the smelt, the policy has been followed of accumulating data on age, growth, length, maturity, ... at every opportunity. This spring samples of about 100 fish each were secured from the St. Ignace region (Straits of Mackinac) and from Wheatley, Ontario, on the north shore of Lake Erie.

The latter collection was of special interest, since it was our first from Lake Erie and came from a region in which an important smelt fishery promises to develop. The fine quality, large size, and rapid growth of Lake Erie smelt, together with the ready accessibility of the area to eastern markets make the outlook for profitable exploitation of the species good. As an illustration of the rapid growth, smelt from Wheatley were 9.9 inches long and weighed 4.0 ounces at the end of 3 years as compared with 7.2 inches and 1.3 ounces for the St. Ignace fish of the same age.

At a later date Dr. Van Oosten plans to prepare a report on the growth of smelt in the various Great Lakes waters.

Other additions to scale collections. In continuation of the policy of making annual collections of scales of lake herring and yellow perch from Saginaw Bay, we secured 205 scale samples of herring from the November spawning run and 208 scale samples of perch in May. Yet another addition to our collections was a sample of 65 herring supplied by a commercial fisherman of St. Ignace, Michigan.

Cooperative lake trout investigations. At a meeting in St. Paul, Minnesota, on September 10, 1946, officials of this Service and of the States of Minnesota, Wisconsin, Illinois, Indiana, and Michigan, invited the Province of Ontario to join in the cooperative investigations and changed the name of the Committee (of which Dr. Van Oosten is Chairman) to the Great Lakes Lake Trout Committee.

The work of the Committee continues to be confined principally to an evaluation of the results of planting fingerling fish. In the fall of 1946, some 151, 402 marked (fin-clipped) fingerling lake trout were planted in northern Lake Michigan, making a total of 411,394 marked fish that have been planted in the lake.

Progress in Current Projects - Statistical

Pounds and value of the catch in the United States waters of the Great Lakes. The war-time arrangement whereby the pounds and value of the commercial catch in the United States water of the Great Lakes and the Boundary Lakes are collected and compiled by the Great Lakes section and forwarded to the Division of Commercial Fisheries has been continued. This work was completed for 1944 in the summer of 1946 and for 1945 in June 1947. The State of Michigan also was supplied with tabulations of the 1945 catch by month and by gear in Michigan waters of the Great Lakes (these statistics are published in the Biennial Report of the Department of Conservation).

Analysis of local fluctuations in the State of Michigan fisheries of the Great Lakes. From these analyses, conducted by methods described in several publications of this office, there are now available records of local fluctuations in the availability and production of the more important fish and in the intensity of the fishery over a 17-year period 1929-1945. Work on the 1946 statistics was considerably delayed because of difficulty in locating a suitable statistical assistant. The vacancy has now been filled.

The adoption by the Province of Ontario of report forms and methods of tabulation and analysis developed in the Great Lakes offices constitutes an important step toward uniform and adequate statistics for the Great Lakes fisheries. As the result of correspondence and consultations with Ontario officials, these methods were installed first in Lake Ontario on an experimental basis. Later, in March of this year, Mr. H. C. McKinley, who is immediately in charge of fishery statistics for the Ontario Department of Lands and Forests, spent four days in Ann Arbor discussing with Drs. Van Oosten and Hile details of the proposed immediate extension of the statistical system to all Canadian waters of the Great Lakes.

Sea Lamprey Program

Although the sea lamprey, a native of Lake Ontario, is known to have been present in Lake Erie in 1921, and to have penetrated as far as central Lake Michigan by 1936, it is only within recent years that it has become sufficiently abundant to constitute a major threat to the fishery. This parasite appears to be most abundant in Lake Huron, where there is good reason to believe that sea lampreys have been a principal contributing factor in the decline in the production of lake trout from 1,372,000 pounds in 1939 to less than 50,000 pounds in 1946. Furthermore, lamprey depredations are now reaching critical proportions in Lake Michigan (especially in northern waters), and sea lampreys have been reported from Lake Superior as far west as Isle Royale.

Members of the Great Lakes staff long have been aware of the menace of the sea lamprey, and as far back as the early 1930's began to gather information on this predator as opportunity presented itself. The almost complete lack of funds and facilities for field work made it utterly impossible, however, even to carry out investigations of the biology of the sea lamprey, much less attempt to devise methods for its control.

The first prospect for an effective sea lamprey program came in August 1946 when the President signed H. J. Res. 366 authorizing appropriations up to a total of $100,000 over a 10-year period for the development of control methods.

In anticipation of Federal support, officials of this Service, the States of Minnesota, Wisconsin, Illinois, Michigan, and New York, and the Province of Ontario formed a cooperative Sea Lamprey Committee at a meeting in St. Paul, Minnesota, on September 10, 1946. The permanent organization of the Committee was effected at a second meeting in Ann Arbor on November 14-15, 1946, at which time Dr. Van Oosten was elected Chairman. At this second conference a detailed, though necessarily tentative, program was worked out (a mimeographed transcript of the meeting was distributed to interested parties). It is anticipated that all of the Great Lakes States will participate in the sea lamprey program.

Since no part of the funds authorized by H. J. Res. 366 was appropriated during the fiscal year 1947, field activities by the Great Lakes Section were limited to a brief survey of conditions in northern Lake Huron by Dr. Van Oosten during the last week of June 1947. Dr. Van Oosten has devoted a great amount of time, however, to his work as advisor and coordinator in activities already being conducted by Wisconsin, Michigan, and Ontario, and to the planning of future operations.

As it stands now, the sea lamprey program can be divided into three major phases: (1) the intensive study of the biology and habits of the lamprey with a view particularly of learning its distribution and abundance and of determining the most vulnerable periods of its life history; (2) the development and testing of devices and techniques for the capture or destruction of adult and larval lampreys; (3) the investigation of the effects of the lamprey on the fish and fisheries--frequency of attacks according to species, locality and season--losses to fishermen through inability to market scarred fish--evidence as to effects of lamprey on abundance of fish (including analyses of commercial fishery statistics).

The states and Ontario are to be primarily responsible for (1) and (2) above with the Service acting as a coordinating and advisory agency and also contributing financial support (to the States). The Great Lakes section is to concentrate on the third phase of the program.

EASTERN INLAND FISHERY INVESTIGATIONS, Charles M. Mottley, Chief of Section

GENERAL

The Section has made significant progress on the research objectives set for the Fiscal Year 1947. Investigations of the requirements of trout for 3 of the important vitamins in the B-complex were completed. Further work was done on the standardization of the treatment of furunculosis with sulfamerazine. The effects of DDT on fish and aquatic organisms in large-scale field applications were studied. Methods for controlling emergent aquatic vegetation with 2, 4-D in fishponds were worked out. A Special Scientific Report on the effects of aquatic weed infestations on the fish and wildlife of the Gulf States was prepared and submitted to the Corps of Engineers. An evaluation of the effect of pond fertilization on the production of fish was made and used as a basis for planning future experimental work. During the spring quarter investigation of new phases of the various projects were started as indicated below.

Headquarters Unit During April Dr. Mottley spent several days in Region 2 conferring with the staff at the Albuquerque Regional Office and planning a program of investigation for Conchas Reservoir, New Mexico. In May he prepared a paper entitled, "Creel Census Methods for Estimating Fish Populations," which was given at the meeting of the Virginia Academy of Sciences. In June a visit was made to the Fish Cultural Station at Lamar, Pa., where the Section is cooperating in a program for the complete sterilization of the supply line, troughs, ponds and equipment. Several trips were made during the quarter to the research laboratories in connection with the planning of the research program.

Leetown Research Laboratory During the year Dr. Snieszko completed the job of organizing his laboratory facilities for conducting bacteriological investigations. The necessary equipment has been obtained and a battery of troughs for controlled experimentation and treatment was constructed. Both Dr. Snieszko and Dr. Gutsell have been cooperating with the Division of Game Fish and Hatcheries in a program for the control of fish diseases. Trips were taken to Wytheville, Va., and Lamar, Pa., in this connection and recommendations for treatments were made. Mr. Saufly B. Friddle was transferred from the Division of Game Fish and Hatcheries and is assisting Dr. Snieszko as a biological aid.

Dr. Snieszko attended the General Meeting of the American Society of Bacteriologists, Philadelphia, Pa., May 13 to 16, 1947. Two papers were presented at this meeting entitled "An Outbreak of a Bacterial Disease of Lobsters" by Snieszko and C. C. Taylor, and "A Study of the Microorganism Causing a Bacterial Disease of Lobsters," by E. R. Hitchner and Snieszko. Abstracts from these papers were published in the proceedings of the meeting.

At the present time there are over one hundred stock cultures of bacteria isolated from the infected fish which are being maintained for the future work. All cultures have to be transferred to fresh media once every month, because of the lack of desirable storage facilities at the station. Storage facilities are being arranged, so that the cultures will need to be transferred less frequently.

Dr. Gutsell continued the analysis and interpretation of the data obtained from previous investigations on the diets of hatchery trout. A series of papers is being prepared dealing with the growth and mortality of trout fed diets containing different kinds of meats and dry feeds.

Cortland Research Laboratory The Cortland Laboratory continued its program of testing various dietary supplements. Various commercial supplements failed to increase the growth rate, decrease the cost of production or have any visible beneficial effects upon brook trout. The cost of these supplements does not appear to warrant their use in hatchery diets. New supplement experiments are in progress and will be completed this coming fall.

Paprika when fed at a level of 2 percent of the diet to brook trout, causes a marked coloration of the fish, approximating the color of wild fish. In the past such studies have been made with the imported brands of paprika. Experiments were made in which the efficiency of a domestic paprika was compared with an imported brand. In all experiments the domestic type was equal to or superior to the imported paprika. Domestic paprika is much cheaper for use in hatcheries diets. Brown trout were not colored by this substance. A new series of experiments has been started to determine if the level of paprika in the diet may be reduced and thus further lower the cost of artificially coloring hatchery brook trout.

Tests of several practical diets are under way to determine if the standard Cortland No. 6 may be improved upon. Such experiments have been made necessary by the lack of a supply of some of the ingredients and the excessive costs of some of the others.

Training Program Classes of about 4 hours each week are held throughout the period from mid-September to the first of June in which instruction was given to personnel of the Division of Game Fish and Hatcheries. Instruction consisted of lectures, recitations, laboratory exercises and field trips in general nutrition, fish cultural methods (including disease identification and control) hatchery management and fresh water biology. This past year two men from Region 1 attended the school in addition to personnel from Region 5.

RESEARCH PROGRAM

PROJECT I. (PHYSIOLOGY) NUTRITIONAL REQUIREMENTS OF SALMONOID FISHES
A. M. Phillips, Project Leader.

Subproject 1--Vitamin requirements of salmonoid fishes.

The study of the vitamin B requirements of trout formed the major portion of the Cortland Laboratory's program during the past year. These studies consisted of feeding various levels of the different vitamins in the diet of the trout and after an elapse of time the trout were killed and their livers were analyzed for their vitamin content. That diet causing maximum storage was taken as the tentative requirement of the trout.

Studies were made upon the riboflavin, thiamin and pantothenic acid requirements. The experiment was so designed that the effects of levels of the vitamins in the diet, species of trout, water temperature and the time of the analyses could be measured in one series of experiments. The data were studied statistically by means of analysis of variance.

Three species of trout were used in all studies, brook, brown and rainbow trout, and the experiments were run at water temperatures of 47 and 52 degrees F. Two series of analyses were made approximately two months apart.

No difference was found between the requirement of the three species of trout for riboflavin. The requirement remained the same at the two temperatures and over the two-month interval. The tentative requirement was found to be between 0.44 and 0.68 milligrams of vitamin per kilogram of body weight daily. Maximum storage was found to be between 15 and 16 micrograms of riboflavin per gram of trout liver.

The pantothenic acid studies showed that all three species had the same requirement and no effect was caused by temperature. The tentative requirement was established at between 0.97 and 1.25 milligrams of pantothenic acid per kilogram of trout per day. There was a difference in liver storage in the cases of brown and rainbow trout between the two series of analyses. The analyses made later in the season when the fish were larger and older, showed a greater amount of pantothenic acid in the liver than the earlier series. Maximum storage of pantothenic acid in the trout livers was approximately 18 micrograms per gram of liver. This was slightly less for the rainbow and brown trout in the first series of analyses.

The thiamin requirement was found to be between 0.150 and 0.186 milligrams per kilogram of trout per day for all three species of trout. Temperature had no effect upon the requirement but there was a difference between the two series of analyses. The larger and older trout (the second series) had a higher liver storage of thiamin than the trout of the first series of analyses. The average storage

of thiamin was approximately 4 micrograms per gram of liver, averaging slightly less for the first series of experiments.

A series of experiments is at present in progress in which the need of trout for niacin (nicotinic acid) and biotin will be established but have not reached a point where conclusions may be drawn.

PROJECT II. (PHYSIOLOGY) ANEMIA IN TROUT

Suffocation experiments at Cortland showed that as the oxygen was reduced and the carbon dioxide increased in an unaerated aquarium, the red cell count of the blood of brook trout increased rapidly for the first hour after which it maintained the new level. The gas content of the water may be an important factor which must be taken into account in the early diagnosis of anemia in hatchery-reared trout.

A mixture of pyridoxine, pantothenic acid and riboflavin fed in gelatin capsules to brook trout, failed to relieve the anemia which developed when the trout were fed a synthetic diet. The same three vitamins and folic acid did cause a significant rise in the blood count of anemic fish, although the rise was far below that resulting from the feeding of fresh beef liver. Folic acid alone had no effect. The anti-anemic factors of fresh meat appear to be a complex mixture and not a single factor as once thought.

Experiments are in progress to study further the effects of various vitamin combinations upon anemia. In addition several commercial supplements are being tested for their anti-anemic value.

PROJECT III (TOXICOLOGY) EFFECTS OF INSECTICIDES AND CHEMICALS ON FISH

Eugene W. Surber, Project Leader and Dorothy D. Friddle, Biological Aid.

Subproject 1--Effects of DDT on Fish

Both laboratory and pond experiments were performed during the period April 1 to June 30. An experiment using two rates of application of DDT in oil was performed in concrete Daphnia ponds with largemouth bass advanced fry of an average length of 26.4 mm. All bass were killed in the ponds which received 0.5 pound DDT per acre, while 100 percent survived in the control pond.

In another pond experiment, in collaboration with the Bureau of Entomology and Plant Quarantine, houseflies sprayed with DDT in oil at the rate of 1.0 pound per acre were fed to bluegill sunfish, 82 mm. average length. No bluegills were killed. This experiment corroborates an experiment conducted during 1945, which failed to show that bluegill sunfish can be killed by feeding upon insects sprayed with DDT.

In aquarium experiments in which DDT-sprayed housefiles were fed to 78 mm. (average) bluegill sunfish, several fish died. Though few showed typical symptoms of DDT poisoning, as usual the results of the aquarium experiment were open to question.

Arrangements were completed for the spraying of a mile section of the St. Mary River in the Big Levels Refuge near Vesuvius, Virginia.

Applications of DDT in oil at the rate of 0.25 and 0.50 pound per acre were made in dirt-bottom ponds containing golden shiner fry, 11.6 mm. in length. All fry visible in the ponds were killed at both levels of DDT. Apparently golden shiner fry are much more sensitive to DDT than adults, since experiments during October 1946 showed that adult golden shiners can survive 0.5 and 1.0 pound DDT per acre treatment.

Subproject 2--Effects of Newly Developed Chemicals on Aquatic Organisms.

Three large plots of white water lilies, Nymphaea odorata, on the premises of the Eudora Farms near Leesburg, Virginia, were sprayed with 2, 4-D on June 4, 1947. Three 2, 4-D formulae were used. In one plot, 5 percent 2, 4-D solution prepared from the sodium salt of 2, 4-D was used; in the second, a 5 percent solution of 2, 4-D with tributylphosphate, a cosolvent; and in the third plot, a 5 percent solution of 2, 4-D in triethanolamine and water. Preliminary observations showed that the tributylphosphate formula was much the easiest to use and caused the leaves to curl before completion of the spraying.

The water lilies, sprayed in Ponds 1-5 and 1-14 survived the spraying during the late fall of 1946 when both leaves and petioles were sprayed after the water was removed. Further efforts will be made to control these plants by additional applications with the tributylphosphate formula.

PROJECT IV (DISEASES) THERAPEUTIC TREATMENT FOR FURUNCULOSIS
James S. Gutsell, Project Leader, S. F. Snieszko, Collaborator

The pipe from the spring, distributing ditch and the 16 ponds of raceway type at the Upper Hatchery, Lamar, were treated with chlorine after sundown on June 11. Dr. Mottley and Mr. Rodgers were present with Dr. Gutsell while this was being done. They, together with Mr. Tanner and the entire staff of the Lamar hatchery, took part in the operation. The residual chlorine was checked on the morning of June 12.

Two papers, "Response of Brook Trout (Salvelinus fontinalis) and Rainbow Trout (Salmo gairdnerii) to various dosages of Sulfamerazine" and "Effect of Simultaneous Treatment of Brook Trout (Salvelinus fontinalis) and Rainbow Trout (Salmo gairdnerii) with Sulfamerazine and Calomel or Carbarsone," have been made ready for final typing, preparation of finished graphs, etc.

The two earlier papers "The Value of Certain Drugs, especially Sulfa Drugs, in the Treatment of Furunculosis in Brook Trout (Salvelinus fontinalis)" and "Dosage of Sulfamerazine in the Treatment of furunculosis in Brook Trout (Salvelinus fontinalis)" still are awaiting publication in the Transactions of the American Fisheries Society.

Plans have been prepared for new experiments dealing with the development of treatment methods for furunculosis. These experiments are to be started in July.

References were studied by Dr. Snieszko on the methods of determination of the sulfonamides in the blood and tissues, and some preliminary tests were carried out. However, the color standards and the intensity of the color produced in the tested blood of the trout were too faint to permit accurate determination. After consultation with Dr. Beyer, a pharmacologist, at the Sharp and Dohme Company, in Philadelphia, it became clear that the accurate determination of the sulfonamides in the blood and tissues is only possible with the aid of a photoelectric colorimeter. Therefore, further studies were postponed until such colorimeter could be obtained. It has been found that the blood collection methods used for the blood of higher animals have to be considerably changed for the collection of the trout blood. These methods are now being developed.

PROJECT V. (DISEASES) DEVELOPMENT OF CULTURE MEDIA AND METHODS
S. F. Snieszko, Project Leader, S. B. Friddle, Biological Aid.

Subproject 1--Artificial infection of brook trout with B. Salmonicida

On June 3 a preliminary test was started on the artificial infection of brook trout with B. Salmonicida. The trout were divided in four separate troughs as follows:

Trough #1. 10 yearling brook trout, five of them were injected with a suspension of B. Salmonicida.

Trough #2. 10 yearling brook trout, five of them had one of the pectoral fins removed and were dipped for a few seconds in a very diluted water suspension of B. Salmonicida.

Trough #3. 10 fingerling brook trout, five injected as in trough #1.

Trough #4. 10 fingerling brook trout, five of them infected as in trough #2.

All trout were fed regularly and the dead trout were recorded, removed and spot checked bacteriologically for the presence of B. Salmonicida in the dorsal vein and the kidney.

Mortalities

Date	Yearlings		Fingerlings	
	Trough #1	Trough #2	Trough #3	Trough #4
June 6	1		4	
" 8	5		1	
" 10	1	3		5
" 14		2		
	pooled		pooled	
" 18	3			
Subtotal	7	5	5	5
Total	15		10	

This preliminary experiment indicated that the artificial infection by means of the intraperitoneal or intramuscular injection, or by clipping of the fins, produced 100 percent mortality. The injected trout died sooner than the trout infected through the clipped fins. There were some additional mortalities in the fingerling trout which probably were due to the natural infection from the artificially infected trout. Additional tests were started because this question is extremely important for investigations involving the marking of hatchery fish.

Subproject 2--Experimental troughs.

The experimental work on the diseases of fishes and their treatment has been limited by the fact that during the large part of the year the troughs in the hatchery are used for the production of fry. Another limiting factor is the large size of the standard hatchery troughs at Leetown. In order to have a desirable quantity of fish per unit volume of water, a large number of fish must be used and the cost of food, drugs and chemicals is proportionately high. Also the fact that the hatchery troughs are arranged in two tiers with water flowing from the upper to the lower troughs, increases the risk of uncontrolled infection. In order to remedy this situation at the lowest possible cost, a plan was prepared for the partition of the eight standard troughs into 24 smaller troughs, each with the separate water supply and a separate outlet. The set-up is expected to be completed early in July.

When the experimental troughs are completed they will be used for preliminary screening tests, for various controlled experiments and several troughs will be reserved exclusively, as a kind of small clinic, for the rapid selection of the best treatments when a disease of doubtful etiology appears at the Leetown Station or nearby.

Subproject 3--The preventive Treatment of Some Fish Diseases

A new subproject on the preventive treatment of certain fish diseases was started. A detailed program of the procedures and aims was prepared and discussed with Dr. Mottley and with the whole staff of the Leetown Station. Full cooperation was assured by Mr. B. Hazen and the personnel of the Game Fish and Hatcheries. Copies of the plan were delivered to the chiefs of the Fishery Biology and of the Game Fish and Hatcheries. The project was approved and operations were started.

PROJECT VI. (FISHERY BIOLOGY) SMALLMOUTH BLACKBASS STUDIES, E. W. Surber, Project Leader.

This project was inactive during the war, but plans are being made to resume the investigations. Conditions in the Shenandoah River below Front Royal, Va., are still unsuitable for bass due to pollution. An attempt is being made to draw the attention of the State authorities to this situation.

PROJECT VII. (FISH CULTURE) PROPAGATION OF POND FISHES, Eugene W. Surber, Project Leader

Subproject 1--Fertilization of Hatchery Ponds

A series of 14 ponds ranging from 0.2 to 0.62 acre in area were stocked on April 14, 1947, with bluegill sunfish at the rate of 20,000 per acre. Two of these ponds served as controls, and the remaining 12 ponds were fertilized with a 10-5-5 inorganic fertilizer. Ammonium sulfate was the source of nitrogen.

The series of 14 ponds were arranged in four blocks with one control each in the first and fourth blocks. One pond in each block received 100 pounds per acre, another received 200 pounds per acre, and a third 300 pounds of 10-5-5 inorganic fertilizer per acre per application at 10-day intervals until June 12, a total of 4 or 5 applications per pond depending upon the turbidity.

The turbidity measurements were taken weekly during the operation of the ponds, since the purpose of the experiment was to produce water bloom of a certain density, viz., such as would prevent the growth of the larger aquatic plants. The main purpose of the project was to measure the production of bluegill sunfish resulting from different quantities of fertilization.

In spite of the heavy application of fertilizer, water bloom did not appear in many ponds. Instead, large masses of filamentous algae or coarse vegetation appeared. In these ponds the water remained clear. Water bloom seemed to appear where heavy water bloom forms in previous years were present, and no relation between the amount of fertilizer added and the production of water bloom forms was found. In other words, the addition of triple the normal amount of fertilizer had no effect on the production of water bloom.

The control ponds averaged 92 pounds of bluegill sunfish per acre, Ponds receiving a single application of 100 pounds of 10-5-5 per acre produced an average of 138 pounds per acre. Those ponds receiving 200 pounds per acre per application averaged 132 pounds of bluegill sunfish per acre, while the smallest average production, 110 pounds per acre, occurred in the series receiving 300 pounds of fertilizer per acre per application. In one pond receiving three times the normal application, bluegill sunfish were noted dying.

The sunfish in all ponds made excellent growth during the short period of operation. They ranged in average length from 2.0 to 2.7 inches and provided fish of very desirable size for stocking farm ponds. The results in detail are shown in Table 1.

Sub-project 2--Farm Ponds

During June, all of the farm ponds which were stocked in October 1946 were seined to determine whether the fish had survived, and how well. In two ponds, very low survival occurred, and in each of these, a large snapping turtle was removed with a seine.

Those ponds were restocked with fish of comparable size to those which had survived. Coarse vegetation was removed by chemical treatment in those ponds containing an excess amount. Fertilization was resumed with 12-5-5 inorganic fertilizer.

Table 1.--Production of bluegill sunfish in ponds at Leetown, West Virginia, 1947

Pond no.	Date stocked	Date drained	Number days operated	Number per acre	Average length inches	Net pounds per acre	Net pounds per acre per day	Percentage survival
A. No applications								
H- 2	4-14-47	6-18-47	66	16,174	2.3	117.57	1.78	80.9
H-13	4-14-47	7- 2-47	80	13,258	2.0	67.25	0.84	66.3
Average				14,716	2.2	92.41	1.31	73.6
B. Single applications								
H- 4	4-14-47	6-19-47	67	13,919	2.5	126.78	1.89	69.6
H- 5	4-14-47	6-20-47	68	10,204	2.5	142.71	2.10	51.0
H- 9	4-14-47	6-27-47	75	15,360	2.4	136.55	1.82	76.8
H-12	4-14-47	7- 2-47	80	21,826	2.4	144.43	1.81	109.1 1/
Average				15,327	2.5	137.62	1.91	76.6
C. Double Applications								
H- 1	4-14-47	6-18-47	66	5,625	2.4	66.13	1.00	28.1
H- 6	4-14-47	6-23-47	71	11,498	2.4	154.86	2.18	57.5
H- 8	4-14-47	6-26-47	74	17,171	2.3	149.76	2.02	85.9
H-11	4-14-47	7- 1-47	79	18,850	2.2	155.10	1.96	94.3
Average				13,286	2.3	131.46	1.79	66.5
D. Triple applications								
H- 3	4-14-47	6-19-47	67	10,448	2.3	86.98	1.30	52.2
H- 7	4-14-47	6-25-47	73	2,040	2.7	25.79	0.35	10.2
H-10	4-14-47	6-30-47	78	17,240	2.2	136.88	1.75	86.2
H-14	4-14-47	7- 3-47	81	15,703	2.7	189.07	2.33	78.2
Average				11,358	2.5	109.68	1.43	56.8

1/ The total number of fish stocked in each pond was estimated from weighing of random samples. The total number present at the time of drainage of the pond gives the actual number produced, since these were counted individually as well as weighed.

PROJECT VIII. (FISH CULTURE) GENERAL DIAGNOSTIC SERVICE, S. F. Snieszko

Diagnostic Service at the Leetown Station The trout at the Leetown Station were examined whenever there was any suspicion of any disease. Several adult rainbow trout were affected by tumors or cysts. There was a serious outbreak of gill disease among the rainbow trout fingerlings in the circular pools. Treatment with Roccal was recommended. In order to make this treatment possible the volume of water in all the circular pools had to be measured and a table was prepared for the rapid determination of the quantity of Roccal needed for each pool. It was found that the treatment of gill disease with Roccal gave very good results. The losses among the treated fishes were small, and the procedure of the treatment was simple and fast, providing that the needed information was at hand. In order to control gill disease so far it has been found necessary to treat the affected trout for three days in succession, one hour at a time, with 10 percent Roccal diluted 1:50,000. The treatment was repeated during the second and the third week in order to cure the disease entirely. So far there have been no new outbreaks of this disease.

There were several outbreaks of costiasis and of fin rot, due to an unknown cause. In each case a one hour treatment with 40 percent formalin diluted 1:4,000 gave very good results.

Other Diagnostic Services

1. Preparation of a memorandum for Mr. Higgins on the disease of the blueback salmon.

2. Examination of preserved goldfish from the Neisser Brothers, Springfield, Mass.

3. Examination of the preserved specimens of brook trout fingerlings from Smokemount, N. C.

4. Examination of white perch from the Maryland Marine Station at Solomons, Md.

5. Examination of diseased herrings from Maine.

6. Examination of the trout from White Sulphur Springs, W. Va.

7. The second examination of white perch from Solomons, Md.

8. Routine (not experimental) treatment of trout fingerlings at the Leetown Station.

9. Examination of catfishes from the Western Maryland.

10. Examination of albino brook trout fingerlings from Dallas, Texas.

PROJECT IX. FISH PRODUCTION IN SOUTHERN WATERS. T. K. Chamberlain, Project Leader

Subproject 1--The Pisgah System of Trout Stream Management

Information was obtained during the winter on the recent developments in the system of trout stream management established at Pisgah National Forest prior to the war. An article on the subject was preparpd in collaboration with Ranger Huber for the October issue of the Progressive Fish Culturist.

Subproject 2--Water hyacinth Investigations

No further work was done on this subproject. A note on the effect of hydrogen sulfide on Florida Everglades fish production was prepared from data obtained while on the water hyacinth detail.

Subproject 3--Conchas Reservoir Investigation

The fourth quarter saw the start of the reservoir study program. Practically the entire quarter was spent at Conchas Reservoir in New Mexico, a problem lake in that it had begun its fishing career at a particularly high level, only to fall in a few years to a level more than ordinarily low. Apparently it may be classed as a border lake between the cold-water and the warm-water types of impoundment. When two-thirds full of water or less, judging from its history, it shows the characteristics of an excellent bass lake. When full, the bass fishing falls off, water temperatures run so low as to reduce natural bass spawning, and it appears to be a cold-water lake that has gotten off to a bad start with its fish population. This is realized to be an over-simplification of the problem, but it makes a starting point for a consideration of known facts. The reservoir has been practically full all year.

The reservoir when full stands at an elevation of 4,201 feet. Much of the impounded water lies in two canyons, giving steep banks and considerable water depth of a hundred feet or more. During the last of May and through June the surface temperature of the reservoir rose several times above 70 degrees but never maintained such a temperature continuously for 24 hours. Through June the temperature at the surface was below 68 most of the time with a low one morning of 52 degrees. Winds have been almost continuous with frequent severe storms that have produced lake "turnovers" at least weekly. This has been determined by temperature readings at the surface and at a 70-foot depth. As a result of these winds and the evident mixing of the upper 50 to 70 feet of water to the extent that has been found, there has never been many degrees difference in temperature between the surface and the 70-foot depth mark. The difference has not been found to be over eight degrees at any time, and occasionally is only four.

Fishing has been extremely unsatisfactory, for which fact four factors are tentatively advanced at this time. First, while the game fish population, particularly of largemouth black bass, appears quite extensive, it appears too limited for the abundant supply of food. Gizzard shad were introduced into the reservoir in 1944 and have increased into a heavy population of excellent forage fish. This year at least there is evidence of unsatisfactory spawning of the black bass, possibly because of the predominantly low temperatures which fluctuate across the recognized optimum bass spawning temperature range. Now at the end of June apparently half the female bass are still carrying all their eggs. In many cases, at least, these eggs give evidence of being held dead ripe too long and of starting to disintegrate. Third, the little difference in water temperature between the surface and considerable depth appears to have "diluted" or spread out the bass population through so much water that fishing is thereby slowed down materially. This may also apply to the other game fishes present. Four, the inexperience of the average angler who fishes Conchas Reservoir has been obvious, particularly in meeting the special problems associated with the spread of the fish population both over the lake and apparently from the top to the bottom of the lake. There is evidence of this last and it is understandable in view of the thorough mixing and aerating of the lake water.

WESTERN FISH-CULTURAL INVESTIGATIONS, Frederic F. Fish, In Charge

GENERAL

Fish-cultural Consultative Service

The advisory service, maintained by District Biologists at the Grand Coulee Hatcheries and at the Coleman Hatchery of the Shasta Fish-Maintenance Project, continued throughout the year. In addition to the service extended to the Division of Game Fish and Hatcheries at these hatcheries through cooperative agreement, the Seattle Pathology Laboratory and the Corvallis headquarters were consulted for fish-cultural advice by Federal, State and private fish culturists.

PROJECT I. PATHOLOGY

Sub-project 1--Control of Columnaris Disease.

Preliminary experiments on the chemotherapy of laboratory-induced columnaris infections were conducted at the Seattle Pathology Laboratory by Dr. Rucker and Mr. Johnson.

Silver salmon fingerlings, infected with columnaris disease, were subjected to the standard one-hour prolonged treatments with 1:50,000 Roccal (10 percent) and another group treated with sulfamerazine at the 6-gram level. Subsequent mortality among the treated groups, as well as among the untreated controls, approximated 90 percent indicating little benefit obtained from the treatments under test.

Another experiment with silver salmon fingerlings involved treatment with streptomycin at three levels. Some evidence was obtained that 10 units of this drug per gram of fish per day may be beneficial in controlling columnaris disease. The invivo observations confirmed previous in vitro experiments in which 0.1 units of streptomycin per ml. of tryptone broth proved definitely bacteriostatic.

An experiment was started on April 24 by Mr.Slater at the Coleman Hatchery to determine the efficacy of one p. p. p. pyridylmercuric acetate in one-hour prolonged treatments as a prophylactic against columnaris disease. The disease has not yet appeared at the Coleman Station this year hence no effects from the treatment, aside from the fact that it has not proven toxic, have been noted.

Sub-project 2--The Development of Specific Disinfectants

The search for disinfectants efficacious in controlling diseases among hatchery fish has been continued at the three field laboratories.

The varying composition of Roccal as received from the manufacturer has complicated the use of this product which, to date, is the only disinfectant effective in controlling bacterial gill disease. Observations by Mr. Burrows at Leavenworth indicate that lots of Roccal

exhibiting a toxicity to salmon fingerlings at a concentration of 1:7,500 (10 percent Roccal) must be used at a 1:40,000 concentration, or stronger, to be effective in controlling bacterial gill disease. Lots of Roccal with an initial toxicity at 1:25,000 (10 percent Roccal) must be used at a 1:50,000 concentration, or less, to avoid risk of toxicity in routine field treatments.

The varying composition of Roccal also led Dr. Rucker and Mr. Johnson to investigate the toxic and bacteriocidal properties of the separate homologs of the product in the hope of isolating and identifying the toxic and/or bacteriocidal components. The results of Rucker and Johnson:

Length of carbon chain	Concentration tolerated by fish	Bacteriocidal 0.1% tryptone	Concentration Buffered water
6	1:25,000	1:10,000	1:10,000
8	1:25,000	1:10,000	1:10,000
10	1:25,000	1:25,000	1:10,000
12	1:50,000	1:200,000	1:100,000
14	1:400,000	1:2,000,000	1:500,000
16	1:1,500,000	1:2,000,000	1:2,000,000
18	1:800,000	1:1,000,000	1:1,000,000
"Roccal"	1:75,000	1:300,000	1:300,000

The results indicate that the toxicity to fish and the bacteriocidal properties of the alkyl-dimethyl-benzyl-ammonium chloride series, of which"Roccal"is a mixture, increase more or less proportional to the length of the carbon chain. The rate of increase of each is disproportional, however, and the myristal (14 carbon) and the cetyl (16 carbon) show the greatest disparity between a bacteriocidal and a toxic concentration. Field tests with myristal and cetyl carbon chain compounds will be made as soon as an adequate supply of each can be furnished by the manufacturer.

The varying composition of Roccal also has stimulated a search for a uniform product possessing the desired chemotherapeutic properties of Roccal. Cooperative studies have been maintained: preliminary in vitro tests of promising disinfectants being made by Dr. Rucker and Mr. Johnson at the Seattle Pathology Laboratory followed by field tests under practical conditions by Mr. Burrows at the Leavenworth Station. "Steri-Chlor" (trade name for a commercial product containing 16 percent chloramine-T) was tested at the specific request of the Division of Game Fish and Hatcheries and rejected when found unsatisfactory. Both laboratory and field tests were conducted with Hyamine 10-X and Hyamine 1622. The former proved toxic to fish in a greater dilution than was required to kill the test organism in test tubes. Hyamine-1622 proved highly satisfactory in comparative bacteriocidal and fish toxicity tests but proved ineffective against bacterial gill disease. An

interesting development arose fromthe field tests with Hyamine-1622. The characteristic filamentous bacterium described by Davis and usually considered to be the causative organism of bacterial gill disease was effectively removed by Hyamine-1622. A smaller plaque-forming organism, previously noted at Leavenworth and suspected of being the actual aetiological agent (the characteristic filamentous organism may be merely a secondary overgrowth) was not affected by the Hyamine-1622 treatments. Only preliminary observations on the effect of selective removal of the microorganisms were possible before all fingerling fish were liberated at Leavenworth during the fall of 1946.

At present writing, pyridylmercuric acetate, Emulsol-607L, and Emulsol-607M have been subjected to critical in vitro tests at the Seattle Pathology Laboratory and are awaiting field tests at Leavenworth.

An experiment involving use of certain sulfanomides in controlling an unidentified internal bacterial infection among blueback fingerlings at Leavenworth is now in progress. Preliminary observations indicate that both sulfadiazine and sulfamerazine may be of benefit in controlling the infection. Sulfathiazole proved toxic to the fish and sulfamethazine proved ineffective at the levels tested.

A check upon the value of routine prophylactic Roccal treatments at the Coleman hatchery--where bacterial gill disease has not been recognized--has been in progress since March 19. No significant difference in mortality is evident to date between the untreated group and the group receiving weekly treatments at 1:50,000 (10 percent) Roccal.

Sub-project 3--A Study of "Gas Bubble" Disease Among Salmon Fingerlings

Increased egg collections during the fall of 1946 necessitated use of both wells at the Leavenworth Station. Water from neither well can be used directly in fish-cultural operations because of high gas tension. To correct this condition, water must be run backwards through the screen chamber to effect de-aeration--the process precluding use of any rearing ponds. Lack of rearing facilities in the early spring months sharply limits the capacity of the Leavenworth Station which, in itself, is a serious disadvantage in view of the progressive upswing in adult fish returning to the Grand Coulee Project.

Following a conference with the Division of Game Fish and Hatcheries Dr. Rucker and Mr. Johnson undertook a study of "gas bubble" disease to determine the basic cause so that proper facilities could be installed for correcting the condition at Leavenworth. Early observations by Burrows, Rucker, and Johnson conclusively indicated that the accepted parallel between "gas bubble" disease in fishes and "bends" in humans is erroneous. After considerable study and experimentation, Rucker and Johnson were able to produce "gas bubble" disease at will in the laboratory. In short, "gas bubble" disease appears as a consequence of exposure to high concentrations of nitrogen at

atmospheric pressure and not, as generally assumed, from changes in nitrogen pressure. After developing equipment and a procedure for producing "gas bubble" disease when desired, further laboratory studies were temporarily postponed in favor of an investigation of new bacterial infections that appeared among fingerling stock at the Leavenworth and Entiat Stations.

Sub-project 4--A study of Unidentified Bacterial Infections at the Leavenworth and Entiat Stations

The appearance of unknown bacterial infections, accompanied by sharp and serious increases in the daily mortality rates, prompted an immediate investigation as to possible causes and control measures for the outbreaks. Various micro-organisms, including Proteus hydrophilus and an Actinomycete, were isolated from the gill surfaces and internal organs of infected fish and which proved highly pathogenic to salmon fingerlings in controlled laboratory experiments. Attempts are now being made to determine--if possible--the role of these various micro-organisms in the Leavenworth and Entiat outbreaks.

PROJECT II. FISH-CULTURAL METHODS

Sub-project 1--Biological Control

During the past year, the Leavenworth Laboratory personnel have withdrawn the surveillance previously maintained over procedures and stock at the three Grand Coulee hatcheries. This action was prompted by the pressing needs of the research program and the belief that the Grand Coulee Project was passing from an experimental project to one of routine operation.

Sub-project 2--Diet Evaluations

Limited funds precluded any nutritional experiments at the Leavenworth Laboratory during the summer of 1946. Nutritional work has been resumed, however, during the past quarter--funds from a grant to the Division of Commercial Fisheries by the Alaska Fisheries Experimental Commission supplying an assistant to care for the fish on experiment. The problems under study at Leavenworth emphasize use of fish products and include: (1) a comparison between the Cortland #6 diet and the standard diet developed in 1944 at Leavenworth; (2) the effect of various methods for processing fish meals upon the nutritional properties of the product; (3) an evaluation of diatomaceous earth and kelp meal as mineral sources; (4) the nutritional adequacy of salmon viscera as a substitute for beef liver; and (5) the nutritional adequacy of prepared frozen diets in comparison with the same diets freshly prepared.

Diet evaluations likewise have been undertaken by Mr. Slater at the Coleman Station to investigate nutritional problems pertinent to the products available in California. In cooperation with the Division of Game Fish and Hatcheries, a series of experiments was undertaken to test locally available substitutes, and previously untested ingredients, in the so-called "standard" diet in use at the Coleman

hatchery. The "Standard Diet" at Coleman varies from the "standard diet" at Leavenworth chiefly in the use of salmon carcass--of which a high grade product is available without cost at Coleman--in place of salmon viscera which is difficult to obtain in California. The variants included in the Coleman experiments include: (1) horse meat in lieu of beef spleen; (2) Columbia River salmon viscera (eggs removed) in lieu of Sacramento River salmon viscera; (3) a locally manufactured bone and meat meal in lieu of "V. D." fish meal; and (4) use of kelp meal as an absorbent and mineral supplement. The results obtained since the experiment started on April 22 indicate that none of the ingredients tested possessed any advantage over those in the Coleman "standard diet."

Sub-project 3--Fungus Control on Incubating Salmon Eggs

The application of prolonged treatments to reduce the amount of labor required in removing infertile eggs was investigated both at the Coleman Laboratory and at the Leavenworth Laboratory. Unless dead eggs are frequently removed from baskets or trays, fungus development will rapidly kill many eggs surrounding the focus of infection. In large-scale salmon operations egg picking constitutes a costly undertaking.

At the Coleman Laboratory, Mr. Slater used six different treatment schedules on 24 lots of eggs averaging 33,000 eggs per lot in studying the value of prolonged treatments with malachite green. His results showed that routine semi-weekly treatments with 1:200,000 malachite green--including a final pick-off of infertile eggs--cost $0.013 per thousand eggs treated through the green stage. In comparison, the usual procedure of picking eggs at weekly intervals cost $0.039 per thousand eggs during the same stage of incubation. The comparison obtained by Mr. Slater is most favorable to egg picking for the percentage of fertilization on the eggs used was exceptionally high. The lower percentage fertilization ordinarily obtained at salmon hatcheries would greatly magnify the discrepancy in comparative costs for those of treatment would not be materially increased by the presence of more dead eggs whereas the cost of egg picking would be much higher--roughly in direct proportion to the mortality.

At the Leavenworth Laboratory, Mr. Burrows obtained equally good results from treating eyed eggs with either 1:1,000 formalin or with 1:200,000 malachite green.

Sub-project 4--The Use of Roccal Ice in Prolonged treatments

Mr. Burrows developed a method for administering routine prolonged treatments with Roccal applicable to the circulating-water type of rearing pond at the three Grand Coulee Stations. Roccal was mixed with water in a 1:453 concentration and frozen (one pound of ice therefore contained one gram of Roccal). The desired weight of chipped Roccal ice was shovelled into the pond under treatment and movement of the water evenly distributed the disinfectant as the ice melted. Use of Roccal ice instead of the usual pump reduced the time required to apply a prolonged treatment by 80 percent.

Sub-project 5--The Use of Physiological Saline in Salmon Spawning Operations

Experiments conducted at both Leavenworth and Coleman indicated conclusively that physiological saline in spawning pails during egg collection is of no benefit provided good spawning technique is employed. The results obtained at Coleman show that the use of physiological saline actually may be detrimental presumably because of the factor of a diluted concentration of sperm.

Sub-project 6--Waterhardening of Salmon eggs in Transit

Mr. Slater found by correlation analysis of the percentage loss to the eyed stage (among 32 lots of eggs averaging 36,500 eggs per lot) that the elapsed time (limits land 130 minutes) between washing the fertilized eggs and the start of a four-mile haul by truck gave a coefficient (r) of -0.08. Mr. Slater's findings at Coleman confirmed earlier conclusions by Burrows at Leavenworth that salmon eggs may be transported safely during the waterhardening process.

Sub-project 7--An Evaluation of Egg Enumeration Procedures

Various methods for enumerating salmon eggs were critically evaluated at the Leavenworth Laboratory by Mr. Burrows. Using hand counted numbers of eggs, it was found that the "von Bayer" technique--which is regularly employed at salmon hatcheries--not only proved the least accurate but also the most time consuming. The displacement method for counting eggs, developed last year at the Leavenworth Laboratory, was found to be the most accurate but it required almost as much time as the von Bayer technique. The method developed jointly by the biological and fish-cultural staff at Coleman was found to offer the most acceptable compromise between accuracy and time required. The results:

Method	Range of Method at 5% level	Estimated Time Required to Enumerate one million chinook eggs
"von Bayer"	+1.61 to +10.17%	8.5 man hours
Coleman Weight	-5.4 to +5.4%	3.5 " "
Improved Coleman Weight	-3.39 to +3.39%	3.8 " "
Displacement	-2.77 to +2.77%	7.0 " "

Sub-project 8--The Carrying Capacity of Salmon-Cultural Rearing Equipment

A preliminary experiment conducted at Leavenworth during the summer of 1946 indicated that the environment of the Foster-Lucas type of rearing pond is more conducive to the development of bacterial gill disease than is that of the circular pool. The circular pool likewise was found to carry a considerably greater poundage of fish per cubic foot of water than the Foster Lucas pool. The observations of 1946 were merely designed to establish limits for more critical studies to be undertaken during the summer of 1947.

An experiment at Leavenworth designed to measure the optimum carrying capacity of the standard deep type trough for varying sizes of blueback salmon fingerlings was abandoned during the quarter after an unidentified internal bacterial infection appeared among the stock.

A comparable experiment conducted at the Coleman hatchery also ended with inconclusive results following complications arising from the spray painting of the hatchery interior, cleaning the water supply ditch, and several improper feedings of the experimental fish by the fish-cultural personnel. The results did indicate that water flows of 5 g.p.m. and 12 g.p.m. exerted no effect upon the growth rate of chinook salmon fingerlings in deep troughs. The results also indicated that light intensity may be an important factor affecting fingerling growth rates in deep troughs.

An experiment is now in progress at Coleman to establish the optimum carrying capacity of the station raceways. The experiment has not been in progress for a sufficient time, as yet, to warrant conclusions.

PROJECT III. STUDIES IN THE APPLICATION OF ARTIFICIAL PROPAGATION

Sub-project 1--A Critical Review of Columbia River Fall Chinook Propagation at the Spring Creek Hatchery

Dr. Fish made an analysis of the production records of the Spring Creek (Big White Salmon) hatchery during the past quarter century. Although the adult fish returning to this hatchery must be the products of artificial propagation, little evidence of association could be found between the number of returning adult fish and the number of fingerlings released. Indirect evidence was found indicating that unknown factors affecting the river populations as a whole exerted a greater effect upon the number of returning adult fish than did the number of fingerlings released.

Sub-project 2--Hatchery Site Survey

A survey for potential salmon hatchery sites in the lower Columbia River Basin (i.e. below the McNary Dam site), undertaken during the spring of 1945, was discontinued in September 1946, for lack of funds. The data acquired in this survey is being compiled in report form at the present time.

Sub-project 3--Interim report on the Grand Coulee Fish-Maintenance Project

Dr. Fish has devoted considerable time to the preparation of a joint report with Mr. M. G. Hanavan of the Section North Pacific Fishery Investigations. This report will include a record of the Grand Coulee Fish-Maintenance Project from its inception in 1939 to the present time. Because 1947 promises to be a critical year for determining the success of the unprecedented fish-relocation project, completion of the report is being withheld until the returns during the summer of 1947 are known. Aside from the 1947 records and the influence they may exert upon certain conclusions, however, the report has been completed during the past year.

Sub-project 4--Report on the Shasta Fish-Maintenance Project

The Coleman hatchery records, 1942-1946, were reviewed and summary data on operations were compiled and analyzed by Dr. Fish during the past quarter. These data will be presented as part of a joint report with Dr. Moffett, Section Southwestern Inland Fishery Investigations, and Mr. Fred J. Foster, Regional Coordinator, River Basin Studies, that was requested by the Washington Office. The purpose of the report is to outline the need for continuing financing of the Coleman Station by the U. S. Bureau of Reclamation.

Sub-project 5--Artificial Propagation of Alaska Pink Salmon

The use of artificial propagation for supplementing natural propagation and for relocating surplus stock from areas of overabundance to areas with diminished runs, appears both economically and biologically feasible in the case of Alaskan pink salmon. Following numerous discussions and conferences with personnel of the Division of Alaskan Fisheries and Section Alaska Fishery Investigations, Dr. Fish prepared an outline of background information, salient problems, and proposed investigations. The outline was submitted to the Washington Office.

SECTION OF SHELLFISHERIES, Paul S. Galtsoff, Chief

GENERAL

Rehabilitation of Oyster Resources in Texas

After visiting the coast of Texas, in March, P. S. Galtsoff prepared at the request of the Texas Game, Fish and Oyster Commission a memorandum summarizing his observations regarding the State program of rehabilitation of oyster bottoms. A high level of production of public oyster bottoms may be maintained in Texas only through a system of management, which consists in the reshelling of bottoms, transplanting of seed, and controlling the harvesting. These operations involve a considerable initial investment and require large operating funds which may not be available to the State organization. Experience in several Atlantic States shows that, under the present conditions, the replanting of one acre of bottom with seed oysters costs not less than $150.00. With many thousands of acres requiring reseeding, the rehabilitation of grounds may require several millions of dollars which are not available to the Texas Game, Fish and Oyster Commission. The other alternative is, of course, the leasing of depleted bottoms to private persons. According to the Texas oyster laws, only those oyster bottoms may be leased to private persons which have been unproductive for five consecutive years. This presents a great obstacle to the leasing program of the State.

There are, however, within the State waters large areas of bottoms, not listed as public ground, which may be adapted to cultivation. The State laboratory under the direction of Mr. Baughman undertook to study this problem by making a number of experimental plantings with the view of finding, a) what type of bottom is most suitable for establishing an oyster bed, b) what is the most desirable density of planting of shells and seeds, and c) what type of seed can be used more advantageously for planting. This work is carried out at present only in Aransas Bay, because the difficulties in patrolling large areas make it impossible to extend the program to the grounds far removed from State headquarters.

Examination of several plantings, made since January 1947, shows that mortality among the oysters planted on newly established beds is rather low and is confined primarily to small oysters, less than one year old. Reefs of Copano Bay provide the principal source of supply of seed used for planting. Copano Bay oysters are usually of a poor quality. On the reefs of this bay they remain thin, their growth is dwarfed, and the meats are frequently discolored.

On previous examinations these oysters were found to be heavily infested by Nematopsis. These observations were confirmed again in March 1947. The percentage of infested oysters was high and a large number of cysts was found in the gills, blood vessels and in the mantles. In spite of such heavy infestation, oysters transplanted from Copano Bay to experimental lots in Aransas Bay showed remarkable recovery. Several weeks after planting the shells materially increased in length and width, the meats were firmer, whiter and contained a fair amount of glycogen. So far, the experiments in transplanting Copano Bay oysters are very successful and appear to be very promising.

Salvaging seed from shucking houses is another principal problem in the conservation of oysters in Texas. Oystermen delivering oysters to the shucking houses are paid by the number of gallons shucked from the load, not by the bushels of oysters delivered to the plant. State oyster law requires that culls of oysters taken from the oyster reefs be scattered, but in practice the law is not enforced. Examination of shell piles near the shucking houses disclosed that every shell of an adult oyster opened by the shucker had from two to ten seed oysters, about one inch long, attached to it. On the average, the shucking houses in Texas destroy at least five young oysters for each oyster used for the market. Very often the shucker neglects to open all the adult oysters in a cluster and, after removing the meat of one, throws the rest away. These oysters may be salvaged if they are immediately removed from the shell pile and returned to the water within 48 hours. Successful solution of this problem may stop further destruction of oyster resources in Texas and bring about gradual rehabilitation of oyster bottoms.

Conference at the University of Miami

At the invitation of the President of the University of Miami, Dr. P. S. Galtsoff attended early in April the conference of the Advisory Board appointed by the President to consider the problems of the establishment of a new Marine Biological Laboratory in Miami. The board was also asked to inspect several sites available near Miami and to make recommendation regarding the most suitable location for the laboratory. After three days of deliberation the board made a number of suggestions regarding the research in conservation of marine fisheries of Florida and recommended that the Marine Laboratory of the University be recognized as a research agency for the office of the State Supervisor of Fisheries.

RESEARCH LABORATORIES

U. S. Shellfish Laboratory, Milford, Connecticut, Victor L. Loosanoff, Director.

A survey to assemble all available data on the nature and abundance of various marine forms, except vertebrates, for Long Island Sound and the Atlantic Ocean off Long Island was completed early in April and a comprehensive report on the results was submitted to the Chief of the Division. The survey summarized data on all important aquatic invertebrates in inshore and offshore waters indicating their economic values and giving a description of the industry dependent upon them.

With permission of the Director of the Service, Dr. Loosanoff appeared before the State of Connecticut Committee on Fisheries to testify in favor of the measure which would prohibit indiscriminate introduction of all foreign species of shellfish in local waters. The bill was passed later by the State Assembly.

Two graduate students of Yale University, candidates for the Ph. D. degree, applied for permission and are now working at the Milford laboratory on their thesis problems. Mr. William D. Hartman is conducting studies under the direction of Dr. Loosanoff on the life history of the sulphur sponge which affects oysters. Mr. Joseph B. Foley is experimenting with the effect of radio-active salts on certain invertebrates. The following bulletins were issued by the Milford laboratory:

Volume 11.

1 - On growth and transplantation of oysters during different months of the year

2 - Distribution and occurrence of starfish on Connecticut oyster beds in the spring of 1947.

3 - Effects of DDT upon setting, growth, and survival of oysters.

4 - Observations on gonad development, spawning, and setting of oysters in Long Island Sound.

Pensacola Research Laboratory, A. E. Hopkins, In Charge

The Pensacola laboratory was inactive in April. In May, the personnel of the station received notices of separation and were on terminal leave. The operation of the station was discontinued because of lack of funds for the coming fiscal year. It is Hoped, however, that the activity of this station will be resumed if funds become available.

Hampton, Virginia, Laboratory, P. A. Hanson, In Charge

With the completion of the pollutional studies in the Hampton Roads Area, the work of the Hampton Laboratory was discontinued in May and personnel placed on terminal leave. Floating equipment has been moved to Annapolis and a considerable portion of bacteriological apparatus was transferred to the Leetown laboratory. With the closing of the laboratory the work in Chesapeake Bay will be conducted from Annapolis.

Woods Hole Research Laboratory, Paul S. Galtsoff, Director

In April the Director approved the designation of Paul S. Galtsoff as Director of the Woods Hole Station. With the closing of the hatchery and discontinuation of hatching operations, the station was transferred to the Division of Fishery Biology. Buildings and grounds of the station, badly damaged by the hurricanes of 1938 and 1941, have been only partially repaired. Laboratories on the second floor of the building have been reconverted after the occupancy by the Navy to their former purpose and were open to investigators on June 16. During the month of June, the aquaria tanks were recaulked, pointed and their outside woodwork painted. Late in June contracts were awarded for asphalt tile floor covering in the aquarium and the lobby. The work was completed about July 1. Invitations to bid were issued for repair of the sea wall and

refill of grounds around the Fishery Residence building and along the street. The lowest bid was within the sum available for this purpose and it is hoped that this urgent work will be completed within a short time. The repair of part of the sea wall is essential to stop further erosion of Fisheries grounds, which, during the past winter, reached a dangerous point and threatened to undermine the main street of the town. The decision to repair the sea wall along the street and to reopen the aquarium is greatly appreciated by the Woods Hole community.

The operation of the research laboratory and the proposed opening of the aquarium about July 10 were made possible because of the cooperative agreement made with the Marine Biological Laboratory. In exchange for the use of the six laboratory tables and storage tanks in the hatchery room at the Fishery Building, the Marine Biological Laboratory agreed to supply the Fishery investigators with live material and certain chemicals, glassware, and apparatus. Furthermore, the Marine Biological Laboratory granted the Fisheries investigators the privilege of using its library on the same basis as the members of the Marine Biological Laboratory Corporation.

In view of absence of any floating equipment, except one 12-foot skiff, the problem of obtaining live material for the aquarium presented great difficulty. It is expected, however, that live fish and invertebrates will be supplied both by the Marine Biological Laboratory and the Woods Hole Oceanographic Institution. Local fishermen also have promised their cooperation. A considerable number of living specimens have been already collected in Long Island Sound and brought by truck from the Milford Laboratory.

Changes in Personnel

Miss Helen Landau, aquatic biologist, P & S-1, was transferred to Annapolis and her place was taken by Arthur S. Hale, aquatic biologist, P. & S-1, transferred to College Park from the Spearfish, South Dakota, Laboratory. Mr. Hale reported for duty at College Park on June 21 and assisted Dr. Chipman in the field survey of Lynnhaven Inlet, Virginia.

Mr. Albert E. Sanderson was appointed as temporary clerk-stenographer at Woods Hole, Massachusetts, and reported for duty on June 20.

Convention of National Shellfishery Association

On June 4 to 6, Messrs. W. A. Chipman, Jr., J. B. Engle, P. S. Galtsoff, and V. L. Loosanoff attended the annual convention of the National Shellfisheries Association and Oyster Growers and Dealers of North America at Asbury Park, New Jersey, and presented the following papers:

W. A. Chipman, Seasonal changes in the fattening of oysters;
P. S. Galtsoff, Respiration in oysters;
V. L. Loosanoff, Effect of Turbidity on the rate of pumping of water by oysters;
J. B. Engle, Distribution of oyster setting guides the Maryland program of management.

Dr. V. L. Loosanoff was elected President of the National Shellfisheries Association.

FIELD INVESTIGATIONS

At the request of the Chief of the U. S. Engineers, Dr. Walter A. Chipman, Jr., made a survey of Lynnhaven Inlet, Virginia, for the purpose of determining the probable effect of the proposed improvement of the Lynnhaven Inlet on oyster and crab fisheries of the Inlet and its connecting waters. Dr. Chipman was assisted in the survey by Arthur S. Hale, aquatic biologist, and R. O. Zeller, biological aid. Men and boats were supplied by the Corps of Engineers and the Virginia Commission of Fisheries.

Lynnhaven Inlet and its connecting waters have produced large quantities of excellent quality oysters in the past, oysters which are distinctive in flavor and quality and marketed under the name Lynnhaven oysters. Extensive crab and clam fisheries are also carried on in these waters. A decline in fishery production and in the quality of the seafoods produced has been of great concern to the people of the area.

Much of the decline in the fishery production has been attributed to the shoaling of the waters and diminution in the tidal exchange, resulting primarily from the partial closing off of the Inlet by the construction of fill areas for a highway bridge.

The Corps of Engineers is considering improving the Inlet by building jetties and dredging the channels so as to allow the use of the waterways by commercial fishing and oystering boats of greater draft and to give sufficient tidal exchange to benefit the fish and shellfish of the inside waters. In order to ascertain the present condition of the shellfish producing areas and to recommend changes for improvement, a survey of the area was made in late June.

From the results of the survey it was found that there was very slight tidal exchange in certain areas, but the inflow of fresh water in small amounts is apparently balanced by evaporation so that, in the main, the salinity of the waters varies but little from what it was some 33 years ago. Lowered salinity in the spring from excessive run-off does lower the salinity of the water in the upper reaches but it is possible that evaporation causes a rather high salinity to prevail in the late summer.

The most critical situation as regards shellfish production lies in the accumulation of silt and the lack of water of sufficient depth for the operation of boats for the proper cultivation of the shellfish-producing bottoms. The complete report of the survey is being prepared for submission to the Corps of Engineers.

RESEARCH PROGRAM

PROJECT I. PHYSIOLOGY, PROPAGATION, GROWTH AND FATTENING OF OYSTERS

Subproject 1--Metabolism of Oysters

A study of the metabolism of oysters, carried on for several years and interrupted during the war, has been resumed during the present fiscal year. The purpose of this physiological investigation is to determine the rate of

oxygen consumption and the carbon dioxide production of adult oysters during various seasons of the year. This knowledge, it is believed, provides a key to the understanding of the conditions inside the organism and in its environment which control the deposition of glycogen, or, in other words, make the oyster fatten. The work carried out by D. S. Galtsoff with the assistance of W. A. Chipman, Jr., is related to the study of the seasonal changes in the chemical composition of oysters (subproject 10) conducted by W. A. Chipman, Jr. The tests made in the course of the present study were designed to answer the following questions: a) what is the minimum requirement of oxygen for an adult oyster, b) are there significant changes in oyster metabolism during various seasons of the year, and c) are there significant differences in the respiratory quotient of oysters of different sex and during different seasons.

Table 1.--Seasonal changes in the oxygen intake of adult Long Island oysters about 10 cms. long and 7 cms. wide. All tests made at 25 degrees C. Oysters 50-62 were tested in 1940 at Woods Hole. All other tests made at Milford, Connecticut. The oxygen intake is in ml. per hour.

OYSTER NUMBER	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July
50	3.51	2.92				1.8		1.8	1.6			1.4	1.9
51	2.69							2.0				1.5	
52	2.45	1.08		1.25			1.3	1.7	1.1			1.2	
53	3.08								2.5				
55	3.65			2.10			2.5		2.8		1.9	3.3	3.0
56		2.86			1.7	2.2			2.0			3.1	2.0
62	3.28			1.8			1.4		2.2			3.8	3.0
M-1						2.4		1.8	1.6				
M-4							2.4		2.7		2.7		
M-6							2.9				2.8	3.1	
M-9								2.1		2.2	2.4		

Table 2.--Mean O_2 intake, in ml. per hour, per oyster, determined in July before spawning, and 2 weeks and 1 month after spawning. The figures are the mean values compiled from 6 observations made at half hour intervals.

TIME OF OBSERVATION	OYSTER NUMBER										
	1	2	3	4	5	6	7	8	9	10	11
Before spawning July	4.29	3.39	3.00	5.13	4.01	2.53	5.84	4.89	3.11	3.64	5.17
Two weeks after spawning August	4.73	3.02	2.84	3.89	3.21	3.10	4.11	4.00	3.08	2.78	5.10
One month after spawning August	3.96	2.38	1.93	3.39	2.26	3.03	2.95	3.12	2.53	2.23	4.37

Under stable conditions of the environment, i. e., when the temperature, salinity and pH of the water remain constant, the intake of oxygen by individual oysters continues at a steady level for a long period of time.

A decrease in the pH reduces the oxygen consumption, and at pH 5.5 respiration slows down to less than 10 percent of its normal rate.

A sudden decrease in the salinity of water from 31 to 24 parts per thousand results in an increased oxygen consumption. Whether this effect holds true for a greater change in the concentration of salts will be shown by further experiments which are now in progress.

The respiratory quotient (R.Q.) was found to fluctuate from 0.7 to 1.2 with no significant correlation with the sex of the oyster or the season of the year.

Oysters which have been kept for a long time out of water show an increased demand for oxygen during the first hour of the test. This is due to the depletion of the oxygen supply in their tissues--the so-called oxygen debt. After the demand for O_2 is satisfied, the intake of oxygen falls to its normal level.

Several conclusions of practical value to the oyster growers can be drawn from these studies of respiration. Since the oxygen demand of oysters is greater during the spawning season, an additional supply of oxygen, greatly in excess of the normal requirements of adult oysters, is needed for the spawn. It is, therefore, important that in establishing spawning grounds the oyster growers select such areas where the water near the bottom is well oxygenated.

After the oysters are removed from water and kept in the air for several days, their metabolic rate is greatly increased to satisfy the incurred debt of oxygen. This fact should be kept in mind when oysters are conditioned for the market in purification or storage tanks which are frequently overcrowded.

An increased acidity of sea water measured by the decrease in its pH value reduces the rate of respiration and creates conditions unfavorable for oyster metabolism. Acid conditions on oyster bottoms may be caused by overcrowding, fouling of shells, and pollution of water by chemical wastes.

From the result of laboratory studies the inference can be drawn that oysters of good quality cannot be produced in the waters containing substances which suppress their normal rate of respiration. Likewise, good, fat oysters are not expected to be found in waters contaminated with trade wastes or other materials which irritate their neuro-muscular system and cause increased shell movement. The presence of these foreign substances in natural waters increases the oxygen demand of oysters and results in the burning up of reserve material in their meat. Oysters grown under these conditions fail to fatten and are generally poor.

Subproject 2--Spawning and setting of oysters in Long Island Sound, V. L. Loosanoff and C. A. Nomejko

The main facts of the 1946 setting season observed by the staff of the Milford Laboratory are as follows: Setting began July 21 and continued until September 29. During this period two definite peaks were observed, one occurring between July 28 and August 4, and the other between September 1 and 8. The intensity of setting was relatively higher during the first peak but the second wave of setting was quite heavy and added considerably to the commercial oyster set. During the setting season, members of the oyster industry were advised through the medium of bulletins issued by the Milford laboratory about the setting, growth and survival of young oysters in different parts of Long Island Sound.

Subproject 3--Feeding and fattening of oysters in northern waters, V. L. Loosanoff

A series of experiments was conducted at the Milford laboratory to determine the average quantities of water pumped by the oysters at different temperatures. This study has been completed and the material is now being analyzed and tabulated for publication.

Experiments and analysis of the data on the effect of turbidity upon oysters were completed and the preliminary report was prepared. Experiments consisted in observing the change in rate of feeding and shell movement of the oysters when exposed to silt, kaolin, chalk, and fuller's earth in concentrations ranging from 0.1 to 4.0 grams per liter. It was found that even in the lighter concentrations, the behavior of the oysters was noticeably affected as shown by the change in their shell movement and by a decrease in the rate of pumping. In higher concentrations the rate of pumping was decreased as much as 94 percent. The observations closely resembled those made in previous studies by V. L. Loosanoff where the oysters were exposed to large quantities of microorganisms, such as Chlorella, Nitzschia, etc. In general, the results of the two studies showed a definite similarity in the behavior of oysters in turbid waters regardless of whether this turbidity was caused by a large number of microorganisms or by silt.

Experiments on the effect of a low pH upon the rate of feeding of oysters also progressed far enough to form general conclusions. It was found that oysters exposed for approximately three hours to water of pH between 7.0 and 6.75 increase the rate of flow. Below pH 6.5 the rate of flow begins to decrease. The oysters continue, however, to pump water, although at a very reduced rate, even when the pH is reduced to 4.2.

Subproject 7--Biology of oyster spat and growth of oysters. V. L. Loosanoff and C. A. Nomejko

Studies on the growth of oysters during each month of the growing period, which were begun in May 1946, were completed. Observations showed that the oysters in Long Island Sound resumed growth in April and during that month achieved 2.2 percent of the total annual growth. The oysters continued to increase in length until the end of November. However, the rate of growth greatly varied during the different months. The increase in length was most rapid during May (22.6 percent), June (19.0 percent) and July (22.1 percent).

During August and September the oysters still showed quite a rapid growth, which was 12.8 percent and 15.9 percent respectively. During October and November the oysters showed only 3.6 percent and 1.8 percent respectively of the total annual increase in length.

On the basis of this information, and of the degree of hardness of the shell, a bulletin was issued to advise the oystermen during what month dredging, and shifting of oysters may be practiced without causing much damage to the oyster shells. In general, these recommendations may be summarized as follows:

In January, February and March the oysters may be shifted provided they are not allowed to freeze. April is a very good month for shifting. From the middle of May to the end of October oysters should not be dredged or mopped. The second part of November and December are good months for shifting.

Observations on the growth and survival of two groups of oysters, one brought from Chesapeake Bay on May 20, 1946, and the other collected from Long Island Sound on the same date, are being continued. The initial mean length of the Chesapeake Bay oysters was 24.5 mm. and the width, 20.7 mm. At the end of the hibernation period in the middle of April 1947, the mean length for this group was 60.7 mm. and the width, 51.4 mm. The Long Island Sound oysters measured 23.9 mm. in length and were 20.6 mm. wide at the beginning of the experiment. In April 1947, the mean length of this group was 63.0 mm. and the width, 51.1 mm. The mortality rate was much higher for the Long Island Sound than for the Chesapeake Bay group. In general, the shells of the Chesapeake Bay oysters are much heavier and sturdier than those of Long Island Sound.

Subproject 10--Seasonal variation in chemical composition of oysters,
W. A. Chipman, Jr.

More and more attention is being given to the production of oysters with high quality meats. So often are we called into an area to investigate the failure of oysters to fatten properly and give a good yield that consideration must be given as to what is involved in this fattening process. True fattening of oysters is reflected in a low water content and a high carbohydrate content. Change in protein and fat are not of particular importance in fattening. This accumulation of carbohydrate is almost entirely in the form of glycogen, or animal starch. As the carbohydrate requirements of the organism vary, so does the quantity of glycogen present fall or rise. In case of need it is apparently converted mainly into glucose, and ultimately undergoes complete hydrolysis and oxidation. Rise of temperature, increased functional activity and diminished food supply are the chief factors which may produce a reduction in the amount of glycogen present in the oyster.

In the course of studies made throughout a number of years, rather extensive information has been collected on the chemical constituents of oysters from a number of localities, particularly of the glycogen content. Oysters have been analyzed from Long Island Sound, various localities in the Chesapeake Bay, particularly in the lower Chesapeake Bay, the Piankatank, York, and James River, and a few samples from South Carolina, Texas, and other points.

If we examine the results presented in table 3, it can be seen that the accumulation of glycogen in the oysters follows a definite seasonal pattern, as has been pointed out so many times in the work of other investigators. There is a period of low glycogen in the late summer, which is followed by an increased storage of glycogen in the fall and early winter until the time of hibernation. The period of high glycogen is followed by a sharp decrease in the spring as the oysters resume their activity and spawn, reaching a low glycogen reserve again after spawning.

Table 3.--Percentage glycogen in dried meats of oysters from various localities in different months.

	Long Island Sound	Lower York River	Piankatank River
August	13	12	10
September	21	12	10
October	25	15	14
November	28	17	18
December	29	19	22
January	27	20	24
February	35	25	29
March	37	25	22
April	26	24	26
May	30	19	23
June	23	13	23
July	19	12	12

The glycogen content of oysters collected from various localities follows the same seasonal pattern, but differ quantitatively. The oysters from Long Island Sound appear to build up glycogen reserve earlier in the fall than do the oysters from the lower Chesapeake Bay. It should be pointed out that fattening of oysters has barely started in September when the oystering season begins, and that the same oyster would be fatter and give a much greater yield if marketed in November and December.

It was observed that fattening of oysters from the same beds differs from year to year.

Attention should be directed to the condition of the water, the abundance of food and, perhaps, the type of food available during the late summer when the oysters are the most active and are vigorously feeding. This is the most critical time of the year as regards fattening as it is at this time that reserve is being stored.

Outside factors regulating the fattening of the oysters, such as water temperature, salinity, currents, availability and type of food, bring about this regulation by changing or altering the inner or physiological activities of the oyster itself. It is through a study of the metabolism and physiology of the oyster, under both normal and abnormal conditions, that we can interpret the mechanisms of fattening and the loss of this carbohydrate reserve. It is to this end that future studies are being directed.

Subproject 11--Biology of the Oyster larvae, V. L. Loosanoff and H. C. Davis

Observations and experiments on the precocious gonad development of oysters, inducing spawning, and the laboratory culture of oyster larvae were continued at the Milford laboratory. The work is still in a preliminary stage, consisting largely in developing a standard method for growing larvae.

PROJECT II. ECOLOGY OF OYSTERS

Subproject 3--Ecology of oyster bottoms in Chesapeake Bay, James B. Engle and Phillip A. Butler

1. Spawning and setting of oysters Plankton samples were collected at weekly intervals at most of the stations used for gathering oyster setting information. All oyster larvae were recorded and grouped into age classes as follows: 1-4 days (straight hinge), 5-9 days (early umbo), 10-14 days (late umbo), older and ready to set ("eyed"). These ranges are somewhat arbitrary and may vary with temperature and other environmental changes.

The larvae per sample were less abundant in the upper parts of the rivers and Bay than at the mouth or lower parts. This was true for all cases except the Chester River. The difference is probably due to the fact that the mouth of the Chester River is wide and is therefore affected by the "Head of the Bay" region where larvae were relatively few in number. The results of the observations are summarized in Table 4.

Table 4.--Average number of oyster larvae per sample.

Name of Station	Straight hinge	Early umbo	Late umbo	"Eyed"	Total
Eastern side of the Bay					
Gum Thicket (lower)	56.7	19.2	2.5	9.2	87.5
Love Point	23.3	0	3.3	0	26.7
Tolchester (upper)	50.0	13.3	0	0	53.3
Western side of the Bay					
Middle Ground (lower)	61.6	22.3	3.0	1.6	90.0
Man-o-war (upper)	21.3	11.3	0	0	32.3
Choptank River					
"B." Buoy (lower)	147.3	114.5	30.9	9.1	301.8
Kirbys Bar (upper)	33.3	35.0	2.5	0	71.7
Eastern Bay					
Millhill (E side of bay)	41.4	103.6	24.3	8.6	177.9
Boadkin Rock (W side)	80.0	186.0	20.0	5.0	291.0
Chester River					
Love Point (lower)	23.3	0	3.3	0	26.7
Oldfields Bar (upper)	295.5	88.2	5.5	0	389.1

Oyster larvae appeared in the tributaries several weeks earlier (June 14) in the Bay proper (July 2 and 3). To some extent this was also true of the time of maximum numbers of larvae. In the lower part of the Bay the maximum number of larvae were found around the end of July while in the upper part it was recorded at the end of August. In the tributaries the maximum occurred several weeks earlier than in the adjacent portions of the Bay,

2. Oyster setting in Chesapeake Bay and Tributaries during 1946

The observations on the setting of oysters in Chesapeake Bay and in some of the tributaries were started June 12, and terminated October 11, 1946. The results are summarized in part in Table 5. For the 1946 season in general, the setting was heavier in the lower portions both in the Bay and in the tributaries. On the eastern side of the Bay there was a sharp break in the distribution of setting between Gum Thicket and Broad Creek. The same definite break did not show on the western side in a parallel line of stations, although a gradual drop from 4.5 to 0 set per 10 shells was evident as the "Head of the Bay" was approached. From the study of the distribution of setting an inference is made that the "Head of the Bay" is not a good setting area.

Table 5.--Total average oyster set on 10 shells taken from the test bags placed at the sampling stations in Chesapeake Bay, Chester River and the Choptank River during 1946.

Chesapeake Bay Proper					
Eastern side			Western side		
Station[1]	Total average oyster set on 10 shells	Range[2] bot.sal. in o/oo	Station[1]	Total average oyster set on 10 shells	Range[2] bot.sal. in o/oo
		4.67			4.80
Gum Thicket	102.0	12.81	Middle Ground	4.5	13.78
		4.26			3.48
Broad Creek	6.0	13.37	Sandy Point	3.0	12.07
		4.27			3.32
Love Point	5.0	13.65	Gibson Island	1.5	9.24
		fresh			fresh
Tolchester	4.5	13.91	Man-o-war	0	8.08
Chester River			Choptank River		
		5.95			7.02
Blunts Bar	8.5	12.39	"B" Buoy	58.5	12.59
		5.70			8.71
Old Fields	2.0	10.28	Piney Island	10.5	12.59
					7.65
			Kirbys	0	11.29

1/ Stations are arranged in the table with the first in the column representing the lower portion of the area and the last the uppermost station.

2/ Salinity range is that of the period of the setting observations with the figure on top in each pair the salinity for the week of June 15, and the figure at the bottom the salinity of the week of September 15.

The period of setting and its progress through the season was checked by examination of shell bags replaced at weekly intervals at 13 major stations. The intensity may be considered light in most places but in isolated instances was sufficiently heavy to be of commercial significance. This was particularly true of Eastern Bay where one of the principal seed areas is located. The set here averaged better than one spat per shell, i.e., exceeded 500 spat per bushel. Likewise, setting in excess of 500 per bushel occurred at Gum Thicket in the Bay proper, "B" Buoy and Piney Island in the Choptank River, and Bodkin Rock in Eastern Bay.

3. Survey of the conditions of oyster bars in Maryland waters In October and November of 1946 all the major bars in the Maryland part of Chesapeake Bay and tributaries were visited by a survey party of biologists of the Fish and Wildlife Service, the oyster investigators of the Maryland Department of Research and Education and members of the Maryland Department of Tidewater Fisheries. The principal items recorded were the age distribution of oysters on the bars, the surviving crop of 1946 set, the types and occurrence of fouling organisms and the condition and amount of cultch on the bars.

The number of oysters both of market and smaller sizes were found to be meager in the Bay proper, and the only bars with any reasonably abundant supply were those recently planted by the State. These areas were small in acreage. The progress in the State management program has been hampered by insufficient funds, and lack of shells and seed for planting. The areas worked under this program made possible, however, a stemming of the decline in production evident over the last few decades.

The 1946 oyster set was found to be light in most places in the Bay, very few areas having more than 100 spat per bushel. The greatest concentration of spat occurred in the vicinity of the lower Kent Island and Poplar Island on the eastern side of the Bay. The setting on the western side was generally lower.

Cultch on all bars in the Bay was inadequate and badly fouled with barnacles, Bryozoa, Molgula, and silt. This may be one of the factors responsible for the low intensity of setting in Maryland waters.

4. A study of the oyster gonads at two places with divergent ecological conditions The extensive flood waters occurring in the upper reaches of Chesapeake Bay during the summer of 1945 and spring of 1946 resulted in an oyster mortality approaching 70 percent. The oysters remaining alive were in an extremely poor condition. In order to observe the effects of this adverse environment on the reproductive activities of the oysters, weekly collections of ten or more market size oysters were made by Phillip A. Butler during the above spring and summer of 1946, and at longer intervals during the fall and winter. Comparable samples were collected from Millhill Bar in Eastern Bay where the environmental factors remained fairly stable throughout the period, and the quality of the oysters was good.

Of the 474 oysters examined, the Tolchester population consisted of 40 percent female, 26 percent male, 33 percent undetermined and one percent bisexual. The Millhill population comprised 72 percent female, 27 percent male, 0.5 percent undetermined, and 0.5 percent bisexual. The three bisexual oysters consisted of two cases of sex reversal from male to female and one instance of true hermaphroditism.

The significant changes which have taken place in the gonads of Tolchester oysters, as compared to the normal Millhill oysters, are concerned entirely with the timing of the successive developmental stages.

Ordinarily, following the complete spawning of the oyster in late summer, there is a period of rest, gonial proliferation, and then early maturation of gametes, by which time water temperatures have decreased and the oyster becomes inactive. Consequently in the early spring the majority of gonads examined has many cells partially differentiated and with a moderate degree of yolk already stored in the oocytes. Oysters from Tolchester, however, contained gonads in which the majority of cells was still in the undifferentiated gonial stage. This condition persisted until late July when as many as half of the sample still showed no development over the resting gonial stages of the previous October. At this time oysters from Millhill were partially to half or more spawned.

The entire cycle in the gonads of Tolchester oysters is characterized by a lag of from one to two months in the normal seasonal development of the gametes. As a rule, one or sometimes two from each sample of the Tolchester oysters exhibited gonad development which was entirely comparable to stages found at Millhill during the same period.

Environmental factors had become sufficiently improved, however, so that in October 1946, a majority of the Tolchester oysters had spawned completely and in the period from November through January had become entirely similar to the stages reached in the gonads of the control oysters at Millhill.

Water temperatures throughout the period were normal. At Tolchester on May 15, 1946, the bottom temperature was 16.4 degrees C.; a maximum temperature of 25.6 degrees C. was reached by July 25, and from that time on it decreased gradually to 15.8 degrees C. at the end of October. Temperatures at Millhill regularly averaged one degree higher during the period. The salt content of the water was less stable. At Tolchester, bottom salinities fluctuated erratically from 0 to 6 o/oo in the period May 15 to August 1. One fourth of the records in this period showed fresh water. In August the salt content increased steadily to 13 o/oo and remained near that level for the rest of the year. At Millhill, a salt content of 6 o/oo was recorded June 25. Before and after that date the salt content increased steadily to 14 o/oo.

The deleterious effect of the environment on the physiology of the oyster would appear to be due to the low salinity of the water. Whether this effect is a direct inhibition of the gamete development, or an indirect effect such as removal of nutritional elements from the water or causing a forced inactivity of the oyster which prevents it from deriving adequate amounts of food from the plankton, cannot be stated with certainty. The fact that from 10 to 20 percent of the oysters go through normal developmental timing in the gonad cycle would seem to indicate that the low salt content of the water acts indirectly on the physiology of the oyster. This is indicated by the fact that on examination these few normally developing oysters had empty digestive tracts, as did the oysters with poorly developed gonads, but they contained a fair amount of stored glycogen and perhaps were thus enabled to elaborate gametes at the usual time.

Summary

Developmental processes in the gonads of oysters exposed for protracted periods to waters of low salt content were slowed by as much as two months in the majority of the population examined. This inhibition of gamete differentiation is best indicated by the fact that in the Tolchester oysters 33 percent of the specimens contained solely undifferentiated gonadal tissue, while in oysters from Millhill, less than 1 percent of those examined were in that condition. Following restoration of the normal salt content of the sea water, there was a complete recovery and fulfillment of the typical gonadal cycle.

5. Relationship of environment to the growth of oysters

The following observations were made by J. B. Engle and P. A. Butler to check the influence of the environment on the rate of growth of seed oysters from Millhill Bar, Eastern Bay. The seed was part of the 1945 oyster set on the above bar. Four groups of oysters of this age were measured and put into large wire cages, one group was put back at the place where the seed was procured; another group was sent to Long Island Sound, Milford, Connecticut; a third was taken to Solomons Island at the mouth of the Patuxent River; and the fourth was taken to Tolchester in the upper Chesapeake Bay. All the cages were suspended just off the bottom. The initial observations and measurements were made at the first part of the summer in 1946.

At the end of the fall growing season all the oysters were again measured, and the amount of linear growth accumulated during the period was recorded. The average length in millimeters and the percent increase are shown in Table 6. All oysters transplanted from the seed bed showed a greater increase in length than that of the group left on the seed bed. The increase in length was more in the areas where the salinity was higher. At Milford, Connecticut, where the fall salinity was the highest, the increase in length was 173 percent, while the control left in Eastern Bay, Maryland, increased only 50 percent. At Solomons Island, where the salinity is slightly less than at Milford, the increase was 93 percent. The percent increase of the oysters at Tolchester (65 percent) was slightly greater than that of the controls (50 percent).

PROJECT III. EXPERIMENTAL OYSTER FARMING

Subproject 1--Controlled management of public oyster bars, J. B. Engle and P. A. Butler

1. The effect of different densities of oyster seed planting on the growth and condition of the planted stock As an aid to the operation of the State Management Plan it was necessary to ascertain the effect of different densities of seed oyster planting on the resulting growth and condition of the planted stock. For this purpose three experimental seed plantings were made during the spring of 1946 at the mouth of the West River; one of 250 bushels to the acre; another of 500 bushels per acre; and the third of 1000 bushels per acre. The last measurements of these oysters, made in April 1947, showed that an average length of the 250 bushel planting was 79 millimeters, the 500 bushel planting, 71 millimeters, and the average length of the oyster in the 1000 bushel planting was 75 millimeters. Since so far there is no significant difference in the three groups of oysters it is planned to continue these observations until the oysters reach marketable size.

Table 6.--Growth of Millhill seed oysters planted in three different locations outside of Eastern Bay.

Location	Number of oysters	Date	Salinity in o/oo	Length in millimeters			
				Minimum	Maximum	Mean	percent Increase
Milford, Conn.	429	5/13/46	25	09	44	22	173
		12/46		(No other record)		60	
Solomons Island	499	7/1/46	18	12	47	28	
	402	2/7/47		23	85	54	93
Tolchester	397	7/23/46	11	10	58	26	
	285	3/31/47		18	84	43	65
Millhill Control	426	6/3/46		07	50	28	
	385	3/24/47	15	14	71	42	50

2. The seasonal condition of oysters Seasonal changes in the condition of oyster meats from eight widely separated bars in Chesapeake Bay and several tributaries were studied during the year. The ratio of the weight of dried meats to the volume of shell cavity multiplied by 100 was used as a criterion of quality. (Condition factor.)

The lowest values were obtained in mid-summer at the close of the major spawning season. In oysters of 'fair' to 'good' quality the condition factor at this time was approximately 5.0. During August and September, as water temperatures decrease, food supply increases and oysters are enabled to store large amounts of food materials as well as undergo considerable growth, the condition factor rises steadily

to about 10.0. During the winter inactivity the condition factor shows only minor variations from this level. The increase in water temperatures and food supply in the early spring is reflected in a slowly rising condition factor which attains its annual maximum in the period prior to spawning. As spawning progresses, the condition factor slowly decreases and then drops abruptly to the yearly minimum.

Oysters from different locations, while following this general pattern, differ in the value of the condition factor. Striking differences were obtained in the oysters from those bars near the head of the bay which had been subjected to freshets for periods of more than two weeks at a time. In the two months following the freshets the condition factor in these oysters decreased regularly and reached values as low as 2.0. Following this, despite an early increase in salinity, the condition factor of the oyster meats showed no recovery for as long as nine months. After that a gradual improvement took place. Oysters from bars subjected to fresh water for periods of less than two weeks did not exhibit this extensive injury. In locations where salinities averaged above 8 o/oo, no constant relationship was observed between the salinity and the quality of the oyster meat. The observations of the changes in the condition factor are summarized in the following table.

Table 7.--The condition of the meats of oysters from the seed oyster plantings of three different concentrations. Figures based on the ratio of the dry meats to the volume of the shell cavity called the condition factor.

Date		Condition Factor*		
		250 bushels per acre	500 bushels per acre	1000 bushels per acre
1946				
April	10	7.95	7.48	7.61
	30		7.22	
May	15	8.41	7.33	9.95
	31		7.59	
June	18	10.63	8.43	9.05
July	9		7.46	
	16	9.41		
	24	7.29	5.63	7.03
Aug.	6	6.73		
	20	6.58	7.97	7.25
Sept.	4		7.03	
	18	9.74	8.34	12.44
Oct.	3		9.77	
Nov.	26	12.98	12.61	11.86
1947				
April	9	11.74	11.74	11.24

* Ratio between dry weight of meat X 100 and volume of shell cavity.

PROJECT IV. PROTECTION AGAINST NATURAL ENEMIES AND PARASITES

Subproject 1--Control of starfish and drills; V. L. Loosanoff and D. D. Shipley.

During April the semi-annual survey on the distribution and occurrence of starfish in Connecticut waters was completed by the personnel of the Milford laboratory. In general, the results indicated that the distribution of starfish remained more or less the same as that found in October 1946. However, there were indications that, as had been anticipated last year, a very dense starfish population found within the section between Charles Island and Stratford Point was moving in easterly and westerly directions toward the cultivated oyster grounds. A warning of this invasion was given to the oyster companies whose grounds were endangered.

Observations on gonad development, spawning and setting of starfish were begun in the spring. Thus far no mass spawning of starfish has occurred. Field experiments, consisting in luring starfish to especially made traps baited with various substances, were conducted during the quarter. The results so far have been rather inconsistent, indicating that starfish lack well-developed sense of smell and come in come in contact with prey merely by accident.

Subproject 1A--Observations on the rate of movement of drills and conchs.

In order to improve the technique of trapping of drills (Urosalpinx) and conchs (Thais), it is necessary to learn more about the movements of these snails and about the factors that control their migrations. To fill this gap in our knowledge a series of laboratory experiments were made by P. S. Galtsoff and A. R. DeMetriff at College Park with the drills and conchs kept at known temperatures and salinity. The problem of measuring the rate of the snail's path was solved by a very simple method consisting in placing the snail inside a light wheel, made of plastic, and mounted on a horizontal axis. As the snail crawls along the periphery of the wheel partially submerged in water, the wheel rotates and its movements are recorded on a kymograph.

Using this apparatus an interesting difference was found between the rate of movements of Urosalpinx and Thais. At the same temperatures (20-22 degrees C.) and salinities (24-25 o/oo) the rate of crawling of Urosalpinx never exceeded 2 feet per hour, while Thais was capable of moving at the rate of 23 feet per hour. In some of the experiments the snails continued to crawl without stopping for twelve or more hours. Experiments conducted by P. S. Galtsoff at Pensacola showed that the drop of salinity of water to 7 & 8 parts per thousand almost immobilized the conchs, only a few of them being capable of crawling at the rate of less than 1 foot per hour. Successful development of a quantitative method of study of the behavior of snails permits now a more comprehensive investigation of their reaction to the changes in the environment and of their response to various baits. It is expected that the results obtained with the new technique may be useful in developing more efficient methods of trapping these pests.

Subproject 3--Distribution of Nematopsis in coastal waters, H. Landau and P. S. Galtsoff

The collection of oysters from many parts of Chesapeake Bay and tributaries for the purpose of determining the distribution of the protozoan parasite, Nematopsis, was made during the summer of 1946. Sampling was started in June and continued throughout September. In all, 75 oyster bars were sampled in the north-south and east-west gradients in Chesapeake Bay and in the tributaries. Observations were made in the James, York, Rappahannock, and Potomac rivers, extending from the mouths of these rivers to their upper parts. Spot sampling was made, also, in Mobjack Bay, Pocomoke Sound, and Nassawadox Creek in Virginia, and the Patuxent, Choptank, Severn, and Chester Rivers, Broad and Harris Creeks, and Eastern Bay in Maryland.

The examination of the oyster tissues was made mostly in the College Park laboratory during and after the field sampling trips. All tissues were studied but the major emphasis for comparison was placed on the presence of Nematopsis spores in the oyster mantle. On this basis it was found that almost all of the 75 oyster bars studied had infected oysters. The highest count of Nematopsis infection was 3500 cysts per square centimeter of pressed mantle tissue. The lightest incidence of infection occurred in the Potomac River, Maryland, and the heaviest in the James River, Virginia.

No correlation was found between the distribution of the parasite and ecological conditions such as salinity, depth, and composition of the oyster beds and bottom. No apparent relation existed between the condition of the oysters and the extent of the infestation.

During the trip to Texas and Florida, P. S. Galtsoff collected and examined samples of oysters near Miami, Florida, at Port Isabel, Texas, and in Copano Bay, Texas. All the oysters were found heavily infected with Nematopsis spores. Infection was particularly heavy inthe oysters from Copano Bay, Texas. From previous observations made by P. S. Galtsoff it was known that these oysters are usually very poor and fail to grow in their native environment. It was found, however, that after being transplanted in Aransas Bay they show rapid and remarkable improvement in quality of their meat, in spite of the presence of large numbers of Nematopsis spores. In the samples collected in March, the latter were so abundant that they clogged the water tubes of the gills and some of the gill vessels. Port Isabel oysters were found rather fat in spite of the presence of a fairly large number of Nematopsis.

PROJECT VI. BIOLOGY AND CONSERVATION OF EDIBLE MOLLUSCS OTHER THAN OYSTERS

Subproject 1--Biological observations on edible mussels and clams, V. L. Loosanoff

Attempts to raise larvae of the surf clam (Mactra solidissima) and the soft clam (Mya arenaria) were made at Milford Laboratory during April and May. It was found comparatively easy to carry larvae of both species through the early stages of development but thus far no setting of these clams has taken place under laboratory conditions. This work will be continued during the winter and early spring.

The Milford laboratory has conducted several experiments on transplanting ocean quahogs (Artica islandica) from the deep water of Rhode Island to the shallow water of Milford Harbor. The purpose of the experiment was to determine whether this species will survive transplantation and whether the new environment will change the taste of its meat. It was found that the quahog survived in the deeper water of the Harbor, approximately four feet below the mean low water mark where the salinity of the water is not much reduced at low tide after heavy rains. However, the quahogs planted near the mean low water mark and above it died very soon. Samples of quahogs are examined every two or three weeks for canning and organoleptic tests.

Subproject 2--Biology of soft clams on the flats of Parker River Refuge, J. B. Engle

A study of the distribution and abundance of the living organisms in the upper layer of mud on the clam flats of Parker River Refuge, Massachusetts, was made to determine the effect of large concentrations of black ducks on the population of soft-shell clams (Mya arenaria). A series of quantitative samples were taken at the beginning of the 1946 duck hunting season early in October and in November and at the end of the duck hunting season during the first week in December.

The animal population of the flats included, in the order of abundance, the following organisms: Gemma, Mya, Macoma, Mytilus, Illyanassa, Littorina, Polynices, small crustacea, Limulus, Mud Crabs (Xanthidae), annelid worms, Ensis. Plant life consisted mostly of Enteromorpha, Ulva, and Fucus, and a plant which has not been identified. Eel grass (Zostera) was found in scattered clusters in the Hales Cove area.

Small soft clams, widely distributed in all the areas investigated, were abundant in the lower part of Hales Cove. Pine Creek had a less concentrated clam population. In most of the Hales Cove area no significant reduction in the clam population was noticed by the end of the duck hunting season.

A reduction of 61 percent in the number of small clams was noted only in a secluded portion of Hales Cove. This area represented, however, only 5.5 percent of the total area examined.

Soft clams were found in the stomachs of 4 of the 8 black ducks captured during the survey. The amount of soft clams present was small, comprising only 9 percent of the total volume of food material in the duck stomachs. It appears that the presence of large numbers of black ducks on the clam flats of the refuge had little effect on the soft clam population except in a small secluded portion of Hales Cove.

PROJECT VII. EFFECT OF DDT ON OYSTERS AND OTHER SHELLFISH

Experiments on the effect of spraying DDT on oyster shells used for catching oyster spat were conducted at Milford by V. L. Loosanoff and in the Chesapeake Bay by J. B. Engle and P.A. Butler. Because of the different ecological conditions and considerable difference in the duration of setting season, the results are not identical and are discussed separately.

A. Experiments conducted at Milford, Connecticut

Studies on the effect of DDT upon setting growth and survival of oysters at Milford may be summarized as follows:

1. In general, oyster shells dipped in a 5 percent solution of DDT in kerosene collected a somewhat smaller number of spat than untreated shells. All the shells, of course, were planted at the same time and in the same place.

2. There is some evidence that the depressing effect of DDT in kerosene will almost disappear if the treated shells are kept in the air for about two weeks before planting. This point will need some additional study, however.

3. The shells dipped in a 5 percent emulsion of DDT collected approximately only 1/9th of the number of oysters attached to the control shells dipped in the emulsion without DDT. Further, the DDT in emulsion was found to be more toxic than its solution of the same concentration in kerosene.

4. Spraying of oyster shells with a 5 percent solution of DDT in kerosene at the rate of one pound per acre did not depress the setting of oysters. Spraying at the rate of 3 or 5 pounds of DDT per acre, however, may somewhat affect the intensity of setting, although this was not clearly shown in the experiments.

5. Spraying of oyster beds with DDT solution or emulsion at the rate of 1-1/2 pounds of DDT per acre has caused no unusual mortality among the adult or young oysters. The beds sprayed with DDT emulsion usually showed a lighter set than either the untreated control bed or the one sprayed with a 5 percent DDT solution in kerosene.

6. Observations on the setting of oysters on concrete collectors painted with a 5 percent solution in kerosene, with kerosene only and on untreated controls showed that somewhat fewer oysters set on the DDT-painted collectors than on the kerosene-painted or the untreated control. The untreated control collected the largest number of spat.

7. The average size of spat on the untreated collector was somewhat larger than that of the spat on the DDT-treated one. However, the difference was insignificant.

8. Dipping of oysters in a 5 percent solution of DDT in kerosene did not significantly affect their rate of growth or increase in weight, as compared with the control oysters.

9. The shell movements of the oysters kept in the aquarium, to which a 5 percent solution of DDT was added in quantity approximating 5 pounds of DDT per acre, was not different from that of the control oysters. No mortality was observed during the exposure ranging from approximately 5 to 8 days and for 6 weeks after the exposure.

10. The oysters which remained in the water to which a sufficient quantity of emulsion was added to create a concentration of 1 or 2 parts of DDT per million parts of water, although showing abnormal shell movements, survived periods of exposure ranging from approximately 5 to 8-1/2 days. It is doubtful, therefore, that such concentrations created under natural conditions for comparatively short periods would seriously affect adult oysters. However, a possibility of indirect effects, such as destruction of some organisms serving as food for oysters, is not unlikely.

11. The treatment of oyster shells with a solution or emulsion of DDT greatly interfered with the setting of barnacles. The shells dipped in DDT solution in kerosene collected virtually no barnacle set.

B. Experiments conducted in the Chesapeake Bay.

Experiments were carried out during the setting period of 1946 to determine the effect of DDT solutions on spatfall and on the attachment of the various fouling organisms may be summarized as follows:

1. Treatment of cultch with DDT resulted in a 180 percent increase in the number of spat as compared with untreated shells and that shells treated only with kerosene or with water emulsion of DDT had received a set of 17 to 37 percent greater than that on untreated controls.
2. Spat mortality, as indicated by scars and empty shells (boxes) ranged from 0 to 5 percent following the various treatments and did not differ significantly from the untreated controls. Treatment of shells with DDT slightly inhibits the growth of young oysters, but the inhibiting effect of the DDT solution gradually dissipates.
3. Examination of fouling organisms showed that by the end of the experimental period, shells treated with DDT had only one-third as many barnacles as the controls. Shells treated with DDT contained only 1/7 of the number of Bryozoa attached to the untreated shells and their algal coverage was reduced as compared with the untreated controls.
4. No significant differences were found in the use of DDT as a solution or as an emulsion. Treatment of shell piles with 5 percent DDT for fly control would have a beneficial effect on cultch, provided that the shells could be placed on the oyster beds one month prior to the setting of the spat.

ICHTHYOLOGICAL LABORATORY, Samuel F. Hildebrand, In Charge

GENERAL

The study of the Clupeidae of the Western North Atlantic was continued during the quarter, and additional accounts were prepared for the general publication of the Sears Foundation, entitled "Fishes of the Western North Atlantic." The study of the Gulf Coast fishes of the United States and the preparation of a descriptive catalogue based on them, too, was continued. The calls for the identification of specimens and for general information by Federal and State agencies, private organizations, and individuals, although unusually numerous, were supplied promptly.

Dr. Hildebrand completed the study of the menhaden, genus Brevoortia, and finished extensive accounts of the four species coming within the scope of the "Fishes of the Western North Atlantic," one of which is new. A preliminary paper which embodies a description of the new species, and descriptions of two little known South American species, a key to all the species of Brevoortia, remarks, and extensive tables showing relationships, also was completed.

A study of the "thread herring," Opisthonema oglinum, was undertaken, and an account for the "Fishes of the Western North Atlantic" was completed. Only one species of this genus from the Atlantic, ranging from Cape Cod to southern Brazil and the West Indies, has been recognized. In the course of the present study bewildering variations were discovered. Some of the extremes of this variation may represent subspecies, or even species. Even now, with hundreds of specimens at hand, there is insufficient material from certain localities to determine the significance of the differences discovered. In the general account prepared for the "Fishes of the Western North Atlantic" attention is directed to the great variations, without attempting to define their significance.

Accounts of all the commercial forms of herrings of the United States were completed for the "Fishes of the Western North Atlantic" during the year. However, several tropical genera of Clupeidae remain to be studied. As they are not of much commercial value, and little is known about their life histories, the accounts will be brief in comparison with some of those already written, which for some of the more important commercial species run upward of 25 typewritten pages.

Mrs. Ann S. Green took care of the routine office work, assisted in compiling the figures for the tables on menhaden and catalogued the specimens of Brevoortia and Opisthonema. Three drawings of menhaden and two plates showing six individual scales and six ventral fins were completed for the preliminary paper on Brevoortia. The bibliography for this paper was compiled and typed.

During the year Mrs. Green has kept up with the regular work of cataloging, filing, and general office routine. Six drawings of young fish were completed for the work on Panama fishes. Eight drawings of herring were finished for the "Fishes of the Western North Atlantic" and nineteen drawings consisting in part of structures, for the preliminary paper on Brevoortia, some of these drawings to be used also in the "Fishes of the Western North Atlantic."

The month of May was spent by Mr. Isaac Ginsburg in New Orleans studying the considerable collection of fishes obtained in the South Atlantic and Gulf, off the United States coast, in connection with the shrimp investigation, and which has accumulated for a number of years. The most notable part of the collection was that made by Messrs. Lindner and Anderson on the "Pelican" during 1938-42.

The collection as a whole proved to be of unusual value and importance. The material was obtained chiefly offshore by trawling. As this method of collecting, employed in the shrimp investigation on an extensive scale and over an extended period of time, was but sparingly used in that region previously, it brought to light many species not obtained by the more commonly used collecting methods. The preliminary identifications indicate as follows: (1) Some species hitherto thought to be scarce appear to be not uncommon in deep water. (2) The collection contains some species which were previously known from only one or two specimens, some of them partly digested and taken from the stomachs of red snappers after being brought up from deep water. (3) A few of the species obtained apparently are the same as were described only within the last few years. (4) Some of the species might still be unknown. In any case, it became evident during their study that the morphologic and geographic ranges of many of the contained species are but scantily or fragmentarily known.

Because of the lack of material for comparison and the unavailability of needed publications in the New Orleans laboratory, especially the later literature published within the last 50 years, the identifications made necessarily were mostly tentative. It was decided then to ship the greater part of the collection to Washington to compare with known specimens and with those of closely-related species, and for definitive study and positive identification.

The rest of the quarterly period was spent in completing the descriptive part of the species of the family Sciaenidae of the Gulf Coast.

The following is a summary of the work done during the fiscal year 1947. The first part of the year was spent largely in revisional studies of the genera of the families Electridae and Gobiidae. A preliminary paper comprising an abstract of a revision of the genus Bathygobius was prepared and is to be published in the Journal of the Washington Academy of Science. The latter part of the year was given chiefly to a study of the Gulf Coast fishes, in accordance with a decision made by the Service of the desirability and necessity of having a single work prepared where existing knowledge of Gulf Coast fishes, together with original observations made, are brought together and treated compactly. A plan of procedure was outlined to carry this into effect. A key to the families now known from the Gulf Coast was prepared to serve as a guide, and to form a basis for improvement and eventual publication. The sciaenidae was the first family taken up for study because of its importance on the Gulf Coast.

PUBLICATIONS, FISCAL YEAR 1947

Burrows, Roger E. and John E. Manning.
1947 An enlarged ricer for pond feeding. Prog. Fish. Cult. vol. 9, no. 1, pp. 42-45.

Chamberlain, Thomas K.
1946 The most trout fishing for the most trout fishermen. Pennsylvania Angler, vol. XV, no. 5, May 1946.

1947 There is no universal pondfish. Prog. Fish. Cult. vol. 9, no. 2, pp. 78-81.

Reprinted. Tex. Game and Fish, Tex. Game, Fish and Oyster Comm.

Davis, H. S.
1947 Care and diseases of trout. Fish and Wildlife Service Research Report 12, pp. 1-98.

Studies of the protozoan parasites of fresh-water fishes. Fish and Wildlife Service Fishery Bulletin 41, vol. 51.

Ellis, M. M., B. A. Westfall and M. D. Ellis.
1946 Determination of water quality. Fish and Wildlife Service Research Report 9, pp. 1-122.

Engle, J. B.
1946 Commercial aspects of the upper Chesapeake Bay oyster bars in light of the recent oyster mortalities. Ann. Rep. of the Maryland Board of Natural Resources.

Galtsoff, P. S.
1946 Reaction of oysters to chlorination. Fish and Wildlife Service Research Report 11, pp. 1-28.

1947 Oyster--The unknown. Southern Fisherman, Jan. 1947. vol.7, no. 3, pp. 176-177, 248.

1947 Sponges, Encyclopedia Britannica, New Edition.

Galtsoff, P. S. and Walter A. Chipman, Jr.
1947 Respiration in oysters, Anat. Rec. vol. 96, no. 4 (abstract).

Ginsburg, Isaac.
1947 American species and subspecies of Bathygobius with a demonstration of a suggested modified system of nomenclature. Jour. of Washington Acad. of Sci. vol. 37, no. 8, pp. 275-284.

Gutsell, James S.
1947 Furunculosis and its treatment. Prog. Fish. Cult. vol. 9, no. 1, pp. 13-20.

Hile, Ralph.
1947 Standardization of methods of expressing lengths and weights of fish. Prog. fish. Cult. vol. 9, no. 1, pp. 62 (abstract).

Keler, George B.
1947 Measurement of salmon spawning by means of aerial photography. Pacific Fisherman, vol. 45, no. 3, pp. 46-51.

Loosanoff, V. L.
1946 Clam fisheries of our Atlantic Coast. Southern Fisherman, vol. 6, no. 3, pp. 182-183.

1946 Survival and mortality of frozen oysters. Anatomical Record, vol. 96, no. 4, p. 90.

1947 Oyster planting in winter and early spring. Comm. Fish. Rev. vol. 8, no. 11, pp. 6-8.

1947 Growth of oysters of different ages in Milford Harbor, Connecticut. Southern Fisherman, vol. 7, no. 3, pp. 222-225.

1947 Effects of DDT upon setting, growth and survival of oysters. Fishing Gazette, vol. 64, no. 4, pp. 94-96.

Loosanoff, V. L. and Charles A. Nomejko.
1946 Feeding of oysters in relation to tidal stages and to periods of light and darkness. Biol. Bull. vol. 9, no. 3, pp. 244-264.

On growth of oysters during hibernation. Anat. Rec. vol. 96, no. 4, p. 68.

Loosanoff, V. L. and James B. Engle.
1947 Feeding of oysters in relation to density of micro-organisms. Science, vol. 105, no. 2723, pp. 260-261.

Perlmutter, Alfred.
1946 The distribution of the winter flounder (Pseudopleuronectes americanus) and its bearing on management possibilities. Trans. of the 11th North American Wildlife Conf. pp.239-250.

The future of the redfish fishery. Gloucester Master Mariners' Association Year Book; pp. 7-9.

Phillips, Arthur M. Jr.
1947 Nutrition of trout. Cortlant Hatchery Report No. 14. Prog. Fish. Cult. vol. 9, no. 1, p. 61 (reprint of excerpt).

Royce, William F.
1947 Gear used in the sea scallop fishery. Comm. Fish. Rev. vol.8, no. 12, pp. 7-11.

Schuck, Howard A. and O. R. Kingsbury.
1947 Survival and growth of fingerling trout reared under different conditions and planted in fast and slow water. (abstract) Prog. Fish. Cult. vol. 9, no. 2, p. 110.

Silliman, R. P.
1946 A study of variability in plankton townet catches of Pacific pilchard (Sardinops caerulea) eggs. Jour. of Marine Research, vol. VI, Dec. 31, 1946; pp. 74-83.

Smith, Osgood R.
1947 The location of sardine schools by supersonic echo-ranging. Comm. Fish. Rev. vol. 9, no. 1, pp. 1-6.

Snieszko, S. F. and C. C. Taylor.
1947 A bacterial disease of the lobster (Homarus americanus). Science; vol. 105, no. 2, 732, p. 500.

Surber, Eugene W., C. E. Minarik and W. B. Ennis, Jr.
1947 The control of aquatic plants with Phenoxyacetic compounds. Prog. Fish. Cult. vol. 9, no. 3, pp. 143-150.

Tunison, A. V., et al.
1947 Coloration of fish. Cortland Hatchery Report No. 11; Prog. Fish. Cult. vol. 9, no. 1, pp. 53-61. (excerpt from Nutrition of trout).

Nutrition of trout. Cortland Hatchery Report No. 13. Prog. Fish. Cult. vol. 9, no. 1, pp. 60.

Van Oosten, John.
1946 Maximum size and age of whitefish. Fisherman, vol. 14, no.8; pp. 17-18.

1947 The American Fisheries Society. (A special publication of the Society; to be reprinted in vol. 76 of the Trans.)pp.3.

Vaughn, Elizabeth.
1947 Time of appearance of pink salmon runs in Southeastern Alaska. Copeia. 1947, No. 1, pp. 40-50.

Walford, Lionel A.
1946 The correlation between fluctuations in abundance of the Pacific sardine (Sardinops caerulea)and salinity of the sea water. Jour. of Mar. Res. vol. VI, no. 1, pp. 48-53.

SPECIAL SCIENTIFIC REPORTS - FISCAL YEAR 1947

No. 30 Water Quality Studies of the Mississippi River. By Wesley S. Platner. 1946.

No. 32 Oyster Bars of the Potomac River. By David G. Frey. Nov. 1946

No. 33 An Investigation of Fish-Maintenance Problems in Relation to the Willamette Valley Project. By Joseph A. Craig and Lawrence D. Townsend. July 1946.

No. 38 Water Quality Studies of the Delaware River with Reference to Shad Migrations. By M. M. Ellis and B. A. Westfall, D. K. Meyer and W. S. Platner. February 1947.

No. 39 Effects of Aquatic Weed Infestations on the Fish and Wildlife of the Gulf States. By J. J. Lynch, J. E. King, T. K. Chamberlain, and Arthur L. Smith. February 1947

No. 40 Evaluation of Fisheries in Determining Benefits and Losses from Engineering Projects. By Richard A. Kahn and George A. Rounsefell. March 1947.

No. 41 DDT Investigations by the Fish and Wildlife Service in 1946. By Arnold L. Nelson and Eugene W. Surber. May 1947

No. 42 Toxicity of Phenyl-Mercuric Lactate for Fish. By M. M. Ellis. May 1947.

FISHERY LEAFLETS

No. 55 Breathing in Fishes. Revised by James S. Gutsell

No. 58 Some publications on diseases and parasites of fishes. Revised by the Division of Fishery Biology

No.123 Sharks, Skates or Rays, by Samuel F. Hildebrand.

No.129 The Pacific Sardine Fishery, By Staff of Southern Pacific Section of Division of Fishery Biology; revised by L. A. Walford

No.198 Haddock (Melanogrammus aeglefinus) by H. A. Schuck.

No. 216 Diamond-back terrapin culture, by Samuel F. Hildebrand and H. F. Prytherch

No.217 Aquatic plant control with 2, 4-D, by E. W. Surber, March 1947.

No.221 Temperature and fishes, by M. M. Ellis, April, 1947.

No.222 Disease control in hatchery fish, by F. P. Fish.

No.223 Commercial Clams of the Pacific Coast of the United States, by Victor L. Loosanoff.

No.225 Gear used in the sea scallop fishery, by Wm. F. Royce.

No.231 The sea urchin fishery, by L. W. Scattergood, May, 1947.

No.235 Kamloops Rainbow Trout, by C. M. Mottley

No.239 Fishery Resources of Micronesia, by R. O. Smith, May 1947.