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

FISH AND WILDLIFE SERVICE
Albert M. Day, Director

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ANNUAL REPORT FOR THE FISCAL YEAR 1948

BRANCH OF FISHERY BIOLOGY

(With Report for the Quarter April-June, 1948)

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Issued November 1948
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National Oceanic and Atmospheric Administration

Report of the United States Commissioner of Fisheries

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INTRODUCTION

This is the second Annual Report of the Branch (formerly Division) of Fishery Biology, covering activities from July 1, 1947, through June 30, 1948. Its purposes are similar to those of the first annual report, from which the following three paragraphs have been adapted. Also like the first annual report, it is a combination of the regular Quarterly Report for the fourth quarter of the fiscal year with a general resume of the entire fiscal year's activities.

In addition to presenting a record of research activities and administrative functions of the Branch 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 Branch.

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 degrees, but it should be realized that the specific bits of scientific information included with an account of the respective activities are nearly in all cases preliminary in 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 1948 saw the inception of the new organizational structure planned during the close of the 1947 fiscal year. Having the four section chiefs in Washington relieved the Chief of the Branch of some of his work load, and permitted a better liaison between the field and the central office. During the last part of the fiscal year, however, all of the section chief positions became vacant by reason of promotion, transfer, or resignation. Immediate recruitment of new incumbents was not possible, and the remaining central office personnel were again faced with an extremely heavy normal work load in the face of an expanding program. This situation has resulted in many delays in handling matters for field personnel, and their patience through the trying period is appreciated by the Washington staff.

Funds made available by Congress for expenditure during the 1948 fiscal year represented a decrease of $124,060 as compared with 1947 funds. There was actually a slight increase, however, in direct appropriations; the large reduction in funds transferred from other agencies caused a net decrease in the total. The table below indicates the amounts made available and expended during the two fiscal years, for each of the six budgetary items.

APPROPRIATIONS-BRANCH OF FISHERY BIOLOGY

Project	1947 Avail.	1947 Expend.	1948 Avail.	1948 Expend.
114 Commercial Fishery Investigations				
Regular	$552,100	$552,000 1/	$540,140 1/	$538,940 1/
Transferred	264,100	208,300 1/	117,400 1/	98,400 1/
Sub-total	$816,200	$760,300	$657,540	$637,340
115 Shellfisheries	176,000	176,000	158,300	157,700
116 Inland Fisheries	49,800	49,800	72,500	72,300
117 Water Quality & Pollution	47,700	47,700	------	------
118 Sea Lamprey	------	--------	19,100	19,000
110 Operation of Fish Screens	34,000	34,000	36,300	35,600
Grand Total	$1,123,700	$1,067,800	$943,740	$921,940

1/ Unexpended balance remains available in following fiscal year.

The situation with respect to publications remained unsatisfactory during the 1948 fiscal year, the amounts appropriated for printing and binding being entirely inadequate. A determined attempt is being made to clear a larger amount for 1950.

SECTION OF ANADROMOUS FISHERIES

ALASKA FISHERY INVESTIGATIONS
George B. Kelez, Chief.

GENERAL

The biological research conducted by the Alaska Fishery Investigations during the 1948 fiscal year was a continuation of the research undertaken during the past two years. The investigations were composed of the following projects: Bristol Bay Red Salmon Project, Karluk Red Salmon Project, Southeastern Alaska Pink Salmon Project, Alaska Herring Project, Fluctuations in Abundance of Alaska Salmon Project, Alaska Fishery Statistics Project, and the Alaska Stream Improvement Project. All but one of the projects conducted active investigations in Alaska, two maintaining summer field stations and one operating a year-round observation and research field station.

The Bristol Bay Investigation continued its very important aerial photographic surveys of the major salmon producing areas in the region. These aerial photographs are providing valuable supplemental information to the aerial spawning ground surveys. To obtain similar information from the ground would require several crews spending considerable time traveling over the salmon spawning grounds.

At Karluk Lake a study was made on the depredation by the bear upon the red salmon that entered the small tributaries of Karluk Lake to spawn. A very interesting and enlightening report has been prepared covering the part that bears play as predators in the life of these salmon.

All of the salmon returning to Little Port Walter were examined for marked fins. Data collected revealed that 4.4 percent of the pink salmon, 8.0 percent of the coho salmon, and none of the chum salmon were identifiable as having definite fin marks. Studies made at Little Port Walter indicate that the commercial pink salmon fishery in southeastern Alaska will operate at a low production level during 1948 and that signs are favorable for increased production during 1949.

The herring investigation continued its recommendation of catch quotas for each district. The abundance of each herring year class was studied and the recommended catches determined to provide sustained production levels in all of the major herring fishing districts.

Statistical data were gathered relative to the fishing intensity and abundance of fishes throughout Alaska. This information was analysed by the statistical staff for use in the proper management, conservation, and utilization of the valuable fishery resources of Alaska.

The Stream Improvement project recommended that salmon ladders be installed in three southeastern Alaska streams at a cost of $190,000. These improvements would soon pay for themselves by increasing a $19,000 annual fishery to a $120,000 annual fishery.

Cooperative use was made during the year of a number of Fish and Wildlife Service vessels, aircraft, and land installations to assist and further the biological investigations.

SALMON RESOURCES IN BRISTOL BAY

As the 1948 fiscal year opened the personnel of the Bristol Bay investigation was engaged in the operation of tagging salmon on the lower reaches of the Naknek and Kvichak Rivers, the object in view being that of ascertaining the racial individuality of the red salmon in respect to their time of passing through the fishing grounds and on up the rivers as well as to determine the amount of time required for the various races to reach spawning maturity after moving on up the river. This was in the nature of a pilot program to determine the feasibility and requirements of such a project. A full scale salmon tagging program is being conducted this season.

A physical survey of the spawning grounds was carried out by three parties of two men each on the Naknek and Kvichak River systems. One of these parties operated on Lake Iliamna of the Kvichak River system, covering the tributaries entering that lake. In addition to physical measurements of the spawning streams and their available nesting areas, counts were made by these parties of live and dead salmon on the streams and searches were conducted for tagged fish or tags lost from fish.

Visual counts of salmon from the air were conducted by Mr. William Peck on all of the representative spawning areas of the Bristol Bay district, while Mr. George Eicher conducted the program of making vertical aerial photographs of spawning populations for a permanent record of these salmon concentrations.

Intensive limnological work was conducted on Brooks Lake, with the collection of numerous plankton and water samples, the latter for chemical analysis for those elements believed to be important in the development of young salmon. These analyses were made in the field. Similar water and plankton data were collected from representative nursery areas in all of the Bristol Bay watersheds.

In 1947 scale samples were taken from the commercial catch and from the escapement. The escapement samples were taken in conjunction with the tagging program on the Naknek River and at the Brooks Lake weir. Total lengths and weights were recorded from the commercial catch and total lengths were recorded at the tagging station.

The following tables give a summary of the age composition of the Naknek River red salmon for 1946 and 1947. Space does not permit a complete resume of more than these two years but the data presented will tend to show that there is a marked difference in the representative age groups from year to year.

Naknek Commercial Sample 1946

Age Composition in Percent

Age	Males	Females	Total
4_2	45.1	36.2	40.8
5_2	46.3	57.1	51.6
5_3	4.0	1.3	2.6
6_2	2.4	0.6	1.6
6_3	2.1	4.8	3.4
Total	51.0	49.0	100.0
Sample	328	315	643

Naknek Commercial Sample 1947

Age Composition in Percent

Age	Males	Females	Total
4_2	17.7	14.9	16.4
5_2	28.5	43.6	35.3
5_3	42.7	27.2	35.7
6_2	0.2	0.6	0.4
6_3	10.9	13.7	12.2
Total	54.4	45.6	100.0
Sample	412	342	754

Collections of fingerling red salmon have been made from various river systems for comparison of age-size data with limnological conditions as developed by the program covering that phase of the project. Collections of plankton are made by two methods; through the use of vertical hauls with the standard net from a depth of 50 feet and through the use of a pump collecting water from a depth of 50 feet to the surface. Both methods will be used in the collections at Brooks Lake and in the widespread Bristol Bay nursery areas, In addition a controlled experiment is underway to determine through a series of parallel samples the relative consistency of both the vertical haul and the pump method in sampling the plankton of a given body of water. Weekly sampling trips are being made around Brooks Lake and daily plankton samples are being made at the outlet of the lake to determine the rate of augmentation and decline of plankton through their growing season.

The project involving the confinement of various numbers of spawning salmon in identical pens in order to determine the effects of crowding was nullified by silting in of the pens. Plans are underway to overcome excessive silting in the pens this season.

SALMON POPULATIONS OF THE KARLUK RIVER, KODIAK ISLAND

Several days were spent in freighting the summer's gear and unpacking, and assembling scientific equipment. The run of sockeye started slowly, the first fish passing through the counting gates on May 21, but no great number of fish appearing until June 3, when 10,733 passed through the gates. There-after the escapement increased rapidly until it soon became apparent that the required escapement of 350,000 for the spring run would be obtained. Fishing was then opened in the Karluk District on June 14 at 6:00 A.M., at which time the escapement at the weir was 279,796.

The downstream migration of sockeye juveniles began in early June, and several samples were obtained at the weir-site. The migration appears to be considerably smaller than in recent years, making the outlook for 1950 and 1951 rather gloomy. No definite statement can be made, however, until complete age analyses have been made.

On June 14 many sockeyes were observed off the mouths of several of the streams tributary to Karluk Lake, and the counting weir at Moraine Creek was installed immediately. No fish were counted through this weir until June 19, when two passed upstream. On the following day 1,328 were counted through. Entrance of spawners into these streams is a full 15 days earlier than in previous years. This, coupled with the appearance of king salmon at the weir-site on June 3, makes it appear evident that the fish of the various species are maturing at an unusually early date. Kings are not usually recorded at the weir-site until late June or early July.

Limnological studies of the Karluk system were begun in early June, and will be continued throughout the season. Stream surveys were begun in late June, while studies of bear depredations were begun with the installation of the Moraine Creek weir.

PINK SALMON RESOURCES OF SOUTHEASTERN ALASKA

The 1947 pack of pink salmon in Southeastern Alaska totaled 681,585 cases, far below the average of recent years and the smallest pack since 1927. The spawning escapement into Sashin Creek, at the Little Port Walter station was 1,486, next to the smallest in 13 years of record exceeding only the 1946 count of 933 spawners.

Adult salmon passing the two way counting weir were examined for fin marks since all of the 41,900 fry resulting from the 1945 spawning were marked by the removal of dorsal and adipose fins before they were released below the weir. Of the first 100 pink salmon examined 16 were marked. The percentage of marked fish declined during the season, the final count of 67 representing 4.5 percent of the total run. Streams in the vicinity of Little Port Walter were visited and spent carcasses were examined but no additional marks were recovered.

Pink salmon fry are approximately 31 mm. in length as seaward migrants. Consequently both mortality and the incidence of fin regeneration are great. With due regard for those qualifications, the returns demonstrate a very high proportion of strays in the Sashin Creek run.

The downstream counting weir was installed in Sashin Creek in March in anticipation that a mild winter would result in an early seaward migration. Subsequent cold weather delayed the emergence and downstream migration of the fry until the latter part of April. The total run, terminating early in June, was 26,452. These fish were marked by the excision of the dorsal and right ventral fins; thus providing a paired marking experiment with the hatchery fry. Returns in 1949 will furnish information concerning the relative marine survival of the two groups.

The following table shows the fresh water and marine survival of the Sashin Creek pink salmon runs since the two-way counting weir was first placed in operation.

Brood Year	Potential No. of Eggs	Fry Produced	Percent Fresh Water Survival	Adult Returning	Percent Marine Survival
1940	52,858,000	3,402,830	6.4	92,085	2.7
1941	88,678,000	1,024,364	1.2	14,983	1.4
1942	81,502,000	674,672	0.8	4,176	0.6
1943	14,980,000	227,673	1.5	5,465	2.4
1944	3,904,000	104,113	2.7	933	0.9
1945	5,062,000	41,900	0.8	1,486	3.5
1946	736,000	1,184	0.2	(Return in 1948)	
1947	1,334,000	27,185	2.0	(Return in 1949)	

In the 13 year period since 1934 the adult count in Sashin Creek has averaged 20,478 fish. In 8 of these years the run has been below the 10,000 fish level while in both 1941 and 1942 more than 80,000 spawners entered the stream. The general agreement between the size of the Sashin Creek escapement and the pink salmon pack in southeastern Alaska, particularly in the eastern district, supports the prediction of a light pack in 1948.

The preceding table shows the considerable variation that has occurred in stream and marine survival. Continuous records, maintained for the past 8 years, indicate that water levels and climatological conditions during the winter months are the principal factors that influence the fresh water survival of eggs and fry. Conditions influencing marine survival have not been studied. It should be noted, however, that straying might be responsible for some of the indicated variability in marine survival.

THE HERRING RESOURCES OF ALASKA

With full scale reduction operations schedules for each of the three major fishing districts (Kodiak, Prince William Sound, and Southeastern), the fourth quarter was devoted mainly to planning and preparing for the field program. Two temporary employees were employed to sample the catch for age composition and the weight and length of fish at each age. Mr. Louis Lund is now stationed at Port Armstrong in Southeastern and Mr. Edward Mains at Port San Juan in Prince William Sound. Mr. Kolloen left Seattle on June 16 and is now at Iron Creek in the Kodiak district. In addition

to the regular sampling it is planned to collect material for vertebral counts which may yield information on the relationship of the populations in each area, and between the several areas. Since it is anticipated that herring captured in the Resurrection Bay district will be delivered to reduction plants at Kodiak and Prince William Sound it will be possible to obtain samples from these catches as well as from those made within the Kodiak and Prince William Sound districts. It is particularly desirable to ascertain the relationship of the Resurrection Bay population to that of Prince William Sound since present regulations are based on the hypothesis that both fisheries are drawing from a common stock.

Analyses of abundance were completed for each district and recommendations for management were submitted to the Branch of Alaska Fisheries. These analyses included the return per unit of fishing effort (abundance index), the determination of the average rates of increment and decrement with each increase in age, the calculation of the total potential yield of each of the year classes within the fishery, and an evaluation of the optimum yield of each of the year classes for the season of 1948. Results of these analyses as they pertain to the condition of the fishery in each district are briefly reviewed.

KODIAK:

The successful catch of 406,000 barrels, made by a combined fleet of nineteen vessels between mid-July and mid-October, was indicative of the high abundance in the 1947 season. The dependance of the catch on the fall run and the shift of the fishing grounds southward in Shelikof Straits were particularly noticeable this year.

The index of abundance calculated by comparing the size of average delivery in each ten-day period to the size of average delivery in comparable periods of all former seasons was 116.4 which is the highest on record. The principle cause for the rise in abundance was the attainment of its 4th year of life by the highly successful year class of 1944. This was as expected, since the ratios of increment and decrement show that on the average only 4.5 percent of the total yield of a brood is made in its 3rd year as compared to 18.4 percent in its 4th year. The recruitment received from this year class plus that received from the entering year class of 1945 exceeded the losses through mortality in the older year classes so that a gain in the number available to the fishery resulted.

A reduction of quota from 400,000 barrels last year to 300,000 in the present season was considered necessary after evaluating the total potential yields of all of the year classes involved. It was found that the successful year classes of 1939, 1940, and 1941 which have been largely responsible for the high abundance of recent years are no longer capable of large contributions, so that the chief support of the fishery now rests with the year class of 1944. The reduction of fishing intensity is intended to permit an adequate survival of this year class until such time as new successful year classes enter the fishery.

PRINCE WILLIAM SOUND:

As the result of a delay in reaching satisfactory price and labor contracts, operations which had been projected for this district in 1947 were abandoned. The only fishing in this district was the removal of approximately 14,000 barrels by vessels of the Kodiak fleet. The irregular operations in this area during the past six years have not provided adequate data for calculation of the return per unit of effort or for the establishmen of ratios of increment and decrement necessary for specific evaluations of abundance.

The quotas established for the 1948 season were based principally on an appraisal of the probable strength of the year classes by observing their performance in the other fishing districts. Past records have shown that a positive correlation exists in the strength of the year classes betwee the major fishing areas. From these comparisons the prospects for the 1948 season appear more favorable than for some time past. The basis for anticipating an abundance in the summer period is the 1944 year class which is now in its 5th year. This year class has been of exceptional strength in both the Kodiak and Southeastern fisheries and if it is of comparable strength in Prince William Sound, it should provide ample abundance for the capture of the 150,000 barrel summer quota. Optimism for the occurence of a significant fall run is caused by the maturing of the 1942 year class into its 7th year. This year class has proven very strong in the other fishing districts and is probably of above average strength in the Prince William Sound district also. The fact that there have been so few withdrawls against it during the summer period of recent years should have permitted it to survive in sufficient numbers to support a fall run in 1948.

SOUTHEASTERN:

Confidence in the restored abundance of the populations in this district was reflected by the entrance into the fishery of several new plants and by the reopening of others that had been idle during the preceding period of low abundance. The seven plants, employing a combined fleet of 28 vessels made a catch of 335,000 barrels during the 1947 season.

The small size of the individual catches resulted in a sharp decline in the abundance index from that of the preceding year. It is believed, however, that the index was abnormally low because of unfavorable weather conditions and therefore did not show the true abundance in this year. The calculation of theoretical abundance from the total potential yield of the various year classes showed an increase in the number of individuals available to the fishery. This increase was caused by the successful 1944 year class maturing into its 4th year, the age at which a year class makes its maximum contribution to the fishery.

The ratios of increment and decrement were revised to include the age composition of the 1947 season. They show that for each individual of a given brood that has entered the fishery in its 3rd year there have been 4.1 individuals of the same brood as 4-year fish in the succeeding year; for each 4-year fish 0.7 individuals as 5-year fish; for each 5-year fish 0.5 individuals as 6-year fish; for each 6-year fish 0.5 individuals as 7-year fish; for each 7-year fish 0.4 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 optimum yield for the 1948 season was calculated from the estimated potential yield of each year class and the rate at which each should contribute its members to permit significant survival until the eighth year. It was shown that the main support of the fishery is now the year class of 1944 which will provide over fifty percent of the catch in 1948. From this it is apparent that unless additional recruitment is soon received, through the entrance of other successful year classes, the present high level of abundance cannot be maintained.

OTHER ACTIVITIES:

An additional activity in the year has been the collection and analysis of Sablefish log records to obtain information on the abundance of this species. A closed season to reduce the fishing intensity has been in force in this fishery since 1945. Preliminary results indicate that under the high intensity of the war years the abundance in the inside waters of Southeastern Alaska has continued to decline, and that the large annual production has only been achieved by an expansion of the fishing grounds into the outside waters along the coast of Baranof Island and into the gulf of Alaska. The first decrease in fishing intensity occurred in the 1947 season with a total landing of only 700,000 pounds compared to nearly 6,000,000 pounds landed in 1946. If this reduced intensity should continue additional curtailment may prove unnecessary.

Log books including suitable statistical maps were prepared to obtain information on the rapidly expanding trawl fishery in the Bering Sea. Trial copies of these books have been distributed to test their usefulness in procuring the information desired.

FLUCTUATIONS IN TIME OF APPEARANCE AND ABUNDANCE OF ALASKA SALMON RUNS

A study was begun to test if a sample of the traps operating during a season in each district, could be used to determine the progress of the salmon run in that district. The first step in this study is to select a group of traps in each district that have operated consistently in the same location from year to year. Changing the location of a trap changes the runs sampled and the efficiency of the trap. The southeastern Alaska fishery records are being checked to determine, if possible, the location of all traps operated each year. A comparison of the daily catch of the "control" traps and of the remaining traps in the district should determine if the "control" set of traps may be used to indicate the progress of the run.

As the pink salmon comprise approximately seventy-five percent of the catch of southeastern Alaska, the opening and closing dates of the fishing season are determined for the protection of this major species. As the pink salmon migrations have become late in the season, the opening and closing dates have been set from two weeks to a month later than in earlier years. The effect of this later season on the catches of chum and red salmon is being studied. From a preliminary inspection of the data, it appears that the time of migration of the chum and red salmon has not varied with the pink salmon, but has fluctuated independently.

In cooperation with the Pink Salmon Investigations, a statistical analysis was made of the relationship between the time of the pink salmon fry migration from the stream to the ocean, the stream temperatures during the incubation period and the percentage fresh-water survival, at Little Port Walter, Alaska. Since these data are available for only seven years, it is difficult to obtain a "statistically significant" relationship, but it is apparent that these three factors are highly correlated and as more data become available a more detailed analysis may be made.

Assistance was given Mr. F. B. Sanford, chemist of the Seattle Technological Laboratory, in the statistical analysis of "E-Value ratios" for Grayfish, Soupfin Shark, Sablefish, and Halibut Liver oils. The results of this analysis have been submitted for publication through the Branch of Commercial Fisheries.

ALASKA FISHERY STATISTICS

Assistance to the Branch of Alaska Fisheries with the daily Bristol Bay gill net catches was continued through the first half of July. This was an attempt to follow the fluctuations in abundance of red salmon as indicated by the catch per unit of gear per delivery, and this attempt was moderately successful. As in following all runs of salmon, there is a time lag between the time the fish are caught and the time the catches are reported, so that by the time the data are received and analysed, the abundance of the run of salmon may have changed considerably. However, the time lag is less for the gill net fishery of Bristol Bay than for the trap fishery of Southeastern Alaska.

Tabulation of thedaily trap-catch data for red salmon in Southeastern Alaska was continued throughout the year, and is now nearly complete. Completion of this lengthy tabulation will permit analyses for trends of catch (and relative abundance) of this species for the specific districts and the general area.

The 1947 trap catch records (on form #3-1362) were forwarded to this office by the wardens who are responsible for their collection. These records were checked in against the card file system kept for the purpose of detecting shortages and then filed for use.

Tabulation of the daily trap catch data of Cook Inlet red salmon was resumed during the fall, but was soon discontinued because of the pressure of other duties. Two radically different classes of traps are operated in this district, the hand traps and the pile traps. Because of their marked difference in size and fishing capacity, the data for the two types were kept separate, a separation that is not necessary in other districts where floating and pile traps are used.

IMPROVEMENT AND EXPANSION OF SALMON SPAWNING AREAS

Fifty watershed maps of the eastern coast of Prince of Wales Island in southeastern Alaska were completed and Ozalid duplicates made during the early part of April for use in the field by aerial and ground survey crews this spring and summer.

This year's stream surveys were begun from Point Baker, the northernmost point on Prince of Wales Island, on May 5 and continued stream by stream along the coastline in an easterly direction. By June 1 the surveys had reached Whale Passage, and by June 30 the aerial and ground surveys of all streams in the fifteen designated watersheds in the northeast quadrant of Prince of Wales Island (to Kasaan Bay) had been completed. The following general data were collected on the lower portion of each stream by the ground crew: air and water temperature; pH; type of rubble and percent of each type; estimated flow, water stage and color; estimated rating as a salmon spawning stream; photographs taken; fish seen; barriers observed; and improvement recommended. The following numerical data were recorded at each station taken; location; azimuth downstream; distance between stations; average width; estimated percent spawning area; number of square yards of spawning area; gradient (number of feet drop in known distance as measured with an Abney Level when possible); average depth; slope and composition of banks; number of salmon-resting pools; estimated percent of bedrock, boulders, large, medium, and small rubble or mud and sand present in the streambed. These data were supplemented by important additional observations collected on the river system as a whole by aerial surveys.

The Stream Improvement Project is conducting a program along the following lines: 1) Locating the barriers affecting the salmon migrations in Alaska. 2) Determining which barriers, through improvement, will increase the salmon runs. 3) Introducing a usable stream numbering system for all Alaskan streams. 4) Comparing streams by size frequency distribution and studying their relative availability as spawning areas and as salmon producers. 5) Establishing the relation between gradient and bottom rubble. 6) Cataloging of all Alaskan streams for future reference.

NORTH PACIFIC FISHERY INVESTIGATIONS

Joseph T. Barnaby, Chief.

GENERAL

The program of the North Pacific Fishery Investigations during the fiscal year has been designed primarily to study the effect of present and proposed water-use projects upon the anadromous fish runs of the Columbia River. A major objective was to develop safeguards for the passage of fish at dams and diversions by guiding methods, or by mechanically minimizing known existing hazards. Stream survey data, the accumulated results of past years of work, have been utilized in the development of the Lower Columbia River Plan as a double check against failure of fish facilities at high dams and loss of spawning areas. Continuing data on the Columbia River salmon have been obtained through the analysis of catch statistics and annual marking program returns.

ABUNDANCE OF COLUMBIA RIVER SALMON AND ANADROMOUS TROUT POPULATIONS

During the past fiscal year work was continued on the sub-projects reported on for 1946-47, and three additional studies were commenced. The largest run of blueback salmon in recent years led to the initiation of blueback salmon studies designed to determine the number and distribution of adult spawners and particularly to detect any possible overcrowding on the spawning grounds (the spawning areas have been much reduced as compared with early years, as a result of irrigation and power developments). The desire of the National Park Service and other agencies to secure improved fishing in Roosevelt Lake (the reservoir above Coulee Dam) resulted in the Fish and Wildlife Service being requested to make Roosevelt Lake studies.

The accumulation of data on the catch of Columbia River salmon, in addition to the counts of fish at Bonneville and Rock Island dams, has made it possible to start an analysis of Columbia River salmon runs. This analysis will provide basic factual information for use in studying the dynamics of the various runs in relationship to water-use projects.

Progress reports on individual sub-projects follow.

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

Since the chinook salmon is the most important of Columbia River commercial species, a special study is being made to develop a measure of its abundance which will be free from the effects of changes in fishing intensity. A chain-link method was devised during the 1946-47 fiscal year and calculations were made for the fishing seasons 1936 through 1940. In the early part of the 1947-48 fiscal year additional cannery records were secured for the seasons 1941 through 1945. Using these records the series was extended during the year to 1943, and the earlier year 1935 was also added.

Study of Average Weights of Columbia River Chinooks.

The data for 1946 and 1947 have been obtained by Bryant at Astoria, and have been treated in a manner similar to that described in Special Scientific Report No. 34, the work being done chiefly by Fulton and Gangmark. The average weights so obtained have been used in converting poundage catch data to terms of numbers of fish, for use in conjunction with Bonneville and Rock Island counts.

Blueback Salmon Studies.

In the fall of 1947 a survey was made of all of the important blueback spawning areas, in order to determine the extent of spawning and number of spawners. Observations were made on foot, by boat and by plane, and practically all of the spawning was found to be confined to the Okanogan and Wenatchee River systems. Taking the maximum observed counts of naturally spawning bluebacks, a total of 15,863 fish was accounted for. In addition, 3,905 fish were handled by the Leavenworth and Winthrop hatcheries.

The total of 15,863 naturally spawning fish mentioned above does not include all of the fish utilizing the stream sections surveyed, for the reason that fish are entering and leaving (as post-spawning mortalities) during the entire spawning season. A figure closer to the truth should be obtainable by using the average of successive counts and multiplying by a factor involving length of spawning season and length of stay on the spawning grounds. It was estimated that spawning lasted 35 days, and that the average period on the grounds was 7 days, so that the average counts should be multiplied by 35/7 or 5. The total of the average counts was 11,298; multiplying by 5 gives 56,490 as the estimated number of fish spawning naturally. When the 3,905 hatchery fish are added a total of roughly 60,000 spawners is obtained.

Roosevelt Lake Studies.

The 150 mile body of water impounded by Coulee Dam, and known as Roosevelt Lake, at present provides only very limited sport fishing. It is the hope of the National Park Service, charged with development of recreational resources of the area, that this fishing might be improved, thereby providing additional recreation for the half-million tourists who annually visit Coulee Dam. Toward this end North Pacific Investigations has been asked to make a study of conditions in the lake. Preliminary work toward such a study was accomplished during the past quarter, and the first survey will be made in July by Gangmark and Fulton. During this survey physical and chemical data will be secured, and gill netting will be done to determine the composition of the fish populations now in the lake.

Analysis of Columbia River Salmon Runs.

Since the completion of Bonneville Dam in 1938 there has accumulated a large body of data on within and between season fluctuations in abundance of Columbia River salmon and anadromous trout populations, particularly those species (chinook salmon, blueback salmon and steelhead trout) which

spawn extensively above the dam. The first year's data were analyzed by Dr. W. H. Rich, and the results were published in his report "The Salmon Runs of the Columbia River in 1938." Similar data for the period 1939-1943 have now been compiled by Fulton and Gangmark, under the supervision of Silliman.

Analysis of the data is now under way, and present intentions are to publish a second report covering the results through 1943. This report would give information on such matters as ratio of return to escapement, fishing intensity and other such statistics of value to Fish and Wildlife Service officials, state fishery administrators and officers of water-use development construction agencies.

FISH PROTECTION AT DAMS AND DIVERSIONS

Engineering Design and Field Operations.

Engineering design, preparation of plans and specifications, and the preparation of engineering reports for the North Pacific Fishery Investigations were accomplished by Messrs. Bair and Lambert, engineers, and Mrs. Barker, engineering draftsman. Field operations, under Mr. Bair's direction, were performed by Messrs. Holcomb and Argetsinger, assisted by temporary laborers. Operations in the field have been devoted to the operation and maintenance of fish screens and fish ladders and the counting of fish at Roza Dam on the Yakima River.

During the 1948 fiscal year, fish screens were operated and maintained by this investigation at the following locations:

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

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

Standard Fish Screen Plans

In view of the numerous requests that have been received for plans of a fish screen suitable for small irrigation canals having a flow of from 5 to 15 second-feet, plans are being prepared for a paddle-wheel operated rotary-drum screen for canals with flows of from 12 to 15 second-feet.

The fish screen has a screen drum 2'-0" in diameter and 6'-0 3/4" in length, with a paddle wheel 4'-0" in diameter. Ratio of rotation of the paddle wheel to the screen drum is 13.5 to 1.0. Plans are practically complete and will be available in the very near future.

Fish Protection - General

Holmes has assisted other Federal and State agencies in several instances of fish protection. The largest of these tasks was design of fish trapping facilities for the U. S. Engineers' Mud Mountain Dam on the White River, in Washington. In lieu of providing fishways over the dam, fish-trapping and hauling facilities are being constructed at a private power dam located just below Mud Mountain Dam. The trap and hauling facilities were patterned after those constructed at Keswick Dam on the Sacramento River in California.

Assistance has been given to the Oregon Game Commission in relation to fish screening at a number of large diversions including Savage Rapids on the Rogue River, Marmot Dam on the Sandy River, and power diversions on Hood and McKenzie Rivers.

Fishways at McNary Dam

Holmes has continued to represent the Service in assisting the U. S. Engineers on the design of fishways for McNary Dam, which is under construction on the main stem of the Columbia River. The design of the fishways for the north shore of the dam has been completed and presented in contract drawings. Designs of facilities at the opposite end of the structure are nearing completion. The fishways are patterned in general after those at Bonneville Dam. Principal reliance for the passage of upstream migrants will be placed in overflow type of fish ladders, but fish locks are provided. Only one fish lock will be completed in the original construction but provision will be made for future construction of one or two more if found necessary. To provide greater attraction to the fishways, all of the entrances will be expanded into "collecting systems" similar to those at Bonneville.

Electric Fish Screen

Stimulated by a proposal from the U. S. Bureau of Reclamation that further study be made of the electric fish screen, Holmes prepared a report entitled "History, Development, and Problems of Electric Fish Screen". Since preparing this report Holmes has visited most of the electric fish screens on the west coast-numbering approximately 20--and has conferred with designers, manufacturers, users, and other investigators. The results of these recent studies will be submitted later. The Pacific Power and Light Co. is installing an electric fish screen at the intake of their power plant on the Hood River in Oregon. This is a trial installation that is to be checked by the Oregon Game Commission and will be followed with considerable interest.

Salmon Studies at Bonneville Dam

One of the most difficult problems in connection with the passage of anadromous fishes at large dams is to facilitate the seaward migration of the fingerlings. The experimental fishing carried on at Bonneville by means of special inclined plane by-pass traps and large fyke nets in the forebay has effectively demonstrated the migration pattern of seaward moving young salmon. During the past year Bonneville Dam has been used as a field laboratory to develop methods of safeguarding the passage of these fish so that they may avoid spillway and turbine hazards. The information gained will be applied at the proposed high dams on the Columbia where the dangers will be greater than at the existing dams.

Young salmonid fingerlings in their journey seaward appear to disperse nearly equally in all parts of the stream. Trap catches show them distributed from shore to shore and surface to the bottom at a 70 foot depth in the Bonneville forebay. This year's fishing has verified that the largest catches are made at 25 to 50 foot depths, however.

Knowledge of the distribution determines the type and placement of equipment designed to guide the young fish into safe channels. Surface screens or sheer booms would be useless. A 100 foot string of lights with resistors and rheostats to provide a moving wave of illumination was suspended below the surface of the water in a fingerling by-pass. Preliminary operation of the lights indicated that small fish can be attracted under ideal conditions. High turbidity and debris cause difficulties.

During this fiscal year the Service was given an opportunity to try the effect of subaqueous sound waves upon fishes as a possible method of guiding them. The first trials, with sound equipment furnished by the Naval Ordnance Laboratory, were made under the direction of Mr. Burner at the Leetown Biological Station upon rainbow trout. It was concluded that the fish were not markedly affected by the two narrow sonic and ultra-sonic frequency bands used. The studies are being continued with new equipment of radical and secret design. A manuscript on the preliminary studies has been prepared by Mr. Burner.

Mr. Barnaby prepared a letter to the Corps of Engineers containing an analysis of the available data on the efficiency of the collecting system at Bonneville Dam. The collecting system is an extension of the fish ladder across the downstream face of the power house. This part of the ladder has numerous openings out of which an attraction flow pours to attract salmon migrating upstream. The point to be determined is whether this system collects salmon as efficiently as it is supposed to do or if it might not be more desirable to have two fish ladders without the collecting system.

It was convincingly determined that chinook salmon and steelhead migrating upstream are not slowed appreciably by a tunnel or darkened passage. A 100-foot portion of the Washington Shore fish ladder was covered with plywood completely so that a photelometer inside registered less than .0001 of 1 foot candlepower. Except for occasional periods it was impossible for an observer inside the structure to discern objects

near or far. The experiment is being continued during the blueback migration.

Bonneville Marking Experiments

Mr. Holmes has devoted considerable time to analysis of data relating to a series of fingerling marking experiments that have been in progress since 1938 as a means of determining the extent of injury to seaward migrants in passing Bonneville Dam. These experiments include 32 individual markings totalling nearly a million and a half marked fingerlings, from which more than four thousand adults have been recovered. Further returns of adult fish will be obtained during the present season and in 1949. A preliminary report of returns through 1947 shows wide variation in loss in passing the dam, but an average loss of approximately 14 percent.

SPECIAL STUDIES

Temperature Studies

The study of seasonal fluctuations in temperature of the Columbia River and its tributaries was continued during the year. Thermographs to record temperatures automatically were installed at 21 points on the system from Bonneville Dam to the Canadian border. This program is designed to assist in the analysis of the effect that future water-use projects may have upon temperatures in the Columbia River Basin. The record flood in May prevented installation of several instruments and destroyed a few placement piers with the protective pipe.

River Basin Studies

During the year Mr. Parkhurst's activities have been divided between River Basin Studies and North Pacific Investigations. In April he supervised the marking of 250,000 chinook salmon fingerlings at the Coleman Station in California for the West Coast Fish Cultural Investigations.

The majority of his time has been devoted to the preparation and submission of the following project reports:

Cowlitz River, Foster Creek, Pudding River, Snohomish River, Green-Duwamish River, and Hoh River. Work was also done on the following project reports: McKay, Cold Springs, Ryan Creek, Minidoka, Lewiston Orchards, Kittitas, The Dalles, and McNary.

In addition to the project reports Mr. Parkhurst worked on the fisheries section of the Columbia River Review Report, and prepared a memorandum report on dams in the Columbia River system.

Recoveries of Marked Fish

In 1948 the Service recovered its largest number of marked fish from the various Columbia River experiments. The total recoveries made by Mr. Bryant, assisted by Mr. E. D. Towler of Astoria, from the commercial

fishery, stood at 1,446 chinook, 1,468 blueback, 378 silvers and 11 steelhead on October 1. Returns from hatcheries and field stations at the end of the spawning season added nearly 600 chinook and blueback for a final recovery of about 4,000 marks from all species.

Average Weight Studies

The weight sampling was continued at the Columbia River canneries in order to obtain correct average weights for use in converting the catch which is recorded only by weight, into numbers of fish. A four year cycle average can now be calculated for each species from the data obtained thus far. Over 80,000 fish were included in the 1948 daily sampling totals.

Stream Survey Reports

Mr. Bryant completed revision of the Area I stream survey report for publication. Area I covers all Washington tributaries entering in the lower 180 miles from the mouth through the Klickitat River. Four hundred individual streams are descriptively listed.

CENTRAL VALLEY FISHERY INVESTIGATIONS

James W. Moffet, Chief.

GENERAL

Central Valley Fishery Investigations continued or undertook studies during fiscal year 1948 which were centered along the following lines of endeavor: (1) Preparation of reports, (2) Conduct of the Shasta Salmon Maintenance Program, (3) Water temperature studies throughout the northern half of Central Valley and in the Sacramento-San Joaquin Delta area, (4) Population studies of king salmon, striped bass, shad, and other important fish species in Central Valley, (5) Experiments with marked salmon, (6) Sacramento River sports fishery evaluation and creel census, (7) Formulation of plans for fish protection in relation to the Delta Cross Channel and Delta-Mendota Canal, (8) Rehabilitation of Convict Creek Trout Experiment Station, (9) Formulation of plans for a research program in Yellowstone National Park, and (10) Miscellaneous service and experimentation. The progress of this unit through fiscal year 1948 is detailed under the headings listed above.

Preparation of Reports

Six River Basin reports were prepared for Region I during the year. In addition, four others, originally prepared by this office, were extnesively revised in accordance with River Basin Studies procedures. Four reports dealing with subjects related to river basin projects were in preparation at the year's end.

Shasta Salmon Maintenance Program

Investigative phases of this program were combined with studies relative to the proposed Iron Canyon Project on Sacramento River. In the interest of both projects, a systematic coverage of all king salmon spawning grounds above and below Iron Canyon Dam site during the fall months of 1947 provided a basis for the following population estimate: Above Iron Canyon, spring run 21,200, fall run 71,400, total 92,600; below Iron Canyon, spring run 11,500, fall run 36,500, total 48,000. The total number of spawning salmon in Sacramento River above Chico, California, was set at 140,600.

Early and abundant fall rains in the upper part of Sacramento Valley filled all major tributaries to the river and spawning salmon distributed themselves throughout that portion of the river system below Shasta Dam. Despite very dry conditions in December, 1947, January and February, 1948, enough precipitation occurred to maintain the streams in fair condition. The drought enforced drastic reductions in water releases from Shasta Dam which, at times, threatened salmon eggs deposited in nests in the main Sacramento. Planned reduction of river flow in October and November, 1947, had restricted main river spawning to riffles generally covered by water at low river stages. Consequently, losses from the flow reductions because of drought were not serious.

Temperature Studies in Central Valley

Thermographs were operated for various periods throughout the fiscal year at the following stations: Sacramento River at Redding, at Balls Ferry, at Squaw Hill, at Knight's Landing, at Walnut Grove, and at Rio Vista; on A.C.I.D. Canal at two stations below the take-off from Sacramento River at Redding; on Deer Creek near Vina; on Feather River at West Branch, at Yuba City, and at Nicolaus; on Yuba River at Daguerre Point; on Stony Creek west of Orland; on San Joaquin River at Mossdale and west of Stockton; on Old River at Clifton Court; and on Middle River at Tracy Road. Water temperatures at Shasta Dam and at several fyke-netting stations were also incorporated in the records.

The unusual climatological pattern in California's Central Valley during this fiscal year was reflected in the temperatures of salmon streams. Air temperatures were below normal throughout the latter half of 1947 and from February through April of 1948. Precipitation was above normal in July, August, and October of 1947, and March and April of 1948, but suffered serious deficiencies during all other months of the fiscal year. Shasta Dam and Friant Dam releases were sub-normal during most of the year, but Shasta discharges in late spring were abnormally high.

A year's study on Feather River was completed in the fall of 1947 and yielded much information having to do with heat uptake in this largest of Sacramento River tributaries.

During the planning stages involved in the Shasta Salmon Maintenance Program, predictions of surface temperatures in Shasta Reservoir were made by Mr. O. E. Sette from data collected at Lake Mead on the Colorado River. The validity of the predictions was tested and compared against actual Shasta Reservoir temperatures recorded at 2-week intervals throughout 1946. The predicted maximum temperature approached the actual maximum temperature for the year 1946 within 0.5° Fahrenheit. A time lag evident in the predicted temperature series is the result of the formula and data used to derive the prediction. Additional data and refinement in the method of application would probably correct this time lag.

Population Studies in Central Valley

In addition to the estimates made of the adult salmon population in Sacramento River, the seaward migration of young salmon was sampled daily by fyke nets fished at Balls Ferry and Squaw Hill Bridge. Water from Shasta Reservoir had its usual accelerating effect on the incubation period of salmon eggs in gravels above the mouth of Battle Creek. The downstream migration of spring-run progeny was in progress in November 1947 when sampling began and a seasonal peak was reached at Balls Ferry before mid-December. Fall-run seaward migrants occurred most abundantly at Balls Ferry between January 15 and February 5. The migration was practically over by the end of February. Drought conditions held the flow of Sacramento River to very minor fluctuations, and the downstream movement of young salmon was quite slow. The spring- and fall-run peaks described for Balls Ferry, did not reach Squaw Hill Bridge, 57 miles downstream, until 40 days later for the spring-run progeny and about 30 days later for the young of the fall run. Distributional characteristics of the seaward---

migration at Balls Ferry and Squaw Hill were less discernible as the salmon moved downstream. Results of sampling at Ords Ferry, Colusa, and Knight's Landing do not follow the pattern described at the upstream stations. Reduced effectiveness of the nets used, contributions of salmon from tributary streams, and loitering of the young salmon in the broad, sluggish lower portion of the river probably account for the inconformity.

Sampling of seaward migrations in Battle, Mill, and Deer Creeks on a daily basis indicates a much later peak in abundance of young salmon. A large downstream movement in Battle Creek peaked during the period March 1-10. Peaks were detected in Mill and Deer Creeks in the period March 10-20.

The peculiar precipitation and run-off pattern which characterized early 1948, affected the movements of young salmon into the Sacramento-San Joaquin Delta and thence into San Francisco Bay. Seaward migrant sampling-nets fished in the lower extremities of Sacramento River at Isleton, Georginana Slough, and Toland's Landing showed the presence of an early but very small movement of young salmon January 5-15 during a series of slight storms. These nets caught no salmon from them until March 23, when presumably the entire Sacramento River population was moved into the Delta by a single flood. From March 23 until April 1, catches of young salmon per hour of effort were phenomenal. Catches dropped to practically zero by April 1, but increased to a secondary peak as the result of a second period of heavy river discharges which lasted until April 15. On the basis of past records, the young salmon migrants were about two months late in reaching the Delta this year. It can be said with comparative surety that practically two months of more were required for salmon passing Balls Ferry to reach Isleton, about 264 miles downstream.

A network of 25 tow-netting stations operated weekly in the Delta waters picked up this wave of salmon migration at Isleton and in Georgiana Slough, and traced its movement, not directly to the sea, but up into and throughout the Delta channels. Tidal action and lack of water in San Joaquin River apparently combined to distribute the Sacramento River waters, and some of the fish they contained, inland. The spread of young salmon throughout the Delta was quite rapid. Within a week salmon were being taken at practically every tow-net station in the network. It is comparatively certain that the salmon taken were from Sacramento River, because one young fish marked at Coleman Station was captured in lower San Joaquin River. Practically no fish were entering the Delta from the San Joaquin River because of inadequate flows.

San Joaquin River salmon young reached the Delta on flood crests which came down in May and June. Although they spread throughout the Delta channels, they were distinguishable from the Sacramento River salmon on the basis of greater size. They were most abundant in the southern half of the Delta.

It had been reasoned previously that young Sacrament River salmon would not be materially affected by the Delta-Mendota pumping plant now under construction by the Bureau of Reclamation. Observations this year, clearly indicate that these migrants will be subject to the pumping plant's

draft in years of drought. The pattern of distribution in the Delta during normal or wet years is not yet fixed.

A wide variety of fish species appeared in fyke-net and tow-net catches in the Delta. Although the sampling did not adequately reveal the presence or absence of the rare species, the common fishes were taken in great enough abundance to follow their movements. The following chart, which is not quantitative, indicates the months during which various species appeared in the catches in the latter half of the fiscal year.

"A" designates adult fish; "I" designates immature fish

Species	Common name	Jan.	Feb.	Mar.	Apr.	May	June
Oncorhynchus tschawytscha	King salmon	I		I	I	I	I
Roccus saxatilis	Striped bass	I	I	I	I	I	I
Hypomesus olidus	Smelt	A&I	A&I	A&I	A&I	A&I	A&I
Spirinchus thaleichthys	Smelt	A&I			I	I	I
Ictalurus catus	Fork-tailed catfish	A&I	A&I	A&I	A&I	A&I	
Gambusia affinis	Mosquito fish	I					
Gasterosteus aculeatus	3-spined stickleback	A&I		A	I	I	I
Pogonichthys macrolepidotus	Split-tail		A	A		I	I
Cottus sp.	Soulpin	I					
Alosa sapidissima	Shad			I	I	I	I
Platichthys stellatus	Starry flounder	A&I					
Entosphenus tridentatus	Lamprey	I		I	A&I		
Ameiurus nebulosus	Brown bullhead	A					
Cyprinus carpio	Carp			A			
Lepomis macrochirus	Bluegill				A		A&I
Pomoxis nigro-maculatus	Black crappie				A		A
Huro salmoides	Largemouth black-bass				I		
Ptychocheilus grandis	Squawfish				I	A&I	
Acipenser sp.	Sturgeon					I	
Chaenobryttus gulosus	Warmouth bass						A
Hysterocarpus traski	Fresh-water viviparous perch						A&I

In addition to the species listed above, the goby, Lapidogobius lepidus and the green sunfish, Lepomis cyanellus, have been taken during the investigations.

Salmon Marking Experiment

The Branch of Game-Fish and Hatcheries in cooperation with Western Fish Cultural Investigations marked approximately 250,000 young salmon at Coleman Hatchery. Single fin-marks were used as follows: Spring run - left-ventral fin 50,394, right-ventral fin 50,508; fall run - left-pectoral fin 51,576, right-pectoral fin 50,965; and late fall run - dorsal fin 53,074. The left- ventral, left-pectoral, and dorsal groups were released between March 26 and April 8. Others were held in the hatchery for fall release. Forty-four marked salmon from the brood-year 1944 were recovered in the Sacramento River fishery during the fall of 1947. At the hatchery during the same fall, incomplete examination of the run to Battle Creek showed returns as follows:

Brood year 1944 - 22
Brood year 1945 - spring run - 1
Brood year 1945 - fall run - 26.

Because of the flood mentioned previously, it was impossible to examine the entire Battle Creek population for marks. Intensive patrols of the stream during and after the spawning period revealed no additional marked salmon. Thus far, recoveries of marked salmon in the Sacramento River fishery for spring-run salmon in 1948 have been very poor. Two, somewhat dubious records, were obtained from the river fishery although most fish landed at the major packing plant were checked by personnel looking for marks. The spring-run catch, incidentally, was very poor.

Sacramento River Sports Fishery Evaluation and Census

A systematic census and evaluation of the Sacramento River Sports Fishery was undertaken by this office in August of 1947. The preliminary work was devoted to exploratory inventories intended to develop a procedure for representative coverage of the Sacramento fishery. The Sacramento fishery was found to consist mainly of seasonal salmon fishing and winter steelhead fishing. There was some fishing for resident, summer rainbow trout. According to the preliminary data gathered on salmon fishing, the catch per hour varied between 0.041 in September and 0.038 in October. During the months September through December, 1947, approximately 3,252 king salmon, weighing 62,440 pounds were taken from the Sacramento River between the upstream limits of fishing at Redding and the mouth of Chico Creek by 23,420 fishing efforts which represent 83,220 hours of angling.

During the months December 1947 through February 1948, approximately 3,808 rainbow-steelhead trout were taken from 106 miles of Sacramento River by 10,913 fishing efforts which represent 43,844 hours of angling.

After the close of the fishing season, February 28, a new sampling schedule and system of coverage for the river were designed form the results of the 1947-1948 study. It was instituted on May 1 at the beginning of the fishing season in 1948.

Plans for Fish Protection in the Delta

Several conferences with State and Bureau of Reclamation officials resulted in formulation of tentative plans for fish protection in the Delta Cross Channel and at the Delta-Mendota pumping plant. Preliminary designs and cost estimates are now being made by the Bureau of Reclamation. The plans for fish protection have not been altered materially from those reported earlier. However, additional data have been secured which prove the necessity for such a screening and by-pass device.

Rehabilitation of Convict Creek Experiment Station

Because of unsatisfactory operation in the past, it was decided that revisions in the physical layout of the stream system was necessary. Three structures, serving to control water in the main creek and to provide water for an additional channel similar to the main creek, were designed. The U. S. Forest Service assisted materially in drafting the plans. After some delays, bids were issued and by the close of the fiscal year construction work was under way. Assistance from the U. S. Forest Service has made possible preliminary excavations and a realignment of stream sections prior to the actual construction of the control works.

Yellowstone Park Investigations

Preliminary investigations undertaken in Yellowstone National Park were designed to furnish information on which a thorough research program could be developed. Dr. O. B. Cope visited the park and observed the spawning runs and fish-cultural activities current during the early spring months. Materials collected by Dr. Cope are being worked into a preliminary report.

Miscellaneous Services and Experiments

Many miscellaneous services and experiments were conducted by this unit during this past year. Preliminary trials of sonic and electrical devices for the control of fish migration were undertaken. Results of these trials were not conclusive. However, the trial served as a basis for future planning, and a more comprehensive program is contemplated.

A random sample of 1,127 salmon entering the Sacramento River fishery was examined, measured, and weighed. Preliminary treatment of this sample on the basis of weight, length, sex, and other combinations, indicates that the gill-net fishery in the river is highly selective and that weight or length frequencies cannot be used to determine the age of salmon caught by gill nets. Scales taken from the fish in this sample were mounted but have not been analyzed.

Dr. Oliver B. Cope completed a detail to Alaska during this year. The purpose of this detail was to determine the effect of newly developed insecticides used in blackfly and mosquito control, on local fresh-water fishes and their foods. Results of the fish and blackfly tests have been treated in a preliminary report and are now incorporated in two manuscripts for

publication. By the way of summary, the most effective insecticides in blackfly control which cause a minimum damage to fish and fish food organisms are: DDT in acetone suspension between 0.3 and 15 ppm.; chlordan in acetone suspension between 0.5 and 15 ppm.; DDT in fuel oil solution between 0.4 and 10 pp.; chlordan in fuel oil solution between 0.5 and 6 ppm.; toxaphene in acetone suspension between 0.5 and 8 ppm.

ATLANTIC SALMON INVESTIGATIONS

George A. Rounsefell, Chief.

The investigations concerning Atlantic salmon, which were started on a small part-time scale in 1941 and were all but discontinued during the war, were revived during the fiscal year 1947. This was due in large measure to the action of the Maine Legislature in creating an Atlantic Sea-Run Salmon Commission empowered to manage the salmon fisheries. The agreement for cooperative salmon rehabilitation work, signed in October, 1941, between the Service and the two state fishery departments, has been superseded by a new agreement, signed on June 26, 1948 between the Service, the Atlantic Sea-Run Salmon Commission, the Maine Department of Inland Fisheries and Game, the Maine Department of Sea and Shore Fisheries, nad the University of Maine. This agreement calls for full cooperation between these parties in conducting scientific research, in propagating and distributing salmon and in salmon management activities. Office and laboratory quarters have been furnished by the University of Maine, and personnel and equipment are being furnished in varying degrees by all parties to the agreement.

Little Falls Stream on the Moosehorn National Wildlife Refuge has been selected as an experimental stream to demonstrate stocking methods. A temporary weir for counting the smelts placed in the stream in the fall of 1947 proved inadequate during the spring of 1948 when the stream reached approximately 1000 cubic feet per second. Arrangements have been made for the state engineer to design an adequate counting weir.

To study the factors affecting survival, experimental areas of the stream have been fenced to study survival of fry planted at different densities. Dr. W. H. Everhart, Professor of Fisheries at the University, is cooperating in this experiment by making a quantitative study of the food organisms in the different stream sections.

Protection of fish from stream hazards such as obstructions, turbines, or pollution, is a main objective of these investigations. During May Dr. Rounsefell visited several dam sites on the Connecticut River and observed the existing fishways. Later Mr. Scott Bair, Service fishway engineer, accompanied Dr. Rounsefell and Mr. Carl Crane, the State fishway engineer, in a survey of fishways on some of the principal Maine rivers. Since then Mr. Bond and Dr. Rounsefell have been making preliminary observations on the efficiency of fishways on several coastal streams. There is need for better fishways at several points.

Improved fish-cultural techniques for Atlantic salmon are desirable since it has not been proven that techniques developed for trout are always applicable. In one experiment at present underway at Craig Brook Station, a series of ponds is being held with shallowwater to determine if increased turnover in the water will stimulate growth and aid in disease control. It has already been demonstrated that the shallow ponds aid in keeping down excessive summer temperatures. 26

SECTION OF INLAND FISHERIES

GREAT LAKES INVESTIGATIONS

John Van Oosten, Chief.

GENERAL

Of major concern in the Great Lakes Investigations of the past fiscal year has been the program for the study of the sea lamprey and the development of methods for the control of that parasite. In previous years, because of lack of funds, the Great Lakes staff had participated in the work of the Great Lakes Sea Lamprey Committee (composed of the Great Lakes States, the Province of Ontario, and this Service) only in an advisory and coordinating capacity. However, when funds authorized by special action of Congress (H. J. Res. 366, August 8, 1946) became available in the late summer of 1947, field studies were started and in the early summer of 1948 the contract was let for the construction of an experimental weir on the Ocqueoc River, a tributary of Lake Huron. This weir is to be operated by biologists of the Michigan Department of Conservation.

Aside from the sea lamprey program, the activities of the Great Lakes staff were directed with one exception toward the maintenance of continuing projects and toward the completion of investigations started in earlier years. Three publications by staff members appeared during the fiscal year, three were sent to press, and three manuscripts were completed and accepted for publication. A list of these papers is attached to the present report.

Close cooperation with State, Federal, and other agencies has continued to feature the Great Lakes program. Indeed, many of our most important projects, both past and present, could not have been initiated or maintained on other than a cooperative basis. Dr. Van Oosten has continued as Chairman of both the Great Lakes Sea Lamprey Committee and the Great Lakes Lake Trout Committee.

Sea Lamprey Program.

During the late summer and fall of 1947, Dr. Frank W. Jobes and Mr. Howard J. Buettner made three field trips that took them to ports along the west shore of Lake Huron, the east shore of Lake Michigan, and to Waukegan, Illinois, where they interviewed fishermen on the abundance, distribution, effects, habits, ... of the sea lamprey and collected biological data on lake trout, whitefish, and other species known to be attacked by that parasite. Field studies were resumed in June 1948 when they began an extended trip along the south shore of Lake Superior, interviewing fishermen, collecting data on lake trout, whitefish, and lake herring, and examining local streams for possible spawning runs of the sea lamprey.

Almost no information on the lake trout, principal victim of the sea lamprey, was obtained on Lake Huron, where the stock of trout is so reduced that fishing for the species has been largely abandoned. In Lake Michigan, where production is still considerable but appears to be starting on a decline alarmingly similar to the one that occurred in Lake Huron, the

available evidence indicates that relatively few lake trout less than 20 inches long but nearly 100 percent of those 28 inches or longer bear lamprey marks. Between those limits the proportion of marked fish rises progressively with increase in length.

Of great significance to the methodology of the sea lamprey-lake trout investigations is the evidence from the careful study of 100 specimens from Montague, Michigan, that the scales of the lake trout, although by no means easy to read, can be used for the analysis of age and growth.

Investigation On Green Bay.

The first field work in the cooperative investigations of the fisheries of Green Bay was carried out in the latter half of May when Dr. Ralph Hile of the Great Lakes staff and employees of the Wisconsin Conservation Department tagged 9,820 yellow perch in southern Green Bay, took scale samples from approximately 750 yellow perch and 250 lake herring, and obtained other biological data.

Age and Year-Class Analysis of Lake Erie Fishes.

In this continuing project, Dr. Jobes made age determinations for more than 2,800 fish from which scale samples were collected in October and November 1947.

Growth of the Saginaw Bay Walleye.

The bulk of the first draft has been completed on the section dealing with life history in Dr. Hile's manuscript on the walleye and the walleye fishery of Saginaw Bay.

Other Age and Growth Investigations.

The annual sampling of lake herring (scales from about 450 fish) and yellow perch (more than 300 specimens) of Saginaw Bay was continued. Scales of about 200 smelt from Green Bay and 100 from Saginaw Bay were added to the materials for Dr. Van Oosten's general study of the growth of the species. Scales from approximately 400 Saginaw Bay walleyes were collected to determine whether the recent high rate of growth was affected by the smelt mortality of 1942-1943 and the resulting loss of smelt as a source of food.

Fishery Statistics.

In continuation of the cooperative arrangement with the Branch of Commercial Fisheries, the statistics on the pounds and value of the 1946 catch in the United States waters of the Great Lakes were compiled in the Great Lakes office and forwarded to that agency.

Compilations of production and fishing intensity and estimates of abundance of the principal commercial species in 1946 were completed for the various statistical districts of the State of Michigan waters of the Great Lakes. Summaries of 1946 production by lake, month, and gear were supplied to the Michigan Department of Conservation.

WESTERN FISH CULTURAL INVESTIGATIONS

Frederic F. Fish, Chief.

GENERAL

The activities of Western Fish-Cultural Investigations during fiscal year 1948 were centered at the Corvallis headquarters and at the three major field laboratories located at Seattle and Leavenworth, Washington, and at Anderson, California.

Work at the Corvallis headquarters was primarily administration, the preparation of reports and publications, and certain field investigations.

Several reports were completed, including: the fishery section of the Service's Report upon the Corps of Engineers Review of Survey Report, Willamette River and Tributaries, Oregon. Major manuscripts included: "The Return of the Blueback Salmon to the Columbia River" by Dr. Fish; "Correlation between Bactericidal Action and Fish Tolerance of the Homologues of Two Quaternary Ammonium Compounds" by Rucker, Ordall, and Johnson; "The Removal of Excess Nitrogen from a Hatchery Water Supply" by Rucker and Tuttle; "Fish Cultural Procedures for Use at the Grand Coulee Stations" and Recommended Procedures for the Sapwning and Care of Salmon Eggs" by Burrows; and "The Biological Assay of the Nutritional Value of Certain Salmon Cannery Waste Products" by Burrows and Carrik.

Field Investigations

Field investigations undertaken from the Corvallis headquarters included: (1) studies leading to the age classification of adult salmon being spawned during hatchery operations and (2) an attempt to artificially propagate Alaskan pink salmon in a comparative test with natural propagation. Field hatchery facilities were installed at the U. S. Fishery Laboratory, Little Port Walter, Alaska, and stocked with approximately 200,000 pink salmon eggs collected from East Creek, Tebenkof Bay. As a result of the fish cultural inexperience of the resident caretaker at Little Port Walter, only 10 percent of the eggs collected subsequently hatched. The Alaskan pink Salmon project was then abandoned pending the availability of better facilities and trained manpower.

Marking Experiments

Two groups of 1944-brood and blueback salmon fingerlings were fed nutritionally adequate diets producing differential growth rates, marked with companion marks, and released during the fall of 1945 to determine the relation between the fingerling size at the time of liberation and their survival rate to adulthood. Recoveries of returning three-year adult fish from the Columbia River commercial fishery during the summer of 1947 totaled 69 for the larger size fingerlings in comparison with but 28 from the smaller stock. As a greater percentage of the smaller size fingerlings might return as older-age adults, definite conclusions at this time are not warranted.

Another marking experiment was undertaken to determine the feasibility of downstream relocation of Columbia River blueback salmon. In a series of three separate marking experiments, a total of 64,532 marked blueback salmon were released in Spirit Lake (Cowlitz River (Washington) drainage). From these, only 15 adult fish were recovered from the commercial fishery during 1946 and 1947. In another part of this experiment, 19,669 1943-brood fingerlings were released at the Service's Little White Salmon Hatchery during April, 1945. A total of 710 of these marked fish have been recovered to date--and several others are known to have escaped capture during the spawning operations at Little White Salmon Hatchery. It is tentatively concluded from these marking experiments that relocation of upper Columbia River bluebacks to areas below McNary Dam may have to be considered primarily in terms of artificial propagation.

Toward the close of the 1948 fiscal year, the third in a series of marking experiments was undertaken at the Coleman Station with 1947-brood fingerlings. As in the previous two series, applied to the 1944-1945 fingerlings, paired marks were applied to representative hatchery fish from the spring and fall runs of the Sacramento River for release during their first spring and first fall of life. The returns from the three marking experiments should demonstrate the comparative efficiency of over-summer rearing of these two races of chinook salmon. In addition, a group of late-running 1947-brood fall-chinook fingerlings was marked for recognition and released during the first spring of life. The objective of this marking experiment was to test the feasibility of short-term, large-scale, fish-cultural operations with the stock of Sacramento salmon that will be least affected by construction of the proposed Iron Canyon Dam. During the fall of 1947, two-year and three-year marked stock, returning from the two experiments previously conducted at Coleman, were recovered during the hatchery spawning operations. The returns to date indicate no advantage to be gained through the costly procedure of over-summer rearing. As the dominant age class (four-year-olds) will not return until the fall of 1948, no definite conclusions are as yet warranted. The marking experiments with the Sacramento River salmon have been conducted in co-operation with the Central Valley Investigations and with the Branch of Game-fish and Hatcheries.

Nitrogen Supersaturation Studies

These studies have included frequent analyses of the Leavenworth Hatchery well water supply (in which nitrogen supersaturation presents a serious problem) and testing the efficiency of various experimental designs of deareators in reducing nitrogen supersaturation to a satisfactory level.

Nutrition Studies

Studies in salmon-fingerling nutrition during fiscal year 1948 were divided into two major categories: (1) the testing of certain dry meals as supplements to a basic meat diet and (2) the growth potentials of certain available hatchery foods. Of the supplemental fish meals tested under the first category--an acetone--extracted salmon viscera meal, a low-temperature-dried salmon viscera meal, and a "flame-dried" commercial salmon offal meal--all produced superior growth rates than were obtained from the basic meat diet alone. No difference in growth rates was found between

The acetone-extracted and the low-temperature viscera meals, and both proved significantly better growth than did the flame-dried product. Kelp meal and apple pomace added to the basic diet showed no significant improvement in growth rate over that of the basic diet alone.

The second category experiments were designed primarily to show the growth potentials of certain available fresh products. Rockfish carcasses, which are fed extensively at various state hatcheries on the West Coast, proved entirely inadequate. Whole rockfish were found superior to the rockfish carcasses but generally a decidedly inferior product. Whole hake exhibited an excellent growth potential. The experimental fish did develop anemia after the 8-week period on the hake diet, but the growth potential warrants further experimentation with the product combined in mixed diets containing other sources of the anti-anemia factor. Salmon cannery waste proved of extremely doubtful promise. Salmon viscera was the only fish product tested which appeared nutritionally adequate in the 12 weeks of experimentation. The experimental fish receiving salmon viscera--either freshly ground or when ground, packaged, refrozen and stored for several months--exhibited a weight gain exceeding 300 per cent of their initial weight in comparison with a 163 per cent gain for the beef liver controls.

During the spring of 1948, an experiment designed to further explore the nutritional adequacy of the preground and packaged frozen salmon-viscera diet was undertaken. The experiment was discontinued after a 12-week period, for the experimental fish exhibited definite evidence of a pantothenic acid deficiency. Both chinook and blueback salmon fingerlings were used in the test and three troughs were used for each species. The results of the 1948 experiment were in sharp contrast to those obtained with blueback salmon fingerlings during the previous summer. Water temperatures prevailing during the 1948 experimentation, however, were considerably lower than those during the summer of 1947. It appears, therefore, that the salmon viscera prepared diet is adequate for blueback salmon when water temperatures exceed 50 degrees, but is inadequate at temperatures below 45 degrees--probably because of the constant vitamin demand, but lower level of food intake by the fish at the lower water temperatures. Parallel experiments with frozen and packaged salmon viscera were conducted with Sacramento chinook fingerlings at the Coleman Laboratory during the spring of 1948 and were terminated with results identical with those obtained at Leavenworth.

Pool-Capacity Experiments

An experiment was conducted during the summer of 1947 at the Leavenworth Laboratory to evaluate the carrying capacity of the standard deep troughs, the Foster-Lucas ponds, and 18-foot circular pools. The results indicate that 60 lbs. of blueback fingerlings, averaging 55 per lb., can be carried in the standard deep troughs with no sacrifice in growth rate. Results obtained from the Foster-Lucas ponds indicate a close correlation between the poundage of fish present and the incidence and severity of bacterial gill disease. When the weight of fish carried in the ponds exceeded 1,000 pounds, the control of bacterial gill disease required prophylactic treatments at two- to three-day intervals. Results

obtained from the 18-foot circular pools indicate a total capacity of about 300 lbs. of fish averaging less than 70 per pound--or roughly 150 per cent of the capacity of the Foster-Lucas pond per unit of volume.

Disinfectant Studies

The routine testing of new and untried disinfectants for controlling hatchery diseases has continued at all three field laboratories. Many compounds were tested during the year, one of which--pyridylmercuric acetate--appears to offer distinct promise. Considerable work has been done with this compound in the control of bacterial gill disease and other bacterial infections. The effective concentrations, the toxic concentrations, and methods for applying this compound in pond treatments have been studied. A technique of treatment has been developed which, it is believed, will supersede other methods for controlling bacterial diseases among hatchery fish.

Hatchery Equipment Studies

Work at the Coleman Laboratory during the past year consisted primarily of the design and testing of new types of fish-cultural equipment for the incubation of eggs and fry. Of the many types of equipment tested, one appears to exhibit definite possibilities. This consists of a vertical hatching cabinet which can be stocked with green eggs and which requires no further attention--aside from routine malachite-green treatments to control fungus when necessary--until the advanced fry are ready either for liberation or for stocking rearing ponds. This equipment promises simplicity in operation as well as a material savings in the capital investment required for hatchery construction for the equipment uses vertical space in lieu of the horizontal space occupied by the conventional type of hatching trough.

EASTERN FISH-CULTURAL INVESTIGATIONS
Eugene W. Surber, Chief.

Effects of Insecticides and Chemicals on Fish.

Two field projects with DDT were carried out in cooperation with the Bureau of Entomology and Plant Quarantine, Division of Forest Insects. These were as follows: A mile section of St. Mary's River, Virginis, near Staunton, was sprayed with DDT in fuel oil at the rate of one pound of DDT per acre, July 9, 1947. The DDT was applied by plane, but the canopy of trees and alders over the stream in early July prohibited most of the spray material from reaching the water surface. According to quantitative determinations, only 0.17 pound of DDT per acre actually reached the stream. As part of the operation, fingerling rainbow and brook trout were stocked in the section and additional specimens of these species were placed above, within, and below the sprayed section. The stream had a good native population of blacknose dace, stoneroller suckers, rainbow and brook trout.

Only one of the trout held in liveboxes died during and immediately following the experiment. Several small stoneroller suckers, and one fingerling rainbow trout were killed by the spraying. Blacknose dace and other species of fish in the stream were unaffected. A mile long section of Back Creek, West Virginia, near Glengary was again sprayed on July 23, 1947, this time with an oil spray of DDT at one pound per acre (0.27 pound deposited). In 1946, only a few of the native fishes were killed by a one pound per acre treatment of DDT applied as a suspension (amount deposited on surface, 0.39 pound). However, with the oil spray, about 7 times as many fish were killed. Spotfin shiners, stoneroller suckers, bluegill sunfish, largemouth bass, were much more affected than during the previous treatment. It was concluded that an oil spray was much more toxic to fish than a suspension of DDT. The damage over this length of stream to the total fish population was not excessive considering the benefits to man that might be derived. It demonstrated that an oil spray at one pound per acre was dangerous to fish life and very destructive to aquatic insects.

Pond and laboratory tests were made with several of the newer insecticides including three isomers of benzene hexachloride, toxaphene, chlordan, tetraethyl pyrophosphate, and parathion, and bis (p-chlorophenoxy) methane. Field formulations of some of these insecticides were tried first. Of these, toxaphene was the most poisonous. Solutions of this chemical in fuel oil and auxiliary solvent (PD544-B) killed all species of fish at the one-fourth pound per acre rate (0.04 p.p.m.). In aquarium tests, toxaphene was found to be highly poisonous to small fingerling trout. This chemical killed small rainbow trout at 0.005 p.p.m. (one part in 200,000,000 parts of water). Young bluegill sunfish, on the other hand, could withstand concentrations of toxaphene up to 0.01 p.p.m. A field formulation of the gamma isomer of benzene hexachloride in fuel oil failed to kill most of the warm-water species of fish even at 1 pound per acre. Laboratory tests with the isomers in acetone solutions

showed the gamma isomer to be more toxic than either the beta or the delta forms. The delta isomer was found more toxic than the beta.

In field formulations, chlordan was relatively non-poisonous to fish at one-fourth pound per acre. In acetone solution, chlordan was found to be toxic at the 0.03 p.p.m. level. Tetraethyl pyrophosphate was found to be toxic to fingerling bluegill sunfish at about 0.3 p.p.m. Since this chemical hydorlyzes and breaks down rather rapidly, it seemed to offer possibilities in the control of undesirable fish populations where it was desired to restock a pond within a relatively short time after its treatment to remove undesirable fish. With this in mind, an experiment was conducted in cooperation with the Bureau of Entomology and Plant Quarantine at Beltsville, Maryland. On May 11, 1948, a 0.61 acre pond (Cattail Pond) was treated with tetraethyl pyrophosphate at the rate of 1.2 p.p.m. Two-thirds of the 37 per cent tetraethyl pyrophosphate solution was applied over the surface and one-third beneath the water surface. Most of the fish were dead within three hours after the application. The rate at which this chemical broke down was determined by the addition of live fish to a livebox placed in the pond. It required about 50 hours at a temperature of 72 to 78 degrees F. for the chemical to break down to the point where it was no longer toxic to fish. Unfortunately this chemical is highly dangerous to humans and must be handled with extreme care.

Parathion was toxic to two-inch bluegill sunfish at about the 0.2 p.p.m. level; bis(p-chlorophenoxy) methane at 0.2 p.p.m. killed all the 2.7 inch bluegill sunfish, while there was only 33 per cent mortality at the 0.1 p.p.m. level. Both of these chemicals were the pure form dissolved in acetone.

Propagation of Pond Fishes.

In the pond program to determine the value of inoculating water-bloom algae, two blocks of six ponds each were randomized according to whether they were to be inoculated or not inoculated and whether they were to receive one of two fertilizer treatments, one employing 50 pounds of 10-5-5 inorganic fertilizer per acre per application, the other 100 pounds of 10-5-5 inorganic fertilizer per acre per application. Half of the ponds were inoculated with 1,000 gallons of water bloom algae from a pond with a very heavy bloom. The remaining six ponds were not inoculated. Slight blooms appeared in two ponds, but in spite of the large quantity of inoculum and fertilization up to five applications each, these ponds produced the same type of plant growths, including surface scums and the coarser submerged aquatic plants, which have been characteristic of them during past seasons.

Management of Farm Ponds

Of five ponds stocked during the spring of 1947 with 1,000 bluegill sunfish and 100 largemouth bass per acre, bluegills and bass had reached a size sufficient for the beginning of fishing on June 22, 1948 in three ponds Angling will be on a controlled basis to determine the effect upon total productivity in pounds of fish per acre.

Field Studies on Smallmouth Bass Streams.

In June 1948, a cooperative agreement with the West Virginia Conservation Commission was completed whereby sections of the South Branch of the Potomac and the Cacapon River were set aside for the testing of various fishery management practices, the object of which has been to improve fishing in these streams. The State of West Virginia has appropriated $5,000 to its Conservation Department for the conduct of this work, which will include collection of data on the actual production of fish in these streams. At least one person will be employed on each section of stream to actively patrol it to see that anglers comply with the regulations.

Pollution Problems

The pollution problem on the Shenandoah River received considerable attention by Messers. Henderson and Surber of the Leetown Staff. Mr. Henderson found that the zinc content of the River water was too high to permit the existence of such aquatic insects as the mayflies, stoneflies, and caddisflies. A mass meeting sponsored by the Jefferson and Berkeley County Chapters of the Izaak Walton League was held in Charles Town on March 31, the purpose of which was to focus public attention on the serious condition of the Shenandoah River. On April 6, Mr. Surber and Mr. Henderson appeared before the Water Control Board of Virginia to testify on conditions in the Shenandoah River before and after the construction of the American Viscose rayon plant at Front Royal.

The Water Control Board issued an order on May 12 requiring the American Viscose Corporation, the principal polluter of the Shenandoah River, to install equipment for the neutralization and clarification of its effluent all of the time by March 1, 1949.

Studies are being continued on the River to determine its rate of recovery.

The Evaluation of Factors in Trout Diets.

"Cod liver oil in the diet of trout" appeared in The Progressive Fish Culturist for April, 1948. In this paper it is shown that the inclusion of a small amount of cod liver oil in various diets improved trout growth, generally at reduced cost. When cod liver oil is not too expensive, its inclusion in trout diets is recommended.

A paper, "Feeding rates for trout, some considerations and tables" is ready for final typing. It is thought that the tables of feeding rates will be of service to practical fish-culturists and that the discussion will be of interest to these and others.

"A comparison of beef spleen and pork spleen in the diet of rainbow trout fingerlings" is being offered for publication in The Progressive Fish-Culturist. With the dry feeds used and under the conditions of

the experiment, losses with pork spleen (pork melts) were nearly twice as high as with beef spleen.

"A comparison of cottonseed meal, soybean meal, peanut meal, wheat flakes and two fish meals, in the diet of fingerling trout" has been prepared and will be ready to offer for publication as soon as it is typed. Losses were highest with soybean meal, lowest with cottnseed meal and white fish meal. Growth was much better with the fish meals than with wheat flakes or the oil meals.

"Characteristics of some hatchery diets, especially their content of protein, fat, carbohydrates, certain B-vitamins, and added metals, in relation to their success with rainbow trout fingerlings" was presented at the Denver meeting of The American Fisheries Society by Dr. Mottley. It has now been completed and submitted for publication in the "Transactions". White fish meal and dried yeast were notable for growth production. Particulars as to the composition and value of several effective dry mixtures (particularly "L-44-9") are given.

In the light of recent findings, a number of trout diets have been designed for trial. One new dry mixture (L-48-1) is now being used at Leetown in place of L-44-9.

Therapeutic Treatment of Furunculosis.

Two important experiments were run with the collaboration of Dr. Snieszko; one for the comparison of various treatments for furunculosis; the other to test the effect, on brown trout, of various sulfamerazine dosage rates.

1. Sulfamethazine, sulfathiazole (heavy dosage rate) and sulfathiazole alternated with sulfamerazine were compared with sulfamerazine (the standard drug for treatment) and with untreated controls (2 troughs of each). This was run in two parts, one with yearling, the other with fingerling brook trout. With yearlings the mortality in the untreated controls was almost complete in 16 days. At end of experiment (28 days), mortalities were as follows: untreated controls, 100 per cent; sulfamerazine, 29 percent; sulfamerazine-sulfathiazole, 43 percent; sulfathiazole 75 percent, and sulfamethazine, 62 percent.

With fingerlings (10 troughs, treatment for 31 days, observation for an additional 17 days) mortality, although finally heavy in the untreated controls, was much less acute. Mortalities were low in all treated lots and were as follows: Untreated controls, 90 percent; sulfamerazine, 7.6 percent; sulfamerazine-sulfathiazole, 5.5 percent; sulfathiazole, 11.4 percent; and sulfamethazine, 5.1 percent.

Important were the revelation of the great difference in the courses of the epizootics in the two parts of the experiment (yearlings and fingerlings) and the apparent correlation of the effectiveness of the treatment with the type of epizootic. However, prompt initiation of treatment may largely explain the effectiveness of all the drugs with the fingerlings.

As in 1946, sulfathiazole was markedly inferior to sulfamerazine. Although yearling losses with sulfamethazine treatment were high, because they ceased early, this drug seems worthy of further trial. Sulamerazine was much the best in the acute epizootic.

2. The response of brown trout to 0, 5, 10, and 15 grams of sulfamerazine (in the food) per 100 pounds of fish was tested with fingerlings (10 troughs). The results emphasized the difference in response with different species. Whereas, in 1946 it was found that growth of rainbow trout fingerlings was not affected but that the growth of brook trout was much reduced by dosage at the 10 and 15 gram rates, in this experiment it was found that brown trout failed to grow on diets containing as little as 5 grams of sulfamerazine per 100 pounds of fish. As in the other cases, dislike of the food and consequent poor consumption of food were apparent and sufficient explanations of the poor growth or lack of growth,

Neither the hemoglobin level nor the red-cell count was reduced by sulfamerazine treatment, with brown trout. This should be repeated with brook trout, and other susceptible species. Not in this experiment nor in any at Leetown was there mortality attributable to sulfamerazine.

From the varying results with rainbow, brook, and brown trout it is evident that the response to sulfamerazine, of all important susceptible salmonoid fishes should be carefully investigated. It is planned to make such a study with the Atlantic salmon as soon as those at Leetown become sufficiently large. The effectiveness of sulfamerazine treatment for furunculosis has been properly checked only with brook trout. As soon as possible it should be tested with brown trout, with which a different dosage rate may be preferable.

"The value of certain drugs, especially sulfa drugs in the treatment of furunculosis in brook trout, Salvelinus fontinalis" is appearing in Volume 75 of the Transactions of the American Fisheries Society, "Dosage of sulfamerazine in the treatment of furunculosis in brook trout (Salvelinus fontinalis)" (prepared with the collaboration of Dr. Snieszko) in Volume 76, "Response of brook, rainbow and brown trout to various dosages of sulfamerazine" (by the same authors)in Volume 77, and "Brook and rainbow trout treated with sulfamerazine and calomel or sulfamerazine and carbarsone" (same authors) in The Progressive Fish-Culturist (July 1948).

"The fish disease know as furunculosis, its diagnosis and treatment" (Gutsell and Snieszko) and "Value of various sulfonamides in the treatment of furunculosis in brook trout (Salvelinus fontinalis)" (Snieszko, Gutsell and Friddle) are ready for publication, possibly in veterinary journals.

The Development of Preventive Treatments for Fish Diseases.

Experiments were started in Spring of 1947 and the completion of this series is expected for March 1950. For these experiments, most

of the trout produced at the Leetown Station are divided into batches, which receive various prophylactic treatments starting as soon as fry begin to eat, and continued until fingerlings or yearlings are removed from the station. So far, it has been confirmed that Roccal protects trout from gill disease; calomel from octomitiasis, and sulfamerazine reduces the incidence of furunculosis. During the 1948/49 season, oral immunization of brook trout against furunculosis is being tried.

Oral Immunization of Trout Against Furunculosis.

Controlled laboratory experiments are being run at this time (July 1948).

Investigation of the Toxic Effect Produced in Trout When Fed Contaminated Food.

In January and February of 1947 occurred a heavy mortality of brook trout fry. Bacteria were isolated from the diseased trout and from the meat fed to these fry. Meat was heavily infected with several types of bacteria. As no fry were available, when the bacteria were isolated and studied, it was necessary to maintain the cultures and to test their virulence or toxicity with the next year's batch of trout. Tests were carried out during the last quarter of 1947 and the first quarter of 1948.

The experiments with the rainbow and brook trout fry indicated that none of the bacteria isolated from the diseased brook trout fry and from the meat were harmful, if fed to the fry during the first few days of feeding. These experiments indicated that neither the bacteria found in large numbers in the intestinal tract of brook trout fry, nor the bacteria isolated from the food were responsible for heavy losses among brook trout fry in 1947.

Studies of Gill Diseases.

Two experiments on treatment of bacterial gill disease (regarding its ethiology there is still a considerable doubt) were described in the report for the second quarter of 1948. In the first experiment the cause of the disease was not clear, at first, and various treatments were tried. It has been confirmed that pyridylmercuric acetate is more effective than roccal in removing the bacteria which are associated with gill disease. As all rainbow trout fingerlings were also infected with Octomitus salmonis, treatments with calomel and carbarsone were compared. Calomel was found to be more effective in the removal of the parasites.

Rainbow trout fingerlings used in the second experiment were infected with gill bacteria, Chilodon and Octomitus salmonis. Single treatments with pyridylmercuric acetate and a mixture of copper sulphate, acetic acid and common salt removed entirely the gill bacteria and Chilodon. The losses were the smallest in trout treated with pyridylmercuric acetate. Treatment with Calomel entirely removed Octomitus salmonis.

Pyridylmercuric acetate was used on several occasions in the routine treatment of gill disease and external parasites, and the results were always satisfactory. This chemical is used now at the Leetown station for the routine treatment of external infections.

General Diagnostic Service (Fish Culture)

All trout at the Leetown station were under constant pathological supervision. Whenever a disease was discovered, treatments were recommended,, and frequently carried out by ourselves. Many specimens were sent from the eastern part of the country and several shipments of specimens were received from the West.

Two major trips were made. On the first trip (August 20, to September 3, 1947), a private trout hatchery at Wareham, Mass., the York Pond station at Berlin, N.H. the station at Boothbay Harbor, Maine, and the station at East Orland, Maine were visited. During this trip information was also compiled on the progress of the investigations on the lobster disease. This disease was described by Snieszko and Taylor in early 1947 (Science 105: 500, 1947) and further investigations are being continued at the Agricultural Experiment Station, University of Maine, Orono, Maine. On the request of Dr. Walford, information was also compiled on the herring disease in Maine. Special reports were prepared in regard to the lobster disease and the herring diseases.

The second major trip was made in May (5-11) of 1948. U. S. Fisheries Stations at Hartsville, Mass., and East Orland, Maine were visited, trout and salmon were examined and treatments were recommended.

SPECIAL PROJECTS

Disinfection Of Rainbow Trout Eggs With Sulfamerthiclate.

During the last quarter of 1947 an experiment was carried out on the disinfection of trout eggs with sulfamerthiolate. It was found that eggs could be disinfected at various stages of their development without any apparent effect on their hatching rate. Results were described in The Progressive Fish-Culturist Vol. 10, No.3, 1948.

Ulcer Disease

During fall of 1947 there was at the Leetown Station an outbreak of ulcer disease among brook trout fingerlings. From the diseased trout a new type of bacterium was isolated. This bacterium is difficult to grow. Repeated experiments indicated that it is pathogenic to brook, brown, and rainbow trout and was regularly reisolated from the artificially infected trout. During the last year much time was devoted to the study of this microorganism and it is anticipated that in the near furture the investigations will be sufficiently advanced to permit the publication of the hitherto accumulated observations.

Construction of the Experimental Troughs.

When work was started at the Leetown station, there was no special space reserved for the experimental treatment of trout. As the regular hatchery troughs and circular pools are often in full use, experiments could only be run during a part of a year. Even so, the use of the regular hatchery troughs was not economical, requiring considerable numbers of fish for practically every kind of experiment. In order to remedy this situation, special funds were made available by the Central Office, and eight regular hatchery troughs were converted during the summer of 1947 into 24 experimental troughs. Each of the experimental troughs is supplied with an individually regulated water supply and drain and any one of them can be used independently of the others.

FISH NUTRITION INVESTIGATIONS

Arthur M. Phillips Jr., Chief.

NUTRITIONAL REQUIREMENTS OF FISHES

Vitamin Requirements of Salmonoid Fishes.

The study of the vitamin requirement of trout was continued this past year. No difference was found in the requirement of brook, brown or rainbow trout for niacin. Maximum storage of the vitamin was found when between 3.0 and 4.1 milligrams of niacin were fed per kilogram of trout per day. The total amount stored in the livers was found to be essentially the same for all three species of trout at a given time interval, but there was a difference between the two times at which the analyses were made. Temperature had no effect upon the requirement.

The amount of biotin stored in the liver of trout was dependent upon the amount present in the food. There was a difference in the requirement between species. Brook and rainbow trout required between 6,780 and 26,880 milli-micrograms of biotin per day per kilogram of body weight and browns between 43,360 and 76,980. There was also a difference in the total liver storage between species. Brook and rainbow trout produced a maximum storage of about 1,200 milli-micrograms of biotin per gram of liver and brown trout about 1,100. There was no difference between the two temperatures of the experiment but the time of analyses did have an effect.

Experiments are now underway to determine the requirement of brook, brown and rainbow trout for folic acid. Considerable difficulty is being experienced in checking the analytical methods but it is hoped to have them working in a short while. No data is available for reporting at this time.

Dietary Supplements

The use of cod liver oil in the diet of brook, brown and rainbow trout forms the basis for these experiments. To date the experiments indicate that such an addition results in a marked increase in the growth rate of brook trout but shows little if any increase in the diet of brown and rainbow trout. It cannot be stated at this time whether these effects are due to the vitamin A or D of the oil.

The chemical Thiouracil is being tested in a diet with brook trout. In higher animals the use of this chemical has resulted in an increased efficiency in the conversion of food into flesh. Since size is a factor (apparantly too early use results in poor skeletal growth) these experiments have been underway only a short while and to date no results have been obtained.

ANEMIA IN TROUT

Anemia in Trout

Studies upon anemia in trout showed that both pork and beef spleen were as effective as beef liver in preventing anemia in brook trout. A new commercial liver product was found to be effective in curing a dietary anemia in brook trout. This is the first commercial product found by this laboratory to have such an effect.

At present it is hoped to continue the anemia work and experiments have been set-up. Due to a lack of help and an increased program it might be necessary to drop these studies from this year's program. A commercial dog food is however, being tested for prevention of anemia an although for the two months period of the experiment it appears satisfactory from this point of view, it is much too soon to draw definite conclusions.

STUDIES OF TROUT PHYSIOLOGY

The Effect of Metabolic Products upon the Carrying Capacity of Troughs and Ponds.

Preliminary studies of the factors affecting the carrying capacity of troughs and ponds have shown that the effect of water flow (changes per hour) upon ammonia produced and oxygen consumed is greater than the effect of total volume. Under the conditions of the experiment it was observed that, in most cases, the amount of oxygen consumed and ammonia produced was directly proportional to the temperature and inversely proportional to the number of changes per hour (flow), weight of fish and volume of water. The per cent increase in ammonia production in all cases was considerably greater than the corresponding per cent increase in oxygen consumption. From these studies it is concluded that the flow (water changes per hour) is more important than the volume in obtaining the most efficient use of a hatchery water supply.

At present the results of the above described experiments are being applied and checked against practical conditions in the raceway and troughs of the production hatchery. Since this program has been in progress only a short while, it is not possible to report conclusions or data. In general, however, the results obtained under controlled conditions are being duplicated under practical conditions. The production of metabolic products is showing similar correlations with changes in temperature, flow and volume.

Effect of Nutritional Factors on Egg Production.

This project was formerly assigned to D. W. Slater, who has resigned. It is hoped that some of the studies will be made concerning the effect of dietary fat upon the fat content and type of fat of the eggs of brood brook stock. These experiments are now underway in a preliminary manner and only if time permits will they be carried through to completion.

The Development and Testing of Practical Diets.

A liquid fish product was found to be equal to white-fish meal when incorporated in the standard Cortland No. 6 dry feed mixture. This product offers a substitute for white-fish meal, which is now difficult to obtain. The addition of kelp meal resulted in no beneficial effects. No difference was found between beef or pork spleen in regard to growth, mortality or conversion when fed in the diet of brook trout.

The use of a domestic brand of paprika in the diet of brook trout for coloration at a 2 per cent level produced the quickest and most economical results.

At present several diets are being tested. One diet containing cooked pinto beans has been inferior to the standard No. 6 diet when fed to brook trout. The amount of growth produced is decidedly inferior although no excessive losses have resulted. A commercial product (BY-500) is being tested as a possible substitute for dried skim milk. To date the results compare favorably with the milk-containing diets. The commercial dog food (Dash, Armour and Company) has been a satisfactory substitute for one half the ordinary meat products in the diet of brook trout, but when it has been used as a sole source of food the growth rate has been very slow. No losses of any consequence have resulted from its use. The use of a blower feed (Cortland No. 6) has produced as good a rate of growth as the standard ricer feed.

The Effect of Diet Upon the Chemical Composition of the Trout Body.

This is a new project necessitated by the new co-operative project with Cornell University and the State of New York. Several diets containing different meats and combinations of meats and dry feeds are being fed to brook trout. These trout will be analyzed from time to time to determine the fat, protein and ash content of their bodies. The first analyses are underway but no data have been collected for reporting. A total of 12 combinations of meats and meats with dry feeds, are included in these studies.

In-Service Training School for Fish Hatchery Personnel.

The classes for the current fiscal year were ended with a picnic on May 16th. For the year 34 4-hour classes were held, In addition 3 extra classes were held on Saturdays. For the first time 6 additional classes were held for 3 of the men in Government regulations and "red-tape". These 3 men had no previous experience in office work. Mr. Lund wrote lessons in outline form and conducted the classes. A total of five "students" attended the classes this year and proved to be very co-operative and willing. A general report will be prepared upon this project within the near future.

Children's Fishing Program

This is a new program held for the children of the City of Cortland as a co-operative project between the Fish and Wildlife Service and The Cortland Rotary Club. A section of Otter Creek, running through the city was blocked off with racks, stocked and interested children were allowed to fish for one day 2 to 8 P.M. The age limits were 7 to 14 years. Persons assigned to help the youngsters and a game warden was on duty to help teach the children what he is like and why he is a necessary person. The no. of fish stocked were as follows:

Brook trout -- 241

Brown trout -- 16

Rainbow trout- 2

Total 259

The children took as follows:

Brook trout-- 174
Brown trout-- 7
Rainbow trout- 1
Total 182

This gave a catch of approximately 70 per cent. The number of children fishing and the number catching at least one fish were as follows:

No. Fishing		No. Catching at Least one fish	
Boys --	176	Boys --	79
Girls--	21	Girls--	6
Total----	197	Total----	85

Thus 43 per cent of those fishing caught at least one fish. The program attracted widespread attention and stirred considerable interest; As a whole it is felt the program was succesful and worth while. The program is already under way for the current year and the fishing will start July 12th, 1948.

SECTION OF MARINE FISHERIES

SOUTH PACIFIC FISHERY INVESTIGATIONS
O. E. Sette, Chief.

GENERAL

The tonnage landed during the 1947-1948 pilchard season was the lowest since 1923-24. There were virtually no landings at San Francisco, relatively few at Monterey and the catch at San Pedro was below normal. The total catch for the state was only 110,000 tons. The situation was no better in the Pacific Northwest, where less than 9000 tons were landed.

In our opinion the immediate causes of the abrupt decline in catch are the following: (1) poor survival of the year-classes resulting from spawnings during 1940 through 1945, which has undoubtedly lowered the abundance level of the stock as a whole, and (2) a probable change in habit pattern of this reduced stock.

Continued industry interest in pilchard research is evident. Funds from the State Legislature have become available for pilchard and oceanographic research by Scripps Institution of Oceanography and additional funds are available as the result of a special fifty cents per ton tax on sardine landings. Plans for a cooperative expanded pilchard research program have been formulated by the Scripps Institution of Oceanography, the California Division of Fish and Game and the Fish and Wildlife Service. Progress in putting these plans into operation has been disappointingly slow.

PILCHARD FISHERY DYNAMICS

Size and Age Composition of the Stock.

Age composition, as determined from scale samples, of the 1947-48 commercial catch was determined in cooperation with California biologists.

The fish taken in the Pacific Northwest were predominantly old fish, the 1939 and 1940 year-classes being taken in largest numbers. The 1946 year-class was overwhelmingly dominant in the small Monterey catch, while the 1945 year-class was of greater importance in the San Pedro catch. It is worthy of note that the 1946 year-class was present in Oregon landings, where such young fish are not usually taken. However, determination of whether or not this year-class is successful one and whether it was spawned in the north to a greater extent than other recent year-classes must await further observations.

Determination of Ages of Pilchard by Means of Otoliths, and Age Composition of California Catches in the Seasons 1932-33 to 1937-38.

Comparisons of age readings of otoliths and scales obtained from the same fish have been completed. The results indicate that determinations of age by means of otoliths are on the average at least as

reliable as those determined from scale samples. A report on the results of this study is being prepared by Mr. Mosher.

During the year, otolith collections from Monterey for the 1932-33 and 1933-34 seasons, totaling about 2000 specimens, were read by Mr. Mosher. About 2500 samples from the San Pedro fishery for the 1932-33 and 1933-34 seasons were read. A preliminary tabulation of the age composition of the commercial catch at Monterey and San Pedro during these two seasons was begun.

RECRUITMENT OF PILCHARDS

Spawning Surveys of 1939, 1940 and 1941.

Work has been completed on estimation of total numbers of pilchard eggs and larvae off southern California and two reports have been prepared. Work is progressing on another paper dealing with short-distance variability in concentration of eggs and larvae of the pilchard in the sea.

Correlation of Sizes of Year-Classes with Meteorological and Oceanic Conditions.

During the year we received a number of series of bathythermograph observations taken by Coast Guard weather ships, running to and from station, from Seattle and San Francisco. Although the observations are not always carefully taken, the bathythermograms are of value in assessing the oceanic conditions from month to month, and variations from season to season.

Barometric pressure data have been extracted from Weather Bureau records at San Francisco airport to fill gaps in the series for the last seven years. Pressure gradients indicative of alongshore wind are being computed; through their influence on the upwelling process in the sea, they may be of significance in the study of fluctuations in oceanic conditions.

Offshore wind and weather forecasts for the central California coast, made twice daily, are furnished to us by the weather bureaus. Extracts are made of daily wind force and direction at several observation points for correlating with other data dealing with influence of wind on the upwelling process off central California.

Experiments with Plankton Catching devices.

A high-speed, self-metering plankton collector was tested by Dr. Ahlstrom during a cruise of the "E. W. Scripps" off Lower California during February 2 to 20, 1948. The instrument towed well at near-surface levels. The volume of water strained was in excess of the amount predicted from length of run and mouth aperture. The collector took numbers of eggs and larvae and gave indications of being more effective for collecting the larger larvae during daytime than conventional gear. The material taken in the collector has been separated,

staged, and tabulated and will be reported upon in a joint paper by Dr. Ahlstrom and J. L. McHugh of Scripps Institution of Oceanography.

EFFECTS ON FISHES OF THE ATOMIC EXPLOSIONS

Resurvey of Pelagic Fishes in 1947.

During the greater part of July and August, 1947, Mr. Marr and Dr. Smith, assisted by three commercial fishermen, participated in the Bikini Scientific Resurvey. Trolling operations were carried out from 18 July to 26 August in the vicinity of Bikini and Rongerik Atolls. The catch consisted of 692 fishes distributed among 18 species. The species list for 1947 is virtually identical with that of 1946. The boat catch data have been analysed, levels of abundance compared between the two localities and for the two seasons, 1946 and 1947, and a terminal report has been prepared and submitted.

Biology of Marshall Islands Pelagic Fishes.

During the 1947 Bikini resurvey, extensive morphometric measurements were made on 215 fishes of five species: yellowfin tuna, oceanic skipjack, black skipjack, dogtooth tuna and two-lined mackerel. A reference collection of the tunas was preserved and conveyed to Stanford.

Organization of the morphometric data in a manner that will permit comparison with similar data from other regions has been largely completed. Preliminary results indicate that the yellowfin tuna of the Marshall Islands area differ significantly in several respects from those examined in Costa Rica and reported upon by Mr. Schaefer.

Evidence was obtained which indicates some spawning by oceanic skipjack and yellowfin tuna in this region.

PRELIMINARY INVESTIGATIONS OF PACIFIC TUNAS

Studies of Central American Tunas.

Analysis of the observations and collections relating to tunas, made off Central American in connection with the 1947 operations of the "Pacific Explorer", have been virtually completed and several reports prepared. Important among the results were the taking of post-larval and juvenile specimens of yellowfin tuna, oceanic skipjack, black skipjack and frigate mackerel.

Studies of the collections of bait fishes, tuna stomach contents and night-light collections have not been undertaken due to lack of funds.

Studies on Central and South Pacific Tunas.

/ A few tunas were taken by trolling from the "Alaska", but no schools were encountered that could be set on with purse seine. According to

natives, the "Alaska" was not in the Marshall and Caroline Islands during the best season for tuna.

The staff of the "Oregon" studied the bait situation in the vicinity of the islands that were visited. It is possible to obtain silversides (Iao) at a number of places by the use of beach seines or by using nets set under lights at night. No success was had in catching bait with a lampara net, the usual method used by tuna boats off Mexico and Central America. The silverside can be kept for some time in tanks with circulating water. Only a small quantity of tuna has been taken by the "Oregon".

NEW ENGLAND FISHING BANKS INVESTIGATIONS
William F. Royce, Chief.

GENERAL

Moving of the central office of the Investigation from Cambridge to the Fisheries Laboratory at Woods Hole, Mass., was accomplished during the year. The new location has many advantages including dock spaces and aquaria, extensive laboratory, office and storage space all of which are needed now that a research ship is being operated in this area.

Reconversion of the pre-war trawler Harvard, which had been made into the war-time U.S.C.G. Bellefonte, into the present Albatross III, was completed during the year. Commissioning of this research vessel took place on March 19 at the Boston Fish Pier. Secretary Krug made the principal address at the commissioning. Director Albert M. Day, Chief of Division (Branch) Elmer Higgins, Chief of the Section of Marine Fisheries, Lionel A. Walford, and prominent people in the industry spoke at the occasion. Several hundred interested people attended the ceremonies and the luncheon provided by the Massachusetts Fisheries Association.

Flounder Studies

Two of the first trips of the Albatross III were spent in tagging yellowtail flounders for the purpose of determining independence of stocks, migrations and mortality rates. Other flounder research during the year was concentrated upon writing up abundance, growth and migration studies of yellowtail. The collection of some basic data was discontinued due to shortage of personnel.

Savings Gear Studies.

The Service has recommended to the industry for some time the desirability of adopting a large-mesh cod end for use in otter-trawl fishing for haddock, cod, and other groundfish. Among the things preventing the adoption of this conservation measure has been the belief of some people in industry that such large mesh, although releasing most baby fish, will not release them in a live condition. Preliminary experiments to test this theory were undertaken on early trips of the Albatross III. Baby haddock which passed through the recommended large mesh were caught in a fin-mesh covering, brought to the surface tagged, and released. The number of these fish that are recaptured by the commercial fleet is expected to give some indication of the survival rate of released fish.

Haddock Studies.

The haddock research staff, restricted by the diversion of personnel, attempted to get important phases of the 17-year study in shape to be published, to refine recommendation for protection of baby haddock, to

bring results to research to the industry, to cooperate with the Atlantic States Marine Fisheries Commission in the drafting of conservation measures, and to take part in discussions held by the State Department on the proposed International Treaty for the Northwestern Atlantic Fisheries.

During the year, the most extensive destruction of baby haddock in recent years onthe New England Banks focussed increased attention on the necessity of adopting a conservation program for haddock. During the calendar year of 1947, at least 17,000,000 baby haddock were killed and discarded on the New England Banks by the otter-trawl fleet. These fish were almost all 2 year-olds, product of the 1945 spawning. Knowledge of mortality and growth rates enabled us to estimate that if these fish had been spared until 1948, it would have been possible for the industry to have harvested an additional 30,400,000 of good-sized haddock. These fish would have been worth about $3,000,000 (ex-vessel prices only) and would have represented a potential increase in production of over 30 per cent. In additionto the 17,000,000 killed and discarded, another 14,500,000 of the larger members of this year class were brought to port and marketed as extremely small-sized scrod. Of the total number of haddock from The New England Banks landed in 1947 (37,931,000), the landings of the 2-year old baby fish amounted to over 38 per cent. At the time of writing (July 1948) the result of this waste of potentially-valuable haddock is being reflected in poor catches, and even some broken trips on the New England Banks.

Research Vessel Activities.

Personnel of all projects of the New England Fishing Banks Investigation have been drawn upon to operate the Albatross III, to plan its research program, and to integrate such research activities with existing shore based studies. Following the experiments on savings gear, a sampling program has been designed to undertake the first census of groundfish on the New England Banks. This census, and others to follow, will provide an inventory of the numbers of each size and species of groundfish, a more accurate measure of changes in the size of the supply, and counts of young fish destined to enter the commercial fishery in future years. All of these data are indispensable if predictions of future fishery success and the development of methods of increasing the total yield of New England groundfish are to be obtained.

In addition to savings gear experiments and census operations, other projects planned included the tagging of various species of groundfish on the offshore banks, for purposes of determining independence of stocks, migrations, and mortality rates, and an evaluation of the effect of prolonged otter trawling upon the basic productivity of the banks.

NORTHERN NEW ENGLAND INVESTIGATIONS
Alfred Perlmutter, Chief.

The Rosefish and Rosefish Fishery.

Final revision was made of the paper titled "Age and Growth of Immature Rosefish in the Gulf of Maine and off Westren Nova Scotia" by Messrs. Perlmutter and Clarke and submitted to Washington for publication. An initial draft of a paper on "The Positional Pattern of the Copepod Parasite, Sphyrion lumpi, on the Rosefish, Sebastes marinus, and its Relationship to the Behavior of the Fish" was prepared by Dr. Perlmutter.

History of the Fishery.

A detailed record of the history of the rosefish fishery is being kept as an aid to interpretation of the changes in the catch and abundance of rosefish. The large rosefish catch in 1947 was due to a continued expansion of the rosefish fishery to the more distant Nova Scotian grounds resulting in a greater percentage of rosefish than ever being taken from Nova Scotian waters, Exploratory trips have also been made to the Newfoundland banks and it is anticipated that if present economic conditions continue these will be more heavily exploited in the very near future.

Age and Rate of Growth on Various Fishing Grounds.

From a preliminary study of the scales of immature rosefish Messrs. Perlmutter and Clarke showed this species to be extremely slow growing. The same technique of scale reading was applied to the older mature fish predominating in the commercial catch, but it was found that (possibly because of the slow growth rate) the annuli were crowded and ill defined. A study of otoliths of commercial-size fish has been initiated and improved; simplified techniques for the preparation of the otolith material are being evolved.

Independence of Rosefish Stocks on Different Grounds.

Fishing concentrations of a sample fleet of rosefish vessels have been plotted for the years 1942 through 1947 and indicate six major areas of concentration in the Gulf of Maine; namely, Grand Manan, Mt. Desert-Matinicus, Monhegan-Jeffreys-Platts, East of Gloucester-Highlands, Channel, and Cigar Ridge-Cashes. In addition preliminary study of fishing concentrations on the Nova Scotian Banks show three major areas; Browns Bank, Sambro and Sable Island. Meristic counts have been and are being taken throughout these areas and in cooperation with Dr. Templeman, Director, NewFoundland Government Laboratory, comparative study of the populations of rosefish along the American shore is contemplated.

Size and Sex Composition of the Commercial Catch on Various Grounds and Population Dynamics.

It has been reported previously that length frequencies of both males and females for each year from 1942 through 1946, for each biological area, show a progressive decrease in the number of mature fish and a corresponding increase in the number of immature fish. This can be explained by a study of the relative abundance of the mature and immature fish during the period in question, which shows that yearly recruitment has been constant but that the abundance of the large mature fish has dropped almost 40 per cent. However, in 1947, with recruitment still at the same level, there was no further decline in the abundance of mature rosefish, suggesting the possibility that equilibrium had been reached between recruitment and catch.

Abundance of Rosefish.

Data on the abundance of rosefish have been compiled for one sample fleet of Gloucester rosefish draggers and a second vessel sample is being studied as a further check.

MIDDLE ATLANTIC INVESTIGATIONS
Clinton E. Atkinson, Chief.

RESTORATION OF SHAD.

Scale Analyses - Correlation with Fishing Effort and Catch.

The results of studies of scale samples from the shad runs in the Hudson River show that since 1939 the total mortality rate has fluctuated somewhat from year to year but in the main has gradually declined from slightly more than 60 per cent to less than 50 per cent of the runs; that the population is now made up of all classes from virgins to seven year repeaters; and that the increment of virgin shad has fluctuated widely with extremely low increments in 1943 and 1946. As a consequence, the runs decreased in size from about 9,000,000 pounds in 1942 to 4,000,000 pounds in 1947. The average weights of shad, taken in 1948, compare closely with the average of former years but there is a noticeable difference in the weight of shad of the same length, both male and female, taken in 1941 and in 1948; the 1948 fish being the heavier.

Scale samples from some rivers were inadequate and methods for collection in these areas must be expanded and improved. A large number of samples from the 1946 run of shad in the Connecticut River were read but not analyzed because there is some doubt that the collections are representative of the total population. Samples taken from shad runs in the Delaware River and the rivers in Maryland and Virginia were too small to give reliable data. Increased funds and personnel are needed to cover this territory as thoroughly as the present size and proposed plans for the restoration of the fishery warrant.

Migration and Mortality of Shad.

Every year, from July to September, large schools of shad appear off Mt. Desert Rock, Maine. In the annual report for 1945, tagging of shad from these schools was proposed in order to determine their point or points of origin. On August 28, 1947, 236 shad were cheek-tagged from two schools off Mt. Desert Rock. By spring nineteen of the tagged shad were recaptured in rivers of Georgia and North Carolina, in Chesapeake Bay and in the Hudson and Connecticut rivers. Apparently adult shad from many rivers congregate in mixed schools to feed in the vicinity of Mt. Desert Rock in the summer. No juvenile shad were taken or seen in the schools from which these shad were tagged. Mr. Scattergood reports that small numbers (hundreds) of them have been taken near shore in herring weirs in summer. Small numbers (hundreds) are also captured with white bait along the shores of Long Island in winter, but, as yet, no large concentration of young shad has been located.

At the request of the Atlantic States Marine Fisheries Commission, specific suggestions were made for regulating the shad fishery of the Delaware River to protect it during the period of restoration when the barrier of pollution is removed. It is important to establish sound conservation practices now, in order to speed restoration of shad as

conditions in the river produce a favorable habitat for their activities.

The Shad Research Committee of the Atlantic States Marine Fisheries Committee was advised of the condition of the Hudson River fishery and a plan for coordinated research to be participated in by the States of New York, New Jersey, and Connecticut and the Fish and Wildlife Service was presented at its last meeting.

During the summer of 1947 shad were reared in ponds at Fairlee, Maryland, and Harrison Lake, Virginia, to bring them to a size large enough for tagging in order to learn the age at which shad reach maturity, since annuli on the scales are obscure, and to test the validity of the parent stream theory in relation to shad populations. The ponds were sterilized to rid them of predators, then fertilized and the larval shad introduced. Artificial feeding was begun late last summer but the young fish did not grow large enough for tagging until late fall by which time the water temperature was so low few of the fish survived the tagging operation.

This spring a pond at Ft. Belvoir, Virginia, was stocked with shad larvae for tagging this fall. Continuous feeding since early July with menhaden meal should bring them to a five inch length well before cold weather. The tagged fish will be held in tanks of saline solution at the pH of blood until the wound is healed and tagging mortality appears complete. The remaining fish will be liberated into the Potomac River.

Trends of Abundance of Shad.

There are current catch figures for the shad fishery of the Hudson River only. These are published daily by the Market News Service for Fulton Market, New York City. Fulton Market receipts cover from 85 to 90 per cent of the catch. They do not include local sales up river or along the New Jersey Coast. Nevertheless they cover the bulk of the catch and have the advantage of being available on the daily basis within one or two days after the catches are made.

The catch of shad in the Hudson, as followed by receipts on Fulton Market, dropped from a high of 5,000,000 pounds in 1944, at the rate of 1,000,000 pounds per year until the 1948 season just past, when receipts rose 263,000 pounds above the 2,000,000 pounds taken in 1947.

In the Connecticut River, the latest figures available are for 1946. The catch in that year was the highest in the history of the fishery. The trend of this fishery has been sharply upward since 1931, the number of fish caught in 1931 being 18,000 compared with 222,000 in 1945 and 302,000 taken in 1946. Although the number of nets fished increased from about 70 (1932-1942) to 100 in 1944, the total mortality rate meanwhile dropped from 80 to 60 per cent. In 1945, the number of nets was increased to 136 and the following year was almost doubled, being 201 in the aggregate. The catch of shad per net fell

off somewhat the last two of those years, indicating that the increase in the size of the population was at a lower rate than the increase in the number of nets

The record catch of shad for the Delaware River system by New Jersey fishermen, with the types and amount of gear employed, has been brought up to date. There are no official records of the shad caught by Pennsylvania or Delaware. The catch in Delaware is thought by State Officials to be a very considerable part of the total catch, but very few shad are taken by the three or four seine fisheries in Pennsylvania.

The catch records in the Chesapeake Bay region are also incomplete, but those which are available from Service sources and the State of Maryland Department of Research and Education are tabulated in as much detail as is obtainable from field notes.

Interdependence of Stocks of Shad along the Atlantic Coast.

Collection of data on racial characteristics of shad from several rivers is complete. They have been tabulated and graphed. In order to determine the linear combination of the measurements and counts which will give the smallest possible frequency of misclassification, the discriminant function will be found for the distinguishing characteristics.

Survey of Shad Fisheries of Virginia.

This study, based on all data available at the present time, was completed and a report with recommendations for future conservation, for better catch statistics and for more intensive study of the fishery was submitted early in 1948 by Louella E. Cable and Edgar H. Hollis.

GULF FISHERY INVESTIGATIONS
William W. Anderson, Chief.

SHRIMP

Preparation of Shrimp Manuscripts.

Two manuscripts, "The Shrimp Fishery of the Southern United States" and "Early stages in the life history of the common marine shrimp, Penaeus setiferus (Linn.)" have been approved for publication. The following manuscripts are in the final stages of preparation:

1. Observations on certain phases of the reproductive cycle in the common marine shrimp, Penaeus setiferus (Linn.).

2. Migrations of the common shrimp, Penaeus setiferus (Linn.) along the South Atlantic Coast as determined by tagging studies.

3. Migrations of the common shrimp, Penaeus setiferus (Linn.) along the Louisiana Coast, west of the Mississippi River, as determined by tagging studies.

4. Tagging studies on the common shrimp, Penaeus setiferus (Linn.) in a section of the Texas Fishery.

5. Offshore distribution of the common commercial shrimp, Penaeus setiferus (Linn.), as determined by exploration of the M.V. Pelican.

6. The growth, life-span and weight-length relationships in the common marine shrimp, Penaeus setiferus (Linn.).

7. Size distribution of the common shrimp, Penaeus setiferus (Linn.), occurring along the South Atlantic Coast and contributing factors.

8. Size distribution and contributing factors, of the common shrimp, Penaeus setiferus (Linn.), occurring along sections of the Louisiana and Texas Coasts.

Conclusion of Shrimp Tagging Experiments along the Mexico-Texas Coasts.

In March, 1947, shrimp were tagged off the northern coast of Mexico to determine if a migration of shrimp was occurring between Mexico and Texas waters. The tagging was done in the early spring so that if the suspected northward spring migration was occurring the tagged individuals would be recovered in the Texas fishery. During the spring and summer 14 per cent of the tagged shrimp were recovered and, with one exception, all were taken north of the point of release. The longest northward migration recorded was one of 172 miles. We believe this clearly demonstrates the presence of a northward spring

migration from Mexico to Texas waters. When a substantial shrimp fishery has developed in the region of Tampico, Mexico, we may be able to show a southward fall movement by tagging in Texas waters and securing returns from the Mexican fishery.

Bottom Fishes of the South Atlantic.

During the several years Mr. Anderson was conducting shrimp studies on the South Atlantic Coast, records were kept of species, numbers and lengths of fish taken in connection with shrimp trawling operations. There was thus accumulated a wealth of valuable data and information on the bottom fishes of this region and the effects of trawling on fish populations. This spring, Mr. Anderson began a study of these data, when time permitted, and has made considerable progress on a paper covering these observations.

Red Tide.

During July and August, Mr. Anderson investigated the "red tide" which occurred along the Florida West Coast. General observations and inquiry were made on many phases of the problem. These included the appearance and extent of the "red tide" waters, color and characteristics, species of fish and other organisms affected, apparent cause of these mortalities and observations on manner of dying. In addition extensive water and plankton samples were obtained and forwarded to various laboratories for analysis. Specimens of dead fish were likewise obtained for study.

The apparent cause of this "red tide" and the associated death of marine organisms was the presence of tremendous numbers of dinoflagellates of the genus Gymnodinium. Counts made in the field gave estimates of a minimum of 56,000,000 to the liter of water in the more heavily infected areas. By the latter part of September the "red tide" condition had apparently disappeared and the waters of the infected area resumed their normal state.

Temporary Assignment to Bering Sea Investigation.

During the period July 1-September 27, Mr. King served on the Pacific Exploration Company's vessel Alaska as biologist-observer on an experimental fishing trip in Bering Sea. During a period of about 6 weeks of actual fishing with trawling gear, the crew of the vessel captured and processed about 14,000 king crabs yielding 60,000 pounds of cooked and frozen crab legs. Detailed records were kept on the fishing operations and the functioning of the vessel and its gear; a representative collection of the fish and invertebrates was made and identified; weight and length measurements were taken of a significant number of king crabs and more important fish; hydrographic and climatological observations were recorded. A report covering these records and observations was prepared and submitted at the conclusion of the trip.

SECTION OF SHELLFISHERIES

NEW ENGLAND SHELLFISHERY INVESTIGATIONS
V. L. Loosanoff, Chief.

STUDIES OF PROPAGATION, GROWTH AND PHYSIOLOGY OF OYSTERS

Observations On Gonad Development, Spawning and Setting Of Oysters In Long Island Sound.

In the summer of 1947 stations were established at representative oyster-producing sections of Long Island Sound for observations on the gonad development, spawning and setting of oysters. This work was conducted by Loosanoff and Nomejko. The information obtained was released through a series of bulletins to the oyster growers of Connecticut, Long Island and Rhode Island.

Regardless of the comparatively low temperature during the pre-spawning period the oysters developed a normal quantity of spawn and began to spawn about July 1. Setting of oysters began, as predicted in our bulletins, on July 17 and 18 and reached its maximum intensity on July 28, decreasing rapidly after that. The second peak of setting occurred in September. In general, however, setting during the entire summer was extremely light and from a commercial point of view was considered unsatisfactory. The laboratory examined hundreds of samples of cultch brought in from different beds by the oyster growers.

Late in May and June of 1948 observations on gonad development and spawning of oysters were again initiated and are being continued.

Development of Methods for Cultivation of Larvae and Studies of the Physiology of Larvae.

A satisfactory method for rearing oyster larvae in the laboratory has been developed by Harry C. Davis. By using the method described by Loosanoff in 1945 for inducing gonad development of oysters during the winter months, and by retarding spawning in the fall by keeping oysters at low temperature it is possible now to work with oyster larvae on a year-round basis. The method now permits investigators to conduct observations on the physiology of larvae consisting in determining the optimum temperature, salinity and other factors needed for development of larvae. At present studies are being made by Davis to determe what microorganisms are important in the feeding and normal development of larvae. Many cultures of microorganisms are now cultivated in the laboratory.

A method for staining oyster larvae for studies of their movements and distribution has been developed by Loosanoff and Davis. The method consists in staining either fertilized eggs, trochophore or straight hinge larvae with certain vital stains, neutral red giving

the best results. The larvae retained the red color for at least 12 days and could easily be identified. The method offers opportunities for studying, under natural conditions, the vertical and horizontal movements, distribution, dispersal and perhaps even the rate of growth and survival of oyster larvae and probably of other lamellibranchs. The method was successfully used for other forms, such as barnacle larvae, copepods, other crustaceans, ctenaphores, worm larvae, etc.

Temperature Requirements of Oysters For Gonad Development.

Experiments conducted by Loosanoff and Davis consisting in taking hibernating oysters in the winter time and placing them in warm water having a temperature of 10, 15, 20, 25, and 30°C. showed that gonad development and production of physiologically-ripe gametes could be rapidly induced. For example, by keeping the oysters in a temperature of 30°C. fertilizable eggs and active spermatozoa could be obtained after five days. At 25°C, eggs and spermatozoa were available after ten days. In some cases oysters kept at high temperatures spawned nine days after taken from Long Island Sound, where the temperature at that time was approximately 0°C. These studies will permit investigators to calculate the day-calories needed for development of ripe gametes.

Growth of Oysters.

Analyses of the data on monthly growth of oysters in Milford Harbor were completed by Loosanoff and Nomejko and the following conclusions were made:

The maximum period during which oysters may grow in Milford Harbor is approximately of 8-months' duration, extending from April to November, both months inclusive. The increase in length was most rapid during May, June and July, and in width, in June. The increase in greatest depth was not appreciable until July.

The increase in volume continued from April through November. The greatest monthly increases were recorded during August and September. The growth of oysters, taken as a group, continued throughout the entire growth period without marked interruption during the spawning season.

The process of gametogenesis did not interfere with growth of shell, at least as far as the increase in length and width was concerned. Spawning activities did not adversely affect the rate of increase in shell length and volume. The chief increase in length and width occurred during the first half of the growing period, while the increase in depth and volume was most pronounced during the second half.

A study to determine the rate of growth of oysters at different temperatures was carried on by Loosanoff and Nomejko. The study consisted in observing the growth of oysters kept in the winter time in an aquarium with running water the temperature of which was maintained at 10, 15, 20, 25 and 30°C. The best growth was noticed in the group kept at 15°. Oysters kept at 20, 25, and 30°C. also showed appreciable

growth, while the group kept at 10° showed the least increase. These experiments will be continued next winter to obtain more data for forming final conclusions.

Another experiment conducted by Loosanoff and Nomejko showed that the rate of growth of oysters the edges of the shells of which were broken was more rapid than that of the uninjured oysters. Experiments involving 100 oysters, 50 of which were used as controls and the other 50 of which had the edges filed off early in the summer, showed that at the end of the growing season the mean length of the oysters with filed off shells was considerably greater than that of the control group. The mean increase in length of the shells of the control oysters was 10.2 mm., while that of the oysters with filed off shells was 19.2 mm. It appears that breaking off the edges of the shells accelerates the rate of growth of oysters in the following months. Experiments of the same nature are being repeated to obtain more data before forming final conclusions.

Studies of oysters in water of different salinities ranging from 3.0 to 27.0 p.p.t. were also performed. In 5.0 p.p.t. virtually no growth occurred. In 7.5 p.p.t. some oysters formed new shell shoots. In higher salinities the oysters grew better, the most rapid growth being recorded in our normal water, salinity of about 27.0 p.p.t.

Observations on the growth rate of Maryland and Long Island Sound oysters of the same age and kept under the same conditions in Milford Harbor were continued by Loosanoff and Nomejko. The following observations were made: The mortality of the Maryland oysters was not higher than that of the local stock and the growth rate of the Maryland oysters closely approached that of the Long Island Sound group.

Studies of Effects of Low Salinities Upon Oysters.

These studies were conducted by Loosanoff and Tommers. Most observations were made on Long Island Sound oysters accustomed to salinity of about 27.0 p.p.t. In some cases, however, comparisons were made between Long Island Sound oysters and oysters shipped from the localities where the normal salinity was low, approximately 15.0 p.p.t. The length of survival in low salinities was controlled by temperature. At 20-26°C. the oysters kept in fresh water began to die on the third day and all died within about 13 days. In 5.0 p.p.t. the majority died within 15-20 days. In 10.0 p.p.t. the majority survived 31 days of exposure.

At low temperatures (8-12°C.) some adult and young oysters were alive after 70 days in fresh water, while others were alive after 115 days in salinities of 3.0 and 5.0 p.p.t.

The majority of the adult and young oysters kept in fresh water or salinities of 3.0 and 5.0 p.p.t. at low temperatures (8-12°C.) for 20, 30, 40, 50 or 60 days opened their shells within a few hours after

transfer to sea water, and began to feed within 24-48 hours. Thus, the oysters endured well the shock of transfer from low to high salinities.

No feeding was observed in 3.0 p.p.t. or lower. In 5.0 p.p.t. approximately 30 per cent fed at temperatures ranging from 15 to 20° C. but fewer, when the temperature was increased. In 7.5 p.p.t. approximately half were feeding. In salinities of 10.0 and 12.0 p.p.t. feeding was more normal.

Experiments conducted up to date seem to indicate that the oysters normally accustomed to comparatively low salinities, such as 15.0 p.p.t. (Maryland) do not show more tolerance to very low salinity, such as 3.0 p.p.t. than high salinity oysters, such as Long Island Sound specimens. These experiments, however, will be repeated before final conclusions are reached.

Extensive data were collected on the rate of pumping and shell movements of oysters which were exposed to changes in salinity from 27.0 p.p.t. to 20.0, 15.0, 10.0 and 5.0 p.p.t. or fresh water. A similar series of experiments was performed on oysters conditioned in 15.0 p.p.t. and then subjected to a sudden change in salinity.

Studies were also made on gonad development, spawning and survival of spawn produced by oysters accustomed to high salinities and then subjected to lower ones. Oysters taken from Long Island Sound soon after the end of the hibernation period were kept in running fresh water or running salt water of salinities of 3.0, 5.0, 7.5, 10.0, 12.0. and 15.0 p.p.t. until spawning temperatures were reached. Histological studies of gonads of the oysters from fresh water, 3.0 and 5.0 p.p.t. showed that their development was arrested. In 7.5 p.p.t. functional spermatozoa and fertilizable eggs were formed but the development was abnormal. Oysters of 10.0 and 12.0 p.p.t. were induced to spawn, fertilization occurred but the gametes developed better in normal than in reduced salinities.

Oysters with gonads half developed were placed in low salinities four weeks prior to spawning. They spawned heavily in 10.0 and 12.0 p.p.t. and less heavily in 7.5 p.p.t. No spawning was recorded in lower salinities.

Oysters nearing spawning conditions in Long Island Sound were placed directly in water of low salinities. Several days later profuse spawning took place in 10.0 and 12.0 p.p.t. and medium heavy in 7.5 p.p.t. No spawning took place in lower salinities. These groups of oysters repeated spawning on several occasions. The eggs of all three groups were fertilizable.

Oysters kept in fresh water or salinities of 3.0 or 5.0 p.p.t. for 60 days at temperatures of 8 to 12° C. and then transferred back to sea water early in April recovered from the exposures, developed gonads and spawned, producing normal larvae.

The crystalline style of the oysters taken from sea water the salinity of which was about 27.0 p.p.t. and placed in fresh water or in salinity of 3.0 p.p.t. disappeared within 12 or 24 hours. In salinities of 5.0 p.p.t. the style also disappeared in some instances but later was re-formed in many individuals. The style quickly regenerated after the oysters were returned to normal salinities. For example, oysters kept 5 days in fresh water and then returned to sea water formed a thin style within an hour after they began to feed. Transferred to normal salinities after 20 days in fresh water the oysters formed crystalline styles in four hours.

If the change from high to very low salinities or fresh water occurs rapidly, the oysters will retain pseudo feces in the mantle cavity and true feces in the cloacal chamber until the oysters die. As a rule, their shells remained closed until they began to gape from exhaustion. Some oysters began to form a new shell inside the old one as additional protection against the unfavorable environment.

An apparatus was devised by means of which salinity of the water in which the oysters are kept is changed gradually, thus simulating the conditions in the intertidal basins when salinity changes are considerable. Thus, within a period of six hours the salinity may be changed from 27.0 p.p.t. to fresh water and returned to 27.0 p.p.t. within the next six hours. These studies are still in progress.

Changes in pH of the shell fluid of oysters from water of different salinities, and specific gravity of the blood of the oysters and body fluid under varied salinity conditions were determined. Observations on the degree of swelling of oyster meats in waters of different salinities after different periods of time at different temperatures are being conducted. Many other variations of the problem mentioned above have been investigated.

PROTECTION AGAINST NATURAL ENEMIES AND PARASITES

Observations on Starfish.

During October 1947 and April 1948 the semi-annual surveys on the distribution and occurrence of starfish on Connecticut oyster beds were made by the personnel of Milford Laboratory. The results of these surveys were made available to the members of the oyster industry through bulletins issued by the Director of the Laboratory. The information given in the bulletins showed the position of large bodies of starfish, their approximate numbers and the direction in which the masses of these pests appeared to be moving.

In general, the starfish population of the oyster-producing section of Long Island Sound showed a very sharp increase. However, this increase was due not to the new set of starfish but to the movement of large bodies of starfish from uncultivated to cultivated oyster bottoms. Several oyster companies requested the laboratory to demonstrate to them and help them construct a lime spreading apparatus for the chemical control of starfish.

Studies of the setting of starfish were carried on during the summer of 1947 and have already been begun for the summer of 1948. In 1947 setting of starfish began about July 5 and continued until October 21. The most intensive setting was recorded on July 18 and again on July 26 and 27. However, in general, the starfish set of 1947 was extremely light. Thus it did not contribute significantly to the starfish population of Long Island Sound. No setting of starfish has been recorded as yet in 1948.

Experiments on the ability of starfish to detect food were completed in the Fall of 1947 by Loosanoff and Shipley. In general, as already reported, the results of the field experiments support the conclusions reached in the laboratory that starfish do not necessarily locate their food by the sense of smell but usually find it by coming in contact with it while crawling on the bottom.

Observations conducted by Loosanoff on the method by means by which the starfish opens the oyster showed that it is rather improbable that oysters are opened by purely mechanical means. It was observed on numerous occasions that oysters were opened by starfish without pulling the shells apart. It is believed that in attacking oysters the starfish forms with its body a small cup which wards off the excess water from the outside. This cup is usually placed in a line dividing the two shells. When the oyster opens, a small amount of substance released by the starfish enters the oyster, probably paralyzing the muscle, after which the oyster is unable to close the shell.

Studies of Boring Sponges.

Studies of the life history and ecology of oyster-boring sponges are being conducted by Willard Hartman, a graduate student at Yale University. Studies on the effect of low salinities upon Cliona celata and other closely related species showed that 15.0 p.p.t. is the lowest salinity tolerated by sponges. The sponge can, however, endure somewhat lower salinities if exposed for short periods and if the temperatures is comparatively low. Studies on the propagation of sponges and setting of Cliona have been conducted and are still in progress.

Horseshoe Crabs.

Experiments were conducted by Loosanoff to determine whether or not horseshoe crabs, enemies of small mollusks, principally soft shell clams, may be controlled by DDT. The crabs were subjected for different periods of emulsion of DDT of different strengths. Even after keeping the crabs for five minutes in a concentration of 1 part of DDT per million parts of water they were not affected.

BIOLOGY AND CONSERVATION OF EDIBLE MOLLUSKS OTHER THAN OYSTERS.

Cultivation of oyster larvae, mussels, soft clams, and Mactra solidissima has been conducted by Harry Davis as part of the general program of study of larvae of pelecypod mollusks.

On the request of Campbell Soup Company observations were made by members of Milford Laboratory on the survival of the ocean quahog, Arctica islandica, transplanted from the ocean off Port Judith to Milford Harbor. It was found that the majority of the quahogs died during the periods of low salinities caused by rains. On the other hand, quahogs kept in a more of less constant salinity of about 27.0 p.p.t. in the laboratory aquaria survived for eleven months and some of them spawned.

CHESAPEAKE BAY SHELLFISHERY INVESTIGATIONS

Walter A. Chipman, Jr., Chief.

GENERAL

In the Chesapeake Bay region the Service has continued to assist the State of Maryland in a program of rehabilitation of its oyster resources. Particular attention has been given to investigations leading to the development of oyster-seed areas. Previous biological studies of the Service located two large areas particularly suitable for the production of seed, one in Eastern Bay and another in Holland Straits. Comprehensive studies of the ecology and distribution of oyster larvae and spat in Eastern Bay have been made with the result that much greater utilization of these valuable grounds will be possible. Biological and ecological studies of the principal public reefs have been continued which will lead to better development and management. Of considerable value is a study, recently completed by the Service, of the effects of lowered salinity of the water resulting from floods, on the development of oyster spawn. Other investigations were made of the adaptation of oysters to water of lowered salinity, particularly changes occuring in the blood and body fluids. Such studies of the action of altered salinities have considerable value to the practical oyster growers who frequently transplant seed and adult oysters from areas where the water is markedly different in its salt content.

Oyster Condition Studies.

Oyster quality, or fatness, varies on the different beds and from the same beds at different seasons. In order to assist the oyster industry in producing as good a quality product as possible, the Service is carrying on investigations in the field and laboratory on the factors concerned with the fattening process. From this work a high yield may be obtained and methods for fattening oysters developed.

Oyster Growth Studies.

Under consideration is the possibility of improving Lynnhaven Inlet, Virginia, by dredging and the installation of jetties providing an increased tidal flow. The Service completed a survey of the oyster beds within Lynnhaven Inlet in order to learn if better shellfish production could be expected from the contemplated changes. From the results of these field operations it was concluded that the improvements planned would benefit shellfish production and this, with the application of proper methods of cultivation as outlined in the report of the Service, would allow a possible increase in production nearly double its present value.

In order to ascertain whether the Maryland "cull" law requiring the return of undersized oysters to the bar has resulted in the development of a stock of oysters genetically constituted to be slow growing, seed oysters were taken from a bed in Eastern Bay and divided into several groups. Each group was planted in entirely different enviroments,

including some areas without the Chesapeake Bay. Comparison of growth rates of the various groups and of oysters growing native to the areas of transplantion showed that growth was dependent on ecological factors and that the oysters of Eastern Bay can attain a growth equal to that of other areas. Apparently the role of enviroment on growth has not yet been counteracted by genetic selection in the case of the oysters of the Chesapeake Bay.

Special Studies.

Because of the extreme fire hazard resulting from oil slicks in harbors, much work has been done in devising means of removal of oil from surface water. The most recent and promising method developed by the Navy involves the spraying of a fine sand coated with a layer of carbon on the slick. This carbonized sand combines with the oil and forms clumps which settle to the bottom. In order to answer the question as to the toxicity of the sand and oil combination to aquatic life, experiments have been initiated by the Service. There is evidence that the oil is quite permanently anchored at the spot below the original slick. This action limiting the movement of the oil may be an important point in considerations leading to abatement of oil pollution. Although the combination may be toxic to localized bottom living forms, its action would be limited primarily to certain harbor areas that are already practically devoid of aquatic life.

Considerable damage was done to the oyster reefs in the States of Alabama, Mississippi, and Louisiana as a result of a hurricane on September 19, 1947. The Service conducted a comprehensive survey of the losses of oysters and damage to the grounds and made definite recommendations to the States as to necessary steps to be taken in the rehabilitation of the oyster reefs.

At the request of the Panamanian Government the Service detailed Dr. Paul S. Galtsoff to conduct a survey of the pearl oyster grounds along the Pacific Coast of Panama with the view of determining the cause of the serious decline of the yield of pearl oyster shells. Detailed biological observations gave evidence that overfishing was the primary cause of the decline. There was no evidence that the pearl oysters were destroyed by starfish, gastropods, skates, or other enemies, or that they may have been affected by injurious parasites or diseases or abnormal water conditions. Recommendations were made in the report for rehabilitation of the pearl oyster industry.

ICHTHYOLOGICAL LABORATORY

Samuel F. Hildebrand, in Charge.

The usual routine of the office, which consisted principally in answering letters of inquiry and in the identification of specimens submitted by individuals, clubs, commercial firms, state governments, other Federal government agencies, and foreign nations, was kept up to date. The Federal Food and Drug Administration, in particular, has repeatedly asked for identifications of specimens and for opinions on appropriate names for canned fish.

Accounts of the herrings and herring-like fishes for the general work on the "Fishes of the Western North Atlantic", to be published by the Sears Foundation, Yale University, were completed during the year. This work, which has occupied most of Dr. Hildebrand's time and attention during the past two years, consists of 555 type written pages. In it 79 species are recognized. Detailed descriptions of the families, genera, and species, with full summaries of virtually all that is know about each species, are included. Also, full synonymies and references to all the literature, so far as known to the writer, (exclusive of some European literature on Clupea harengus), containing information on each species are given. Keys to the genera and species also are furnished. Illustrations of all species, except a few obscure ones of which no specimens were available, are at hand, many of them being new ones prepared especially for this work.

The publication entitled, "A Review of the American Menhaden, Genus Brevoortia, with a Description of a New Species" by Samuel F. Hildebrand (Smithsonian Misc. Coll., vol. 107, No. 18, 1948, 39 pages, 9 figures) is almost wholly a by-product of the study of the American herrings, mentioned in the preceding paragraph. A second paper (in press) consisting of descriptions of a new genus and several new species also is in part a by-product of the same study.

After completing the work on the herrings for the "Fishes of the Western North Atlantic" Dr. Hildebrand turned his attention to the study of a collection of anchovies from southern Brazil, sent by Dr. Joao de Paiva Carvalho of the Department of Agriculture of Sao Paulo State, Brazil. This interesting collection contained specimens of little and imperfectly known species, and of four apparently undescribed forms. The paper based on this study, of which Dr. Carvalho is junior author, awaits publication.

During the past quarter Dr. Hildebrand devoted considerable time to the study of an unusually interesting collection of fishes from Talara, Peru, made by Mr. Otis Barton (designer and builder of the "Bathysphere"). The collection, although small, was carefully selected by Mr. Barton, who himself is an ichthyologist of repute, Nine new species were included, of which Mr. Barton has described two. Descriptions of the others are included in a paper entitled "On a Collection of Fishes from Talara, Peru" by Samuel F. Hildebrand and Otis Barton. This paper will be ready for publication when Mrs. Green finishes the drawings of the new species.

While studying the fishes from Talara, Peru, unidentified specimens from Panama belonging to the families represented in the Talara collection were examined at the same time. Accounts or notes on these were prepared for the supplement to "The Marine Fishes of Panama", a work interrupted a few years ago for the apparently more urgent task of writing up the Clupeidae for the "Fishes of the Western North Atlantic".

Completed during this quarter were: One drawing of Dixonina nemoptera, four of Etrumeus sadina (including two modified drawings from camera lucida sketches of young by the late W. W. Welsh), and three structures or parts to illustrate the key to the genera for the "Fishes of the Westren North Atlantic"; four drawings of new Brazilian anchovies for Dr. Hildebrand's paper with Dr. Joao de Paiva Carvalho; drawings of two new species of eels (genus Priodonophis) and of a new dragonet (genus Synchiropus) for the paper on fishes from Talara, Peru.

The Gulf species of the family Sparidae was worked up, and the descriptive part of the accounts of the species and genera prepared. Great difficulty was experienced in preparing the account of the genus Calamus and considerable time was spent on that genus, more so than on the rest of the family. Through an examination of the available material it became evident that at least four species of that genus occur in the Gulf. However, current accounts of the taxonomy of the genus are in such an egregious state of uncertainty that it was found extremely difficult to elaborate usable characters for distinguishing the species properly. And after they were distinguished, it was uncertain what where the proper names to apply to them. It was necessary to study all the species in the National Museum and virtually revise the genus before a satisfactory account of the Gulf species could be prepared.

Two shorter papers were prepared for separate publication. One deals with the species of Bathystoma (family Haemulonidae). The other describes five new species from the Gulf in the families Serranidae, Sparidae and Sciaenidae.

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