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

FISH AND WILDLIFE SERVICE
Albert M. Day, Director

* * * * * * * *

ANNUAL REPORT FOR THE FISCAL YEAR 1949

BRANCH OF FISHERY BIOLOGY

* * * * * * * *

Issued November 1949
Washington, D. C.

National Oceanic and Atmospheric Administration

Report of the United States Commissioner of Fisheries

ERRATA NOTICE

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

Discolored pages
Faded or light ink
Binding intrudes into the text

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

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

TABLE OF CONTENTS

INTRODUCTION

The fiscal year 1949 saw a considerable enlargement of, and several changes in, the activities of the Branch of Fishery Biology. New programs initiated were the Clam Investigations, Gulf Oyster Investigations, Red Tide Investigations, Gulf Fishery Investigations, and the Section of Biology and Oceanography of Pacific Oceanic Fishery Investigations; these are described at the appropriate places in the report. Also described is the reactivation of the Beaufort, North Carolina, station as a research laboratory. The Central Office staff was increased by the appointment of William F. Carbine as Chief, Section of Inland Fisheries and Ralph P. Silliman as Chief, Section of Anadromous Fisheries. The positions of Chief for the Marine and Shellfish sections are, however, still vacant. The Gulf Shrimp Investigation was terminated upon the establishment of the Red Tide Investigation.

The chief purposes of this report continue to be the provision of a record of research activities, the establishment of a means of exchange of ideas and information among investigators and the furnishing of a means of appraisal of the progress made and the contributions to scientific knowledge of fishery problems. As always, free exchange of comment and criticism among investigators is encouraged.

Appropriations for new projects mentioned above, plus some increases for existing projects, resulted in a substantial gain in the funds made available by Congress for our use in fiscal year 1949, as compared with fiscal year 1948. This gain is shown in the table below, which gives the detail of the appropriations for the two fiscal years. In addition to the amounts shown in the table, $293,270 of Pacific Oceanic Fishery Investigations funds were allotted to its Section of Biology and Oceanography. Although POFI is not directly under the Branch of Fishery Biology, its biological work during fiscal 1949 was closely associated with the Central Office staff of the Branch. Worthy of special note is the item "Contributed Funds" for 1949; this represents grants made to the Service by private organizations for specific research projects.

APPROPRIATIONS-BRANCH OF FISHERY BIOLOGY

Project	1948 Avail.	1948 Expend.	1949 Avail.	1949 Expend.
114 Commercial Fishery Investigations				
Regular	$540,140	$538,940 1/	$883,225	$881,222 1/
Transferred	117,400 1/	98,400 1/	76,170	64,012 1/
Contributed	---------	------ --	33,225	15,649 1/
Sub-total	$657,540	$637,340	$992,620	$960,883
115 Shellfisheries	158,300	157,700	213,700	213,300
116 Inland Fisheries	72,500	72,300	89,825	89,404
118 Sea Lamprey	19,100	19,000	10,755	10,621
110 Operation of Fish Screens	36,300	35,600	25,236	25,195
Grand Total	$943,740	$921,940	$1,332,136	$1,299,403

1/ Unexpended balance remains available in following fiscal year.

Although the amounts made available for publications in fiscal year 1949 were again below needs, an increased amount has been secured for 1950, as a result of a determined effort on the part of the Branch staff. Manuscripts for publication should be submitted as early in the fiscal year as possible.

SECTION OF ANADROMOUS FISHERIES

ALASKA FISHERY INVESTIGATIONS
George B. Kelez, Chief.

GENERAL

Alaska Fishery Investigations in 1949 included four major field research investigations; The Bristol Bay Red Salmon, Karluk Red Salmon, Southeastern Alaska Pink Salmon, and Alaska Herring. These were supplemented by a statistical research program; "Fluctuations in Abundance of Alaska Salmon" and by a newly established project "Age Analyses" devoted to scale studies.

In June the exploratory fishing project of the Branch of Commercial Fisheries chartered the trawl vessel "Deep Sea" for exploratory fishing in the northern area of the Bering Sea. The Alaska Investigations assigned Mr. Henry Hildebrand as biologist aboard this vessel to collect data on the occurrence and abundance of the various species of fish taken. He also obtained length and weight data, scales and otoliths for age determinations, water temperatures, and other data relative to the biology of fish in this area.

A contract for the construction of a 38 foot vessel of the purse-seine type was awarded to the Grandy Boat Building Company of Seattle, Washington. Construction of the hull is well advanced and it is anticipated that the vessel will be ready for use in the early part of the next fiscal year.

SALMON RESOURCES OF BRISTOL BAY

In July 1948, the Bristol Bay investigation was engaged in red salmon tagging operations on the Naknek and Kvichak Rivers. Returns on the Kvichak system showed very little racial disparity in regard to time of passage through the fishing grounds in relation to spawning ground placement. Fish tagged in each period were more or less equally distributed over the entire range of spawning grounds around the perimeter of Iliamna Lake. Results are not complete inasmuch as some of the tags are still coming in from natives who picked them up in the fall, but indications are that the late returns will not materially change the picture. Over one hundred tags have been recovered of the some three thousand placed on migrating adult salmon at Igiugig on the Kvichak.

Following the tagging operations, ground crews were deployed to the spawning grounds for the multiple purposes of recovering tags, furthering the physical survey of spawning area, collecting racial data, and enumerating spawning populations with a breakdown by species and sex. Two parties covered Iliamna Lake, and two other parties covered the spawning grounds of the Naknek system.

Besides individual counts of salmon on the principal spawning grounds, aerial counts covering all of the Bristol Bay spawning areas were carried on. The latter estimates were made through direct observation and by the use of vertical photographs. The photographic method is still in the developmental stage, and further experimentation with filtering, films, and development of film will be necessary before a completely satisfactory picture of red salmon below the water's surface can be obtained under the poor light conditions encountered at this time of year. A twin-engine Beechcraft airplane was used in this season, with the Fairchild F-56. camera mounted in the belly just aft of the pilot bulkhead. This proved to be more satisfactory in arrangement than that used in the Norseman airplane of 1948, but still leaves a problem of blindness when approaching the spot to be photographed.

Limnological studies, including water analyses and the collection of plankton, were continued throughout the season. These studies are designed to determine and evaluate the factors that affect fingerling growth and survival. Aircraft were used to permit sampling in representative nursery lakes in each watershed while more complete studies were conducted at Brooks Lake.

During the winter quarter data gathered during the preceding field season were analyzed. Mr. Peck worked out a new system for the important and difficult task of accurately reading salmon scales collected from each river system. The reading of these scales is complicated insofar as stream growth is concerned by the differences inherent in each system. Differing times of migration between years and within each year necessitate familiarity with the characteristics of scales from each locality if they are to be read accurately. Research in the Bristol Bay area has shown the necessity of a good range of scale readings in every cycle and from each river. In spite of the large number of scales taken in the past, there is not a good sequence for any of the rivers of the Bristol Bay area.

A great portion of the winter quarter was spent by Mr. Eicher in the analysis of weather data in relation to the survival of red salmon. In the series of cycles covered by the past three decades good escapments have not always resulted in good ensuing runs and conversely poor escapements have sometimes resulted in good runs. Although there is a slight correlation between escapement and return, the deviations from the regression line are excessive. A comparison of weather data with returns from escapements demonstrated a rather high negative correlation between the March-April-May mean air temperatures at time of incubation and hatch of a cycle population. For Bristol Bay as a whole, with the exception of the Nushagak River, in seventeen out of twenty-one years examined, the survival was in inverse ratio to the mean air temperatures at hatching time.

SALMON POPULATIONS OF THE KARLUK RIVER, KODIAK ISLAND

The total escapement for 1948 was 754 thousand, 558 thousand of which passed through the gates prior to July 24. Thus, the fall run, which has suffered alarming depletion since 1921, obtained an escapement of only 195 thousand.

It was found that the thermocline in Karluk Lake disappeared about mid-September, while the autumal turn-over of the lake waters occurred during the first week of November. By the tenth of that month the temperature was constant at 5.9° C. from the surface to the bottom. The last series of recordings was made November 26, when the temperature was constant at 4.6° C.

Late stream surveys showed there was some stream and lake spawning as late as early December, although this activity appeared to be nearly done at the time of the last surveys. Bear predation continued until the very close of field operations.

During the winter all of the Karluk red salmon scales were examined and the age composition thus obtained was applied to the entire run by weekly periods after necessary data had been obtained from the catch statistics. It was found that an unusually high percentage of 5-year fish occurred in the run, marking unusual success of the brood stock of 1943.

Mr. Nelson devoted much of his time to an analysis of the chemical data collected during the 1948 season. Juday, Rich, Kemmerer and Mann made quantitative studies of soluble phosphorous and nitrite nitrogen in the lake waters during 1927; Barnaby made further examinations in 1935 and 1936. When the data collected during 1948 were compared to these data, it was found there had been a decline, believed to be significant, in the amounts of these chemicals present in the waters of the lake; smaller quantities of each of these chemicals were found for each successive series of tests.

In October Mr. Shuman submitted to the Journal of Wildlife Research a manuscript concerning the measured bear predation on the Karluk red salmon. During the winter a second manuscript was prepared and submitted to the Washington office. This was a report of studies made on the dispersion and effectiveness of spermatazoa of pink salmon. It is anticipated that both of these will be in print in the near future. Considerable time also was devoted to the completion of a manuscript dealing with the red salmon populations of the Karluk system.

The operation of the temporary counting weir continued from May 22, and by June 30 the counted escapement of red salmon was 341 thousand. Limnological work was begun in June, and plans were formulated for conducting experimental work on the fertilization of lake waters through the introduction of inorganic phosphorous and nitrites. It is hoped this work can be extended to include actual fertilization of a small test lake in the vicinity of Karluk during the summer of 1949.

PINK SALMON RESOURCES OF SOUTHEASTERN ALASKA

The 1948 pink salmon pack in Southeastern Alaska totaled 691,377 cases compared with 696,366 cases in 1947 and with the average pack of 894,000 cases for the past five years. Scarcity of pink salmon, particularly in the northern districts, was forecast by the poor freshwater survival of the 1946 brood at Little Port Walter. The declining abundance of the Little Port runs has shown a highly significant correlation with the pack in the Eastern district for a period of eight years ($r = .84$); indicating that the causes of the decline are not confined to the study stream but are of general occurrence in the adjacent district.

Year-around operations were continued at the Little Port Walter laboratory. The two-way weir was installed in Sashin Creek early in August, the first fish was counted through on August 31, the 50 percentile count was on September 12, and the 95th percentile count was on September 22. Following are the dates of the 50th percentile of the count for the previous six years:

1947 - September 14	;	1946 - September 15
1945 - " 13	;	1944 - " 10
1943 - " 11	;	1942 - " 12

The total count was 597 pink salmon of which 256 were females. Since the 1946 brood produced only 966 fry, with a survival expectancy of about 2 percent, it is evident that nearly all of the 1948 spawners were strays from other streams. Observations of neighboring spawning grounds in Big Port Walter, Port Herbert, Deep Cove, and Patterson Bay, showed a higher ratio of spawners to available spawning area than occurred in Sashin Creek.

Thermal units reaching the eggs deposited in Sashin Creek are recorded by means of a thermograph. This instrument records temperatures in the gravel at a depth of eight inches. For purposes of estimating the rate of development of eggs and alevins, and the time of emergence of fry from the gravel, reference is made to the total number of thermal units that accrue during a twenty-six week period starting the first of October. Following are the thermal units recorded in the fall and winter of 1948-1949, the previous winter, and the nine year average:

1948-1949	1947-1948	9 year ave.
950.8	1,134.4	1,109.6

A low increment of themal units during the past winter forecast a late migration of fry in the spring of 1949. The migration proved to be the latest in nine years of record. The 10th percentile of the count fell on May 17, the 50th percentile on May 30, and the migration ended on June 19. In the eight preceding years the 50th percentile mark was recorded on the following dates:

1948 - May 20	;	1947 - May 19
1946 - " 23	;	1945 - " 8
1944 - " 1	;	1943 - 17
1942 - " 4	;	1941 - Apr.15

From the spawning of 256 female pink salmon the estimated potential egg deposit was 512,000. Fry counted through the weir totaled 9,016, resulting in a survival factor of 1.76 percent. Following are the survival factors determined in a similar manner during the previous eight years:

1948 - 2.0%	;	1947 - 0.2%	
1946 - 0.8%	;	1945 - 2.7%	
1944 - 1.5%	;	1943 - 0.8%	
1942 - 1.2%	;	1941 -6.4%	Nine-year average - 1.93%

During the nine-year period that an upstream and downstream weir has been operated in Sashin Creek, only one brood has succeeded in producing an increase in the number of spawners returning to the stream. This was the 1940 brood, significantly related to the 1941 survival factor of 6.4%. Since the 1948 brood experienced an average survival, and since this average has been associated with eight years of declining abundance, it is not anticipated that a marked increase in the spawning population will occur in 1950.

Pink salmon are invariably two years old at maturity; thus the downstream migrants of one year produce the catch of the following year. For a seven year period of comparison, ending with the 1948 catch, the downstream count at the Sashin Creek weir shows a highly significant correlation with the catch in the Eastern District ($r = .95$), indicating that the direct annual measurement of migrant output from a representative stream will provide an estimate of the size of the adult population returning to the contiguous district.

To obtain quantitative migrant production data from as many of the seven fishing districts of Southeastern Alaska as possible, a sampling method was devised and undertaken in the spring of 1949. Sampling stations were established on Herman Creek, Southern District; Old Tom's Creek, Clarence Strait District; and Katlian Bay, Western District with a control and calibration station in operation above the Sashin Creek weir. Hanavan and Brewington were assisted in the program by Management Agents Headlee and Scudder, Olson, foreman of the Little Port Walter laboratory, and other Service personnel.

Trapping stations are of uniform design consisting of two tripods on which a working platform extends approximately twenty-five feet into the stream. Five small-mesh wire traps are fished from the platform. These traps are suspended between pipe guides and are raised and lowered independently. The traps themselves are of simple cylindrical form with an entrance opening one square foot in area and an over-all length of

eighteen inches. Each station, trap, and staff gage is placed in measured relation to fixed datum points to assure accurate replacement of the entire installation each spring and a consistent sampling effort from one year to the next. Results for the current season are not complete. The performance of the equipment has been satisfactory, producing samples of adequate size with very low mortality. Additional stations will be installed in 1950 in the Icy Strait and South Prince of Wales districts to provide a more complete geographical distribution of migrant production measurements.

THE HERRING RESOURCES OF ALASKA

The herring studies during the year were concerned chiefly with changes in population levels as determined from estimates of recruitment and mortality under conditions of average fishing effort. Forecasts of abundance were used to establish catch quotas in each of the three major fishing areas of Kodiak, Prince William Sound, and southeastern Alaska. These quotas were based on estimates of the maximum yield that could be obtained from each major population consistent with maintaining the average survival which had prevailed during past operations of the fishery.

Field activity was confined mainly to the sampling of the commercial catch for age and weight composition and to the collection and analysis of catch data for determination of the return per unit of fishing effort. During the fishing season of 1948, samples in the Kodiak fishery were collected by Mr. Carl Elling, in the Prince William Sound fishery by Mr. Edward Mains, and in the Southeastern fishery by Mr. Lewis Lund.

Age composition data of past years weighted by the abundance in each season were used for estimating average mortality rates which have prevailed in the past. These data (average ratios of increment or decrement with each increase in age) were revised in each district to include the age composition data of the 1948 season. Estimates of the potential yield of each year class contributing to the 1948 fishery were obtained through the calculation of the number of individuals actually removed, the estimated number that would have been removed had the fishing intensity been equal in all years, and the rate at which the average year class had contributed its numbers to the fishery. The estimated total yield of each year class apportioned according to the average survival of the past, provided the quota recommendations for the season of 1949.

As an adjunct to the collection of age and weight samples, a number of vertebra counts were made by field personnel during the 1948 season. Counts were made from 973 individuals captured in the Shelikof Strait area of Kodiak island; the mean vertebral count was 53.65. Only slight differences in vertebral count were encountered among individuals captured within the various localities of the Shelikof area, indicating that there are no racial differences in the sampled area or that racial separation by the use of this character is not feasible. Differences in the means

of counts made between different year classes from specimens captured in the same locality were also not statistically significant. Approximately 500 preserved specimens were obtained from the Resurrection Bay and Prince William Sound fisheries from which counts are yet to be made. The primary consideration in obtaining these data was to determine if this character might yield information on the homogeneity of the stocks supporting the fishery in the Resurrection Bay and Prince William Sound areas.

A survey of spawning on the Sitka grounds of Southeastern Alaska was conducted during March and April by Mr. Elling. The object of this survey was to obtain a relative measure of the size of the spawn deposit and to obtain data on the relative importance of the year classes contributing to the spawning.

The conclusion obtained from survey was that the spawning of 1949 was of at least average magnitude. The bait fishermen reported a large concentration of adult spawners while a fair deposit of spawn was observed in various localities of Sitka Sound extending from Katlian Bay on the north to West Crawfish Inlet on the South. The first spawning in the Sitka area was on March 30 and spawning was still in progress when the survey was terminated on April 14. The age composition of the spawning stock corresponded closely to that of the stock taken on the Cape Ommaney grounds during the previous summer. Forty-five percent of the fish sampled were of the year class of 1944 now in its 6th year, thirty-eight percent of the year class of 1945 now in its 5th year, and ten percent of the year class of 1946 now in its 4th year.

A survey of the Craig spawning (principally Fish Egg Island) revealed that the 1949 spawning was the poorest in many years and was estimated to be about twenty percent of average. Where in former years the entire shore of Fish Egg Island has been utilized for spawning, in the current year it occurred only at isolated localities along the southern shore. The eggs suffered a high mortality because of a heavy southwesterly storm which washed many of them up on the beach above normal high water level. An inspection was also made of the Juneau spawning area but no spawning had occurred by April 14. It was the opinion of the residents that spawning would be late because of the exceptionally cold spring weather.

A summary of abundance evaluations during the past year in each of major districts follows:

Kodiak: The abundance index for the 1948 season was 107 with the base year of 1937 equal to 100. A decline in abundance for the 1949 season was indicated by the poor recruitment received from the year classes of 1945 and 1946, together with the fact that the successful year classes of 1942 and 1944 have already passed the age of maximum productivity. A reduction of quota to 250,000 barrels was recommended for the season of 1949 on the ground that the fishery would be almost entirely dependent on the year class of 1944. It is anticipated that this year class will provide 60 percent of the catch in 1949 as 6-year fish.

Prince William Sound: Reliable estimates of abundance are not possible in this fishery because of sporadic operations of recent years. It is presumed, however, that the abundance has declined because of poor recruitment from the year classes of 1946 and 1945 since year class strength has been found to have a similar pattern in all the major fishing areas.

Southeastern: Failure of this fishery to make a significant catch in this district despite an anticipated high abundance was perhaps the outstanding development of the 1948 season. Despite the efforts of twenty-eight vessels, only 130,000 barrels of the 400,000 barrel quota were caught. Failure of the catch to approach the anticipated yield has been attributed to (1) subnormal availability of the schools during the season due to unknown hydrographic and ecological factors influencing the behavior of the fish and (2) over-estimation of the strength of the year classes now within the fishery.

Abundance for the 1949 season was calculated on the data of the period of 1943-1948 only and the estimates of year class strength obtained were much reduced from those previously obtained. The revised estimates together with the apparent weakness of the year classes of 1945 and 1946 resulted in a recommendation for a quota of only 150,000 barrels for the season of 1949. This quota with supporting data was presented to the industry at a hearing held in Seattle on February 15. The quota finally established for the 1949 season was 200,000 barrels.

FLUCTUATIONS IN TIME OF APPEARANCE AND ABUNDANCE OF ALASKA SALMON RUNS

Attempts to establish an objective measure of relative abundance and trends of the salmon runs in Alaska were made during the 1947 and 1948 fishing season in Bristol Bay and the 1948 season in southeastern Alaska. As this project will be continued during the 1949 season, the methods used in these analyses were reviewed and summarized in a memorandum "Methods for determining within-season changes in abundance in the Alaska salmon fisheries", prepared in cooperation with Dr. Willis H. Rich. It was demonstrated that the average catch per net-day for each half-weekly period, computed separately for drift nets and set nets, gave a good index for the abundance of the salmon run in Bristol Bay, while the average daily catch per trap was used in southeastern Alaska.

A comparison of the analysis of the data received by the telegraphic reports during the season with the analysis of the more complete data received on form 3-1632, "Daily Catch of Salmon Traps", following the close of the season, indicated that an analysis of the telegraphic data as the season progresses gives a reliable index of the progress of the salmon runs.

Dr. V. B. Scheffer and Mr. F. B. Sanford were assisted with a statistical problem arising in the analysis of vitamin content of seal-liver oil. As the data could not be considered as coming from a "normal. population", the usual statistical constants of means and standard deviations

could not be applied and new constants describing the distribution were computed. Prof. Z. W. Birnbaum of the University of Washington also cooperated on this problem.

AGE ANALYSES

The check reading of the sockeye salmon scales from the 1948 season at Karluk has been continued with only a very few remaining to be examined of the approximately 4,500 taken last year.

Experiments showed that the dried salmon scales carried in the untreated scale books could be cleaned and mounted in perfect condition with little more work than if they were transported moist. Consequently, a routine procedure of collection, utilizing the usual scale books for holding and transporting the scales to the laboratory, was established.

Scales of approximately 600 sockeye salmon received in this manner via airmail from the Karluk field station were mounted in the laboratory using the following procedure for cleaning and mounting. One or more of the scales from each fish were transferred to plain water in the consecutive depressions of a scale mounting tray from the scale book. A clean glass microscope slide was placed on a piece of black paper or cloth to render the scales more easily visible on the slide. A scale from the first fish (the first depression on the tray) is taken with the forceps, and gently rubbed between the thumb and forefinger, dipped in a solution of laboratory Calgonite (or other good detergent) and again rubbed between the fingers until all scum and other dirt is loosened. The scale is then dipped in fresh water, rubbed between the fingers to remove the excess water, and by holding the anterior edge of the scale with a forceps, the sculptured portion of the opposite edge is carefully touched to a dilute solution of glue or mucilage. The excess glue is quickly removed with the fingers by rubbing the scale away from the sculptured part so that no glue is allowed to get on the readable portion. If any gets there, it can be wiped away with the fingers. The scale is then laid on the micro-slide with the sculptured portion to the top of the slide and in this manner a total of 30 scales are placed on each slide with three rows of 10 scales each. Another clean glass slide is then placed carefully on top of the scales, and the two slides fastened firmly together with a piece of moistened brown kraft tape over each end. The tape also serves as a label since the information on locality of capture, date, and fish numbers can be written over the left-hand end of the mounted slide. Usually the scales are in better condition to age if they are thoroughly dried after mounting by allowing them to stand at room temperature overnight, before examination.

STREAM IMPROVEMENT

The Stream Improvement Project stream survey staff under the direction of Mr. Hutchinson, project leader, and including Messrs. Morton, Stanton, Brewington and Farr continued the survey of streams on the east coast of Prince of Wales Island, southeastern Alaska from Point Baker at the northern tip of the island to Cape Chacon at the southern tip. These surveys were made from the FWS "Heron" and for a short period also from the Territory of Alaska, Fisheries Experimental Commission, M/V "Researcher".

The primary purpose of these surveys was to locate streams in which barriers existed, which were suitable for improvement, and which contained sufficient area of spawning gravel above the barrier to warrant the expense of improvement. Of the many streams surveyed, five were recommended for improvement. These were streams containing low falls located at or near the mouth and containing large amounts of spawning area above. Although there are many streams containing larger falls, twenty or more feet in height which if improved would open up vast spawning areas, the cost of fishway construction over barriers of such height is prohibitive with the funds available.

Reports of these surveys was analyzed and a summary report of all streams surveyed since 1946 was prepared and presented for consideration for selection of improvable streams. From this report eight streams were selected for improvement in 1949. These were Dora Bay in Chomondeley Sound, Beauty Creek in Port Johnson; both on the southeast coast of Prince of Wales Island; Naha River at Loring on the north coast of Revillagigedo Island, Navy Creek on the southwest coast of Etolin Island flowing into Burnett Inlet, and Fall Creek south of Petersburg on Mitkof Island flowing into Wrangell Narrows, Klakas Lake Stream in Klakas Inlet, Keete Creek in Keete Inlet, and Eek Lake Stream which enters Hetta Inlet. The last three streams are in the southwest quadrant of Prince of Wales Island. Topographic surveys and proposed fishway construction layout drawings were prepared and reproduced, and made available to the construction project. After re-surveying Dora Bay Stream and Beauty Creek in May, 1949, it was decided they were not of sufficient value in relation to costs, to warrant improvement.

Of secondary importance was the evaluation of all streams for the total spawning area present to provide an estimate of the number of spawning salmon which could be accommodated. It was determined that streams under eight feet in width were not used for spawning to the extent commonly believed. The presumption that the myriad small streams of southeastern Alaska accommodate large numbers of spawning salmon was not borne out by this investigation.

Aerial surveys of streams on Prince of Wales Island were conducted to provide advance information for the ground stream survey parties. Aerial photographs of streams which were being considered for improvement were made from a Service Norseman Aircraft with an F-56 aerial camera with an 8 1/4 inch lens on 7 inch by 7 inch film at an altitude of 2,000 feet.

OTHER ACTIVITIES

Logging Study: A cooperative program of study of the effects of logging on salmon streams in southeastern Alaska by the Forest Service Research Center under the direction of Mr. R. F. Taylor, Forester-in-Charge, and the Fish and Wildlife Service was organized and planned. This program is deemed necessary because of the large scale logging operations necessary to supply timber for the pulp mill which is to be built within the next three years in Ward Cove, five miles north of Ketchikan, and for other pulp mills proposed for construction at Juneau, Sitka and Petersburg.

Four streams were choses for study. Two of those are to be logged - Maybeso Creek and Harris River - and two of similar nature - Indian Creek and Old Tom's Creek - are to serve as control streams which will not be logged. The Forest Service and Geological Survey have topographically mapped the streams, cruised the timber, and determined the general floral coverage as well as nature and distribution of soil within each watershed. They have established stream gauging stations and precipitation gauges and constant recording thermographs in each stream.

The Fish and Wildlife Service has established and manned a downstream migrant fry trapping station in one of the check streams to obtain the number of seaward migrants produced. Other factors to be studied are erosion, siltation, turbidity, increased run-off, chemical effect from logging debris or soil uncovered by logging, and change in water temperatures.

Pollution Study: In connection with the proposed pulp mill installations and operations, a program of study of possible pollution from the effluents of these mills was organized. The program is divided into two primary studies, i.e. ecology and oceanography. The present investigation will be conducted in Ward Cove, Tongass Narrows and the adjacent area. Mr. Stanton, who was assigned to this project, commenced work at Ward Cove on June 20.

Engineering: During the April - June period, plans and specifications were prepared and material contracts awarded for the all-metal test section of the Ugashik River weir and for a permanent weir on the Karluk River. The Ugashik River weir, for counting of upstream-migrant fish, has been designed utilizing aluminum tubing for pickets and aluminum structural members for stringers and weir supports. The weir will differ somewhat from the conventional type in that the supports will consist of a single front leg and back leg with pinned connections, in lieu of tripods. The Karluk River weir will permit simultaneous counting of both upstream and downstream migrant fish. It will be of timber-crib construction, with aluminum structural members and supporting stop logs to control the water level above the structure. Inclined-plane screens placed on the crest of the stop logs will screen out fingerlings on their way downstream. A fish ladder at one end of the structure will allow fish moving upstream to pass the weir. Plans were also prepared for the installation of fish ladders at falls in Beauty Creek, Dora Bay Creek, and Naha River in Southeastern Alaska and at Brooks River in Bristol Bay. Ladder locations were staked out at Beauty Creek, Dora Bay Creek, and Naha River in advance of work by the stream clearance and construction crew.

NORTH PACIFIC FISHERY INVESTIGATIONS

Joseph T. Barnaby, Chief

GENERAL

The construction of dams and diversions in the Northwest and particularly in the Columbia River in the interest of hydro-electric power, irrigation, navigation, and flood control, is progressing at an ever increasing pace. These water-use projects have a profound effect on the anadromous, and in some instances on the resident fish populations of the region. Each project presents a great number of problems peculiar to itself and in addition contributes to the overall problem resulting from the presence of a large number of obstructions and diversions in the migration route of the important salmon and trout populations of the region.

As many if not most of these water-use projects are being constructed by the Federal government and as the Service has the legal responsibility of advising other federal agencies as to the probable effects of a project on the fish and wildlife resources of the region, the program of the North Pacific Fishery Investigations has been designed to obtain basic information that can be utilized to minimize the deleterious effects of such projects, on the fish life of the area.

During the fiscal year Mr. Barnaby completed a report on the preliminary studies to determine the efficiency of the collecting system at Bonneville Dam. The report forwarded to the Corps of Engineers and also the agencies concerned, resulted in a change in the design of the collection system gates proposed for the New McNary Dam. He also recommended changes in the operation of the collection system gates at Bonneville Dam, to compensate for tail-race fluctuation and thereby enable salmon to enter the system during all flow conditions.

ABUNDANCE OF COLUMBIA RIVER SALMON AND ANADROMOUS TROUT POPULATIONS

Bluebacks. Limnological surveys of the two important blueback salmon lakes, Wenatchee and Osoyoos, were continued with the assistance of Mr. Gentry of the Branch of Game Fish and Hatcheries. The data have been tabulated and analyzed and a preliminary report entitled "Blueback Salmon Studies, Columbia River, 1948", has been prepared. The report outlines the experimental fishing by means of graduated mesh gill nets. Several large Dolly Varden trout were taken, the largest of which measured 30 inches and weighed eight pounds dressed. Two of these fish had salmon fingerlings in the stomachs.

Each year, a number of blueback salmon spawn in the river below Lake Wenatchee. A study of scales of fingerling bluebacks which were taken in these spawning areas reveal that all of them had spent at least one year in fresh water. There is no apparent difference between scales of fish taken in the river below the lake and scales of fish spawning in tributaries of the lake. Just exactly what happens

to the progeny of the fish spawning below the lake is still a problem that needs solution. They might perish in the river from lack of food, or they might migrate upstream into the lake. It seems most probable that they migrate upstream into the lake though direct evidence of such a movement has not been obtained.

Roosevelt Lake. Several surveys have been made of Franklin D. Roosevelt Lake (Grand Coulee Dam reservoir) during the year. Messrs. Gangmark and Fulton have summarized the data obtained and completed a report which has been submitted for publication. General conclusions are: (1) Roosevelt Lake has a high potential productive capacity as evidenced by the available quantity of forage fishes, and also the presence of large rainbow trout of the Kamloops type. (2) Intelligent management and stocking of the lake might well provide one of the most valuable sport fisheries in the State of Washington.

FISH PROTECTION AT DAMS AND DIVERSIONS

Experimental Fish Ladder. In order to determine the success of a Denil fish ladder for the passage of salmon at dams on West Coast streams, an experimental installation was made at the Dryden Dam on the Wenatchee River, near Leavenworth, Washington. The design prepared by Messrs. Bair and Lambert was patterned after a Denil-type ladder constructed at the Herting power dam on the Atran River, near Flakenborg, Sweden, and consists of a timber flume 4'-3 1/4" in width by approximately 30 feet in length, with U-shaped baffles spaced at 2'-10" on centers and set at an angle of 45 degrees with the floor of the flume. Gradient of the ladder is 1 on 6.

The experimental installation was designed to utilize one-half of the width of an existing pool-type ladder. Such an arrangement is ideal for comparing the preference of the fish for one or the other type of ladder. Protracted high water in the Wenatchee River during the upstream migration of blueback salmon enabled the fish to negotiate the dam without utilizing the ladders so that an adequate comparison of the two types cannot be made with the data obtained. However it is of interest to note that during the period of observation over one hundred fish passed through the Denil ladder while none passed through the pool type ladder.

Standard Fish Screens. Standard plans have been completed for a paddle-wheel operated rotary-drum fish screen suitable for installation in small irrigation canals having flows of 12 to 15 second-feet, and plans are being prepared for a paddle-wheel operated screen installation for canals with flows of approximately 50 second-feet.

The smaller installation consists of a single screen drum 2'-0" in diameter and 6'-0 3/4" in length, powered by a paddle wheel 4'-0" in diameter, with a ratio of rotation of the paddle wheel to the screen drum of 21.2 to 1.0. The larger installation will consist of two screen drums each 3'-0" in diameter and 8'-0 3/4" in diameter, powered by paddle wheels 6'-0" in diameter, with a ratio of rotation of the paddle wheels to the screen drums of 16.0 to 1.0.

Screen drums for both installations are mounted in lifting frames to facilitate removal from the canal and bypass facilities are included in both structures to provide for safe passage back to the river of downstream-migrant fish as their down-canal movement is blocked by the fish screen.

Engineering Assistance to Other Agencies. Engineering assistance in regard to fish protection has been given to other Federal and State agencies in several instances.

Fishway plans, submitted to the Federal Power Commission in connection with an application for a Federal power permit have been referred to this office for approval. Among these being the fishways for the proposed Wilder Dam on the Connecticut River near Wilder, Vermont. The design of the fishways is based upon a study and recommendations furnished by Mr. Bair. The plans were later reviewed and various suggestions and revisions made to permit greater flexibility.

In cooperation with the Montana Department of Fish and Game, a preliminary drawing has been prepared for a proposed fish ladder at the Thompson Falls Dam on the Clark Fork River, near Thompson Falls, Montana.

Recommendations were also furnished to General Electric Company engineers regarding satisfactory by-pass facilities and screening of a river pump intake on the Columbia River.

High-Pressure Fish Lock. In anticipation of an experimental high-pressure fish lock being included in the plans for one of the proposed dams in the Columbia River System, a schematic plan has been prepared for a high-pressure fish lock for installation at dams of considerable height. Designed by Messrs. Holmes and Bair the arrangement consists of a series of ladder pools below the dam leading to a lock chamber within the dam structure. A gated tunnel, sloping upward, connects the lock chamber to the forebay.

Studies at Roza Dam. The fish ladder at Roza Dam is a conventional pool-type ladder at the left end of the dam, with the main entrance located on that side of the river. An auxiliary entrance of lesser proportions is located on the right side of the river and is connected to the fish ladder at the left end of the dam by a tunnel which extends laterally through the base of the dam. This passageway is approximately 250 feet in length, and, due to its position within the dam, is quite dark. Since there was some question as to whether fish would use this darkened passage, observations were made at the right-bank entrance to determine if the tunnel was being utilized by fish. During the course of the observations, 173 minnows, 13 relatively large scrap fish (squawfish and carp) and 2 salmon were counted into the entrance, and 17 minnows were counted out. While these data are quite inconclusive, there is an indication that fish may pass through the darkened area.

McNary Dam. Prior to the beginning of the present fiscal year the design of fishway for the north-shore end of McNary Dam on the main Columbia River had been virtually completed, and the north shore cofferdam had been constructed. During the fiscal year the U. S. Corps of Engineers, with the cooperation of the fishery agencies have been particularly concerned with the fish facilities at the south end of the structure, where the powerhouse is located. Attention also has been given to the passage of fish during the several years of construction during which the river will be obstructed by cofferdams and partially completed structures. Mr. Holmes has devoted approximately half of his time to this work. Mr. Barnaby also has attended several conferences and demonstrations of hydraulic models of the structures and prepared a manuscript entitled "Effect of McNary First-Step Cofferdam on Upstream Migration of Salmon and Steelhead Trout, 1948", which was issued as an informal report in April 1949. Mr. Weber and other members of the staff assisted with an extensive series of observations of fish activity at Bonneville Dam, which were conducted jointly by the Service, the Corps of Engineers, and the State fishery agencies to obtain basic information for application to the design of fishways for McNary Dam.

Ice Harbor Dam. Early in the fiscal year Mr. Holmes assisted the Corps of Engineers in a preliminary consideration of fish protection at Ice Harbor Dam, which is to be the first of a series of four power and navigation dams that are to be constructed by the Corps of Engineers on the Snake River between its mouth and Lewiston, Idaho. The passage of fish at these dams is of major importance because the Snake River is the largest branch of the Columbia River, and its tributaries furnish the principal spawning grounds of the high-quality, spring-chinook salmon, as well as for major portions of other runs of salmon. Design of Ice Harbor Dam has been discontinued temporarily due to a shortage of appropriations.

Mud Mountain Dam. When the Corps of Engineers started construction a number of years ago on Mud Mountain Dam on the White River in Northwestern Washington, a temporary fish trap was constructed at Buckley Dam, a few miles below the dam site, for use in transporting migratory fish around the construction area. It then was planned that a permanent fishway would be provided at Mud Mountain Dam when completed. It later was decided that trapping Buckley Dam and hauling from there to above Mud Mountain Dam should be continued permanently. This plan required the construction of a more satisfactory and permanent fish trap. Prior to the present fiscal year, Mr. Holmes had served as principal advisor to the Corps of Engineers on the functional design of the new trap. When construction of the trap was completed early in 1949 Mr. Holmes assisted with a number of problems of operation. Since that time the trap has been operated continuously by the Corps of Engineers under the supervision of the Washington Department of Fisheries. During the fiscal year 2,091 chinook salmon, 2,040 silver salmon, and 1,354 steelhead trout were trapped and transported to above Mud Mountain Dam.

Electric Fish Screen. In recent years there have been no electric fish screens in use in the North-Pacific states. In 1948 the Oregon Game Commission permitted the Pacific Power and Light Company to make a trial installation of the latest design of Burkey electric screen in the company's diversion from Hood River, a tributary of the Columbia River. Mr. Holmes has aided in the planning and interpretation of a study of the success of this installation which is being conducted by the Oregon Game Commission. Preliminary results indicate little if any success in diverting salmon and trout that are on their seaward migration.

Fish Screen, Sandy River Diversion. After many years of effort upon the part of fishery interests, arrangements finally were made by the Oregon Game Commission for the Portland General Electric Company to screen their 600-second-foot diversion from the Sandy River, a tributary of the Columbia River near Portland, Oregon. Mr. Holmes has assisted the Game Commission by serving as an advisor to the power company on the functional design of this rather large, drum-type screen installation. Plans were nearing completion at the end of the fiscal year and construction was soon to be started.

Sonic Studies. The most recent experiments with sonic vibrations were carried on by Messrs. Burner, Weber and Barnaby at the Leetown, W. Virginia station, in March and April of 1949. Tests were conducted using a classified sound head referred to as a "Wampus", as well as a so-called K-1 transducer manufactured by the Bell Telephone Company. The Wampus put out a wide band of frequencies of a character considered as "noise". The intensity of the emitted sound was rather high. Mr. D. W. Beecher, of the Naval Ordance Laboratory, under whose directions the equipment was used, expressed the opinion that the intensity was great enough to burst ones eardrums if he put his head beneath the surface. While the fish appeared to "start" when the noise was turned on, this re-action was only momentary, and numerous tests indicated quite clearly that this piece of apparatus had no value in so far as scaring fish away from a diversion. The K-1 sound head had a frequency range of from about 200 to 10,000 c.f.s. Repeated trials showed that these frequencies had no effect on the movement of the fish.

Briefly summing up the results with sound, sonic equipment with frequencies ranging from 65 c.f.s. to 70,000 c.f.s. has been tested; both with sine curve characteristics and discontinous wave form characteristics. Considerable correspondence and personal interviews have been held with sound technicians. All of the sound producing equipment that the Naval Ordnance Laboratory has made available to us has been tested. None of the frequencies showed much, if any, promise of being of value in guiding fish away from dangerous routes of passage at dams or diversions.

Because of the extremely diverse nature of the instruments used, to produce sound, as well as the complex types of sound waves, and intensities elicited, sound has not entirely precluded as a possible method of guiding fishes. Mr. Burner is exploring these possibilities and is completing a report upon the two years work with sound.

Fingerling Studies at Bonneville Dam. The staff at Bonneville Dam, comprised of Messrs. Burner, Weber, Gauley, Lehman, and Schedin, were occupied early in the year with the repair or replacement of experimental fishing equipment damaged in the 1948 flood. As the flood waters receded, mud and detritus had to be removed from the special inclined plane traps used to obtain fingerling migration data. From the catch in the five by-pass traps it is possible to determine the daily, seasonal, and shore to shore distribution as well as the distribution by broods, of small salmonid fishes enroute to the sea.

During the year Messrs. Gauley, Lehman and Schedin lift the traps, measure the small fish and then release them to continue their seaward migration, scales are taken from a representative sample of thesefingerlings for purposes of determining the age and size at migration of the four species of salmon, and also trout. The fingerling by-pass trap catches for the year were as follows: Chinook 28,974, Blueback 2,604, Steelhead 2,245, Silvers 1,166.

Temperature Studies. Mr. Weber, assisted by Mr. Bryant and Mr. Gauley have repaired thermograph stations damaged by the flood. This season, 17 thermographs were in operation in the Columbia River Basin to record temperature conditions as they are, before additional dams are constructed. This is a continuation of a seasonal study begun in 1943 when the loss of a great many blueback salmon appeared to be concurrent with higher than average river temperatures. The results of this study will become of increasing importance as additional years data are obtained for comparison and analysis.

STREAM SURVEY REPORTS

Mr. Parkhurst assisted Mr. Bryant in the completion of a report describing streams on the Washington side of the lower Columbia River System (Area I), published as Special Scientific Report No. 62, and has continued the tabulation and preparation of other stream survey data for publication. The results of these studies which formed the basis for the Lower Columbia River Development Program, have been of great value as a source of material on the past, present, and future productive potential of the Columbia River.

Several field investigations were made and reports prepared in cooperation with the Office of River Basin Studies. The Sultan River power project in the Snohomish River Basin, and the Cowlitz and Deschutes Rivers proposed power projects are the more important of these.

CENTRAL VALLEY FISHERY INVESTIGATIONS

James W. Moffett, Chief.

GENERAL

Central Valley Fishery Investigations emphasized a continuation and amplification of the studies under way to resolve major Central Valley fishery problems and an intensification of these programs pertaining to trout investigation during this fiscal year. The principal activities in this work were:

(1) Preparation of reports
(2) Continuation of the Shasta Salmon Maintenance Program
(3) Water temperature investigations in the Central Valley
(4) Sacramento River sport fishery evaluation
(5) Development of recommendations for the screening of the Delta Cross-Channel and Delta-Mendota Canal.
(6) Further development activity at Convict Creek Experimental Stream
(7) Preliminary analysis and further planning for problems at Yellowstone Lake

Synopses of accomplishments under these projects follow:

PREPARATION OF REPORTS

Unpublished reports were issued under the following titles:

MOFFETT, JAMES W. and STANFORD H. SMITH. "Biological investigations of the fishery resources of Trinity River, California." pp. 1-35, 17 figures, 24 tables, 1 map. February, 1949.

MOFFET, JAMES W., REED S. NIELSON, and OLIVER B. COPE. "A report on the fishery of American River and its relation to the American River Water Development Plan." pp. 1-17, 4 plates, appendix A-D. September, 1948.

CRAMER, FREDERICK K. and DAVID F. HAMMACK. "Deer Creek Operations, Sacramento River Salmon Maintenance Program, 1940-1948." pp. 1-16, 7 tables. September, 1948.

COPE, OLIVER B. "The effect of mosquito insecticides on wildlife." Paper read at Annual Meeting, American Mosquito Control Association and California Mosquito Control Association, Berkeley, California. February, 1949.

COPE, O. B. "Water temperature records from California's Central Valley, 1939-1948." pp. 1-79. Submitted for publication as a Special Scientific Report.

The Stanford and Delta staffs spent considerable time during the latter half of the year in the preparation of an interim report on the progress of investigations pertaining to the Delta Cross-Channel and the Delta-Mendota Canal. The report was not yet completed at the end of the year.

Several reports first prepared in the Stanford Office were issued in revised form by the Office of River Basin Studies.

SHASTA SALMON MAINTENANCE PROGRAM

The staff under the supervision of Mr. Cramer was engaged this year in a variety of activities, all directly related to the management of the king salmon fishery within the influence of Shasta Dam. Studies relating to methods of enumeration of populations of both upstream and downstream migrants were carried on, although not all studies were productive.

Early in the year, Balls Ferry Rack was installed across Sacramento River, and plans were made to count adult salmon through the rack. The impossibility of rendering the rack fish-tight and the threat of damage from flood were grounds for changes in plans, and the rack was dismantled permanently. A substitute plan involving seining, tagging, and recovery of adult salmon for the purpose of determining the distribution of spawners was attempted, but was also abandoned on grounds of feasibility.

Marking Experiments

Marked salmon released from Coleman Hatchery from the 1944 and 1945 brood years entered both commercial and sport catches this year in considerable numbers. Mr. W. H. Davenport was detailed to the A. Paladini Fish Company in Pittsburg, California, to check all incoming salmon for marks. The staff of the Sport Fishery Evaluation Study patrolled the Upper Sacramento River for marked salmon taken by anglers, and Coleman Hatchery personnel recovered those fish returning to Battle Creek. Of a total of 183,768 King salmon marked and released, 120 have so far been recovered in the river fishery, and 86 at the hatchery.

In March and April, 1949, fin clipping of fall run king salmon was carried out at Coleman Hatchery, with Dr. F. F. Fish as Project Leader and Mr. Z. E. Parkhurst as Marking Supervisor. The first lot of 100,000 fish was released into Battle Creek on April 4, and the second lot of 100,000 will be liberated this fall.

Fyke Netting

The fyke-netting program for the capture of downstream migrants was carried on in an experimental manner this year, in order to derive information relative to the interpretation of fyke-net data for former and future years. In addition, routine collections were made to match the series of 1946-1948 for the same localities.

Among the general conclusions reached as results of the experimental program, the following observations are worthy of note:

a. The hourly movement pattern at Balls Ferry during January, February and March was characterized by one or more peaks during the night. At Squaw Hill Bridge, 58 miles downstream, the movement was generally more constant throughout the night, with smaller peaks. There were no significant or consistent differences between hourly catches during periods of darkness at either station. At both places larger catches occurred during hours of darkness than during hours of daylight.

b. Large numbers of immature fish moved downstream during the daytime when flood flows were cresting. Turbidity was apparently not the determining factor influencing daylight migration.

c. Escapement from 1/4-inch mesh webbing was greater when nets were fished uninterruptedly throughout the night than with hourly removals. The percentage of fish escaping from the Squaw Hill net was greater than that from the Balls Ferry net (79.3% against 37.1%).

d. More fish were caught by hourly removals than by uninterrupted fishing. At Squaw Hill, the ratio was 25.4/100; at Balls Ferry, it was 65.4/100.

e. The average percentage of fish caught in the 1/4-inch webbing was 45.5% of those caught in bobbinet-lined nets at Balls Ferry; at Squaw Hill, the figure was 17%.

f. The catch ratio between nets having 5-foot and 3-foot openings was 1:3; the smaller nets were more efficient than the large ones.

Fyke netting was also conducted on Door Creek and Battle Creek, and considerable data accumulated.

Other Studies

Various other projects were completed by the Shasta staff during the year, among which were:

A study of the damage done by anglers trampling on salmon redds, in which the data indicate that more than 93% of the eggs recovered from trampled redds were alive at recovery, and 98-99% of the eggs from untrampled nests were alive at recovery.

Counts of adult salmon entering Door Creek during the spring of 1949, extending from April 11 to June 9. A total of 753 adult salmon was checked upstream, while 367 adult steelhead were counted.

The annual estimate of the size of the salmon population in the upper river and tributaries in the fall of 1948. The total number estimated as being above Iron Canyon was 40,600, as against 92,600 for 1947. For the area between Vina and Iron Canyon, the total estimated was 21,200, as against 48,000 estimated for 1947.

An investigation of the extent of utilization of new spawning areas by king salmon in Deer Creek. A fish ladder erected in 1943 permitting salmon to pass a formerly impassable barrier has proven to have functioned as expected. In the fall of 1948, 85 live salmon and 5 dead ones were observed above the ladder, and 39 nests were counted.

Constant checking of river flows and levels was carried on, with a view toward protecting occupied redds from desiccation, and contact was maintained with Bureau of Reclamation personnel concerning river discharge.

WATER TEMPERATURE STUDIES

This year saw the completion of a third complete year's temperature recording at several Central Valley stations. The records for key sites on Sacramento River are now on hand in sufficient depth for the recognition of relationships to other physical changes and to biological dynamics. Additional temperature data were recorded at critical points in the Sacramento-San Joaquin Delta and in streams tributary to Sacramento River.

SACRAMENTO RIVER SPORT FISHERY EVALUATION AND CENSUS

A creel census of the Upper Sacramento River sport fishery was started on the first of September, 1947, directed by Mr. Stanford Smith. Early creel census methods were exploratory, leading to a well-defined random sampling method of censusing the 108 miles of river between Middle Creek, near Redding, and Chico Creek. An airplane was used to census fishermen in isolated portions of the river and to check the adequacy of the random sampling technique. The refined method was used for the fishing season May 1, 1948 - February 28, 1949. Analysis of data from creel census samples involved determination of the portion of the fishery sampled and increasing it accordingly to represent the whole.

The monthly catch pattern followed closely the movements and abundance of king salmon in the Upper Sacramento River. The catch and number of fishing efforts for salmon increased during the fall of 1948 over the same period of 1947 due to increased interest in the fishery. The length of the completed fishing effort for salmon seemed to be influenced by the weather and the availability of salmon but had no set pattern. The catch per hour showed a strong inverse relationship with the catch and fishing intensity.

The trout catch seemed to be influenced somewhat by the availability of fish as shown by the catch per hour but had a much stronger direct relationship with the number of fishing efforts. The catch per hour did not vary directly with the abundance pattern of the rainbow and steelhead trout. There were fewer trout caught and fewer fishing efforts during the winter of 1948-49 than for comparable months of 1947-48 due to unusually cold weather in December, 1948, and January, 1949.

During the months from May through September, 1948, there were approximately 600 striped bass taken in 14,300 hours of angling by 5,100 fishing efforts. The catch, number of fishing efforts and catch per hour all varied directly with the apparent abundance pattern of striped bass as they moved into and out of the Upper Sacramento River area.

During the most important months of catfish fishing, May through September, 1948, approximately 1,300 catfish were taken in 4,700 hours of angling by 2,500 fishing efforts. The catfish apparently made thermal migrations into the river from slough areas during these months and the catch, fishing effort, and catch per hour followed closely the supposed migration pattern.

DELTA INVESTIGATIONS

Studies in the Sacramento-San Joaquin Delta carried on by Mr. Erkkila and his staff are designed to yield physical and biological information on which will be based the recommendations of the Service in relation to engineering projects under construction at points which will affect the fisheries. The general aims of the 1949 program were identical to those of the 1948 campaign, but some phases were carried on with more refined methods than formerly. The principal features of the program are discussed in the following sections:

Tow Netting

Sampling of eggs, larvae, juveniles, and adults of the fish and invertebrate species present in the Delta was the chief field activity during the year. The sampling was done with tow nets, using standard mesh sizes, hoop sizes, and towing speeds throughout the collecting season. One additional station was added during the year, bringing the total number of tow-net stations to 26, each sampled once a week.

Striped bass (Roccus saxatilis) of the brood year 1948 appeared in tow nets as juveniles at the beginning of the fiscal year, reached a peak of abundance in early August, and declined rapidly in September. Distributional data from these catches indicate that virtually all of the striped bass fry taken in nets were in the heart of the Delta, and had never gone beyond the egg stage in the rivers supplying the Delta.

One collection of striped bass fingerlings made in October, and later collections in the fall, indicated their presence mostly in the saline waters of Suisun Bay. Young striped bass of the 1949 brood were

first detected on April 7, when eggs were collected in San Joaquin River; larvae were taken later that month in San Joaquin River. The numbers of eggs and larvae increased during April and May, and the first juveniles were collected on May 25 in Old River. The numbers of juveniles increased weekly through the end of the year, with 1,079 bass taken at 24 of the 26 stations in the last week of June. The spawning time of striped bass in the Delta was about a month earlier than in 1948.

These distributional studies show that in July and August, months of very high irrigation demands, striped bass juveniles ranged widely throughout the entire Delta, and were present in abundance. In terms of the Tracy Pumping Plant, which is a key point in the diversion system proposed for the Delta, this means that numerous immature striped bass will probably be susceptible to the draft of the pumps. The extent of the occurrence of fish in these waters was not clearly understood by anyone prior to these studies.

King salmon (Oncorhynchus tschawytscha) of the 1947 brood were taken as seaward migrants in only small numbers during July. The major portion of this brood had cleared the Delta prior to July. King salmon were not taken in appreciable numbers again until the progeny of the 1948 brood entered the Delta in February of 1949. A study of the distribution of the immature salmon taken up to March 30 led to the conclusion that all fish caught in sampling operations were from Sacramento River. The first migrants from San Joaquin River appeared on April 5. The contribution from San Joaquin River dispersed rapidly in the Delta, with the largest concentrations in the vicinity of the proposed Tracy Pumping Plant. Catches of Sacramento River salmon corresponded to fluctuations in river flows, but decreased to practically negative catches at the end of June.

The picture concerning the seaward migration habits of king salmon passing the Delta now assumes more clarity. It was formerly supposed that immature salmon either bypassed the Delta on their way to Suisun Bay or that they passed quickly through Delta waters, depending on the route traversed. It is obvious from these preliminary studies that in 1948-1949, vast numbers of fingerlings were diverted from Sacramento River through Georgiana and Three-mile Sloughs, and even up the mouth of San Joaquin River, and that they did not go directly to the ocean. The hundreds of miles of warm, food-bearing Delta channels served as an incubation ground for millions of fingerlings, which lingered well into the summer before abandoning the area in favor of ocean waters. This species also was widely distributed in the Delta, and would be susceptible to danger from pump drafts caused by the Tracy Pumping Plant operations in spring and summer months.

Shad (Alosa sapidissima) appeared in tow-net catches at the beginning of July, 1948, as juveniles. Their abundance and size increased during July, peaked in abundance at the end of July, and were taken occasionally by the end of September. The few taken at the end of September measured over 70 mm. in length. Catches of shad were next taken in appreciable numbers in May of 1949, when the progeny of the 1949 brood came into prominence. Mokolumne River was the greatest contributor to the catches during May and June.

Shad was also distributed throughout practically the entire Delta in the summers of 1948 and 1949. With their particularly long spawning period and peak of abundance in June and July in Delta waters, these fish would appear to be in danger of influence from the pumps at Tracy in years such as 1948 and 1949.

The smelt (Hypomesus olidus) was taken in insignificant numbers in the Delta during the period July - November, but catches increased noticeably from December onward. Sexually mature smelt entered the catch in large numbers, and were particularly abundant in February. By the end of March, practically all Hypomesus taken were ripe or spawned out. In the middle of May, the progeny from these fish were appearing in tow-net catches in the post-larval stage.

This species reached a high state of abundance in the middle and western parts of the Delta at the beginning of the irrigation season, in March of 1947 and 1949, and might be subjected to danger from the pumps.

Fyke Netting

Long series of fyke-net data were accumulated at key Delta points throughout the fiscal year, and furnished practically continuous records for comparison with catches of former years at the same localities. Fyke nets maintained on San Joaquin River at Antioch and on Old River at Clifton Court were operated through the entire fiscal year. Those on Sacramento River at Isleton and on Georgiana Slough at Tyler Island Bridge were fished from December 15, 1948, to the end of May, 1949. From analysis of catches in fyke nets, it became possible to ascertain:

(a) A comparison of the extent of salmon fingerling migrations in Sacramento River and Georgiana Slough.
(b) The sizes and times of movement of salmon, striped bass, smelts, shad, and other species of importance in the Delta.
(c) The times of entry of immature fish into the Delta, from Sacramento and San Joaquin sides.
(d) The optimum times and localities for emphasis on tow netting.

Through experimental fishing with lined vs. unlined nets, and with continuous vs. discontinuous fishing, and by comparisons of different fishing places at the same locality, it was possible to fix the fishing efficiency of our standard gear, and to adjust subsequent methods accordingly.

In general, where fyke netting was carried on near tow-net sites, the agreement between the two methods was good.

Report Writing

A considerable share of the time of all personnel was spent in preparing material for an interim report to the U. S. Bureau of Reclamation. These duties included compilation and analysis of catch data, organizing and interpreting

ecological data, preparing approximately 45 maps and charts, and writing explanatory text material. Several conferences with Bureau of Reclamation personnel were held for the purpose of outlining the significance of the data and requesting information for use in the report. Stanford Office personnel also devoted much time and attention to the preparation of the report. The final compilation was not complete at the end of the year.

CONVICT CREEK

The principal activity of Mr. Nielson at Convict Creek at the beginning of the fiscal year was the construction of new water-control structures and the re-channeling of the stream sections. The completed work resulted in the replacement of small, atypical streamlets with larger, paired channels suitable for experimentation under typical trout stream conditions. Complete control is now possible over the flow in any of the four new sections created by the building project, and the details of the concrete structures are such that various kinds of screens can be utilized in test work. When the station was opened in the spring of 1949, a set of walkways, flashboards, and screens was constructed, and the anticipated repair work on eroded banks was begun. Biological work was begun near the end of the year, when preparations were made for testing various methods of censusing trout in streams.

YELLOWSTONE LAKE STUDIES

Mr. Cope made two trips to Yellowstone Park during the year. The first, in August 1948, was undertaken to gain information on which to base recommendations requested by the Branch of Game-Fish and Hatcheries. The outcome of that summer's observations was a report to the Central Office outlining the various points which seemed essential as a foundation for management of the Yellowstone cutthroat fishery. A program and budget were included.

Funds for the initiation of the program were not available for use in the spring of 1949. However, money was made available for a short trip in June 1949, when 1,250 trout were tagged with Peterson tags. Additional arrangements were made for the recovery of tags, the counting and measuring of fish, and an inventory of fish caught in Yellowstone Lake. Personnel at the U. S. Fish and Wildlife Service hatchery at Yellowstone cooperated in this work, and early indications are that much will be learned in 1949 concerning the biology of this fish.

ATLANTIC SALMON INVESTIGATIONS

George A. Rounsefell, Chief.

PROPAGATION

An effort is being made to expand the salmon propagation program. The collection of adult salmon in 1948 was a failure, the 34 taken being the lowest number in ten years. The Dominion of Canada Department of Fisheries generously contributed 300,000 eyed salmon eggs from Miramichi River stock and the State of Washington assisted with 200,000 eyed silver salmon eggs, to bring the total number of salmon eggs over 700,000. In 1949 racks for taking adult salmon were installed in the Ducktrap and Narraguagus Rivers, and fishways were trapped on the Penobscot and Machias Rivers. The failure of the Penobscot River run in 1948 and again in 1949 shows the necessity for planting young salmon in the headwater tributaries if any quantity are to survive.

RESEARCH

The research program has also been hampered by the necessity for providing adequate physical facilities for the work, but this handicap is being gradually overcome. Mr. Bertrand Smith, Manager of the Moosehorn National Wildlife Refuge cut all the hardwood timber needed for constructing an up-and-down-stream counting rack on Little Falls Stream; and enough softwood to construct dams on the two headwater lakes to store water to provide summer flow. It is hoped that the weir and dams can be finished in the autumn of 1949. This will be the only National Wildlife Refuge able to boast of an Atlantic salmon stream.

In April a meeting was held at St. Andrews, New Brunswick, attended by biologists, fish-culturists and administrators to discuss informal cooperation in restoring salmon runs in the St. Croix and Aroostook Rivers. Plans were laid for determination of the biological condition of these rivers and for estimates of the cost of needed fishways.

Because of the inconsistent and small returns of adult salmon that have resulted from stocking young salmon of an advanced age, several plants have been made distributing feeding fry widely over riffle areas. In this strenuous task valuable assistance was furnished by the Ellsworth Rod and Gun Club, the wildlife students at the University of Maine, and Inland Fisheries and Game wardens. In most cases the results cannot be measured quantitatively until the adult salmon return.

The report "Growth Contol Charts for Atlantic Salmon", by Dr. Rounsefell and Mr. Bond is in press for publication in Transactions of the American Fisheries Society.

SECTION OF INLAND FISHERIES

GREAT LAKES INVESTIGATIONS
John Van Oosten, Chief.

GENERAL

Because of the critical situation that is developing in Lake Michigan as the result of the tremendous decline in the abundance of lake trout, Dr. John Van Oosten, Chief, Great Lakes Fishery Investigations, spent the period, April 26-May 7, in the field interviewing operators and gaining first-hand information on fishing conditions and on the extent of depredations by the sea lamprey. He also examined a number of streams tributary to southern Lake Michigan in search of spawning lampreys.

While he was in the southern Lake Michigan area, Dr. Van Oosten spoke on the Great Lakes Fisheries with special reference to the sea lamprey problem before the Illinois Commercial Fishermen's Association at Waukegan, Illinois, the Men's Club of Gurnee, Illinois, and the Sportsmen's Club of St. Joseph, Michigan.

Galley proof has been corrected and returned for the paper, "Age and Growth of the Lake Whitefish, Coregonus clupeaformis (Mitchill), in Lake Erie," by John Van Oosten and Ralph Hile. This article will appear in Volume 77 of the Transactions of the American Fisheries Society.

Manuscripts sent to press or submitted for publication were: "Age and growth of the whitefish, Coregonus clupeaformis (Mitchill), in Lake Erie," by John Van Oosten and Ralph Hile (to appear in Volume 77, Transactions of the American Fisheries Society) and "Present status of the United States commercial fisheries of the Great Lakes," by John Van Oosten (to appear in the Transactions of the Fourteenth North American Wildlife Conference).

Dr. Jobes has continued the revision of his manuscript on the age and growth of the yellow perch in Lake Erie, and Dr. Perlmutter has continued work on his manuscript on the abundance of rosefish off the coasts of Maine and Nova Scotia.

SEA LAMPREY-LAKE TROUT INVESTIGATIONS

Dr. Van Oosten has drawn up for distribution progress reports on the 1948 activities of the Great Lakes Lake Trout Committee and the Great Lakes Sea Lamprey Committee. These memorandum reports contain information on programs and accomplishments as supplied by the several cooperating agencies.

Dr. Perlmutter has completed the preliminary arrangements for a proposed experiment on the possible effectiveness of the American eel as a predator on the larvae of the sea lamprey. During the period, May 4-11, he, with cooperation of Mr. Clyde Taylor, Maine Department of Sea and Shore Fisheries, and Mr. Leslie Scattergood, North Atlantic Herring Investigations, Fish and Wildlife Service, collected elvers in the vicinity of Boothbay Harbor, Maine. Approximately 300,000 elvers were shipped to Cheboygan, Michigan, where Mr. Vernon C. Applegate, who represents the Michigan Department of Conservation in this cooperative project, sorted out the survivors (estimated at 10 percent and placed them in holding tanks pending further development of the experiments. In addition to the elvers, 20 larger eels (5-11 inches) were transported to Ann Arbor for use in experiments on predation.

In connection with the experiments with eels, Dr. Perlmutter has drawn up a memorandum on the possibilities of using that animal as a predator on sea lampreys and has prepared a review of the available literature on the feeding habits of eels.

While he was in Maine, Dr. Perlumttor visited the Sheepscot River, where a run of the sea lamprey exists, to study the relationship between the eel and the lamprey and the possible factors limiting the size of the runs of the sea lamprey along the coast.

Series of marine sea lampreys collected by Mr. Scattergood in both northern and southern Maine are being compared with the Great Lakes form to determine whether the two are identical.

Dr. Jobes, Mr. Howard J. Buettner, and Mr. Daniel W. Garn were at Charlevoix and Frankfort, Michigan, May 16-27, where they made observations on the relative abundance of hatchery-reared (fin-clipped) and "wild" lake trout in the catches of commercial chub nets, obtained data on the scarring of fish by sea lampreys, and collected biological materials. Fourteen of 105 "baby" trout seen at Charlevoix, but none of 230 examined at Frankfort, were fin-clipped. One baby trout at Charlevoix and 17 at Frankfort bore lamprey scars. In the commercial catches the percentages of scarred lake trout and whitefish were: lake trout--31 at Charlevoix and 58 at Frankfort; whitefish--20 at Charlevoix and 7 at Frankfort. Scale samples were obtained from approximately 650 lake trout, 350 whitefish, and 100 blackfins.

GREEN BAY INVESTIGATIONS

The initial 1949 field work in these cooperative studies was carried out May 9-20 when Dr. Ralph Hile and Mr. D. John O'Donnell, Mr. Glenn Voskuil, and Mr. Orville Weberg of the Wisconsin Conservation Department marked 9,363 yellow perch (4,937 tagged; 4,426 fin-clipped) and collected biological data and materials. Scale samples included approximately 500 yellow perch, 450 lake herring, 185 whitefish, 30 walleyes, and 10 white suckers. Stomachs were preserved of all whitefish, about 300 yellow perch, and 19 walleyes. Two memoranda covering certain aspects of this work have been distributed to officials of the cooperating agencies.

Dr. Hile has completed age determinations for yellow perch collected in May 1948 and has started the measurement of the scales.

OTHER INVESTIGATIONS

Dr. Van Oosten and Mr. Garn are making age determinations for numerous samples of smelt collected at various points in Lake Michigan within recent years. Dr. Hile and Mr. Buettner were at Bay Port (Saginaw Bay) April 10-13 where they collected scale samples from somewhat over 200 walleyes and 100 smelt. Through the cooperation of the Michigan Department of Conservation we received on May 10 a sample of more than 250 yellow perch from Saginaw Bay.

FISHERY STATISTICS

The original tabulations of fishing effort and catch in the State of Michigan waters of the Great Lakes in 1948 have been completed for the first 10 months. The Service has also cooperated with the State of Wisconsin in compiling its 1948 fishery statistics at Sturgeon Bay, Wisconsin. The Statistical Section of the Branch of Commercial Fisheries transferred funds to the Great Lakes laboratory to provide the salary of a clerk for a period of two months.

LIFE-HISTORY STUDIES

Dr. Frank W. Jobes has completed age determinations of yellow perch collected from Lake Erie in 1948 and has made growth calculations for fish of the 1945-1948 samples. Data for the more recent years (1943-1948) have been or will be incorporated, as suitable, in a revision of his manuscript on the Lake Erie perch, prepared some years ago and based principally on 1927-1929 materials.

WESTERN FISH CULTURAL INVESTIGATIONS
Frederic F. Fish, Chief.

CORVALLIS LABORATORY

Impounded Water Studies

During mid-May, Dr. Fish assisted by Mr. R. A. Wagner, reactivated studies on the Cottage Grove Reservoir. Preliminary studies of this reservoir were started by Dr. Fish in 1945 and carried during the following year by North Pacific Fishery Investigations. The objective of the present studies are to establish the physical and chemical characteristics of fluctuating-level flood-control reservoirs so that the effect of these characteristics upon the use of impounded water in hatcheries can be determined. The reservoir studies will be shifted to Dorena Reservoir when water is impounded so that the complete picture in a new reservoir will be obtained. Reconnaissance studies will be maintained at Cottage Grove to determine what changes, if any, can be expected through the processes of reservoir aging.

Dr. Fish and Mr. Wagner are maintaining weekly vertical sampling for temperature, DO, BOD, conductivity, and turbidity at four stations in the Cottage Grove Reservoir.

Willamette Pollution Studies

Spot sampling for DO and BOD over the 185-mile reach of the main-stem Willamette, as well as major tributaries, is maintained at weekly intervals from the Corvallis Laboratory.

Definite evidence of an oxygen block in the Lower Willamette is now appearing in the samples. This work will continue until increased river flows following the fall rains lift the block. It is hoped that this study will reveal, for the first time, the exact circumstances leading to the formation and lifting of the Willamette pollution block.

Dr. Rucker terminated his studies of organic pollutants as potential media for fish pathogens in anticipation of a trip East for study at the Cortland and Leetown Laboratories. These studies will be resumed during the next quarter.

Pathological Studies

Dr. Rucker continued his studies of the larval stages of Nanophyetus salmincola, the so-called "salmon poisoning fluke," in cutthroat trout fry and fingerlings at the Oregon Game Commission's Alsea hatchery. The adult fluke, needed for taxonomic identification, was obtained by feeding infected fish tissue to hamsters. The study of this common hatchery parasite, and its effect upon the fish intermediate host, was undertaken several years ago but terminated under the pressure of more urgent studies.

Pathological material collected from diseased fish at Entiat and Winthrop Stations, is being sectioned for microscopic study.

Water Quality Studies

Dr. Rucker made several trips, upon request, for chemical analyses of hatchery water supplies. The Corps of Engineers requested oxygen, nitrogen, carbon dioxide, pH, and conductivity determinations at both water supplies to the Marion Forks Hatchery, from Little Sardine Creek, and from the North Santiam River at Niagara. The Branch of Game-Fish and Hatcheries requested similar analyses from a number of their stations including Spring Creek, Husum Springs, Hagerman, Warm River, and Ennis. Nitrogen supersaturation was found in the water supplies at both Ennis (133 percent saturation) and Warm River(132 percent saturation)--both concentrations being well above the accepted upper limits tolerated by trout. Deaeration accomplished by a modified Venturi at Ennis reduced the nitrogen concentration to 119 percent saturation. A jet type of inflow employed at Warm River reduced the nitrogen concentration in the troughs to 109 percent saturation. The degree of nitrogen supersaturation at both stations remained close to the upper tolerance threshold of fish. It is believed that the persistently high mortality of stock reported from both stations (and particularly from Ennis) might be reduced by the installation of more efficient deaerators.

COLEMAN LABORATORY

Carp as Substitute for Salmon Flesh in Hatchery Diet:

A shortage of salmon flesh and viscera at Coleman, as a consequence of the reduced runs to the Sacramento River last fall, emphasized the need for a substitute for the salmon flesh that constitutes 30 percent of the production diet. Carp are readily available from the Sacramento Fishery and, in view of favorable results reported from Colorado, their flesh was evaluated as a substitute for salmon flesh. The carp were received, scaled and in the round--most of them being gravid females. Immediately upon receipt at Coleman, the carp were frozen in the same manner as spawned-out salmon carcasses. The diets were ground and mixed daily except that Saturday's food was ground Friday but not mixed until Saturday morning.

Six troughs, each containing 2,000 chinook salmon fingerlings, were used in the experiment. The fish in three troughs were fed the standard station production diet and in the remaining three the fish were fed the same diet in which carp was substituted for carcass. The experiment was terminated at the end of eleven weeks. Although the gains made by the fingerling salmon fed the carp diet were good and the mortality was not excessive, at the time the experiment was discontinued these fish were obviously abnormal. A greater percentage of the fish had become dark, some almost black, frequented the lower end of the troughs, and were very difficult to frighten. Many fish swam listlessly on their sides or rested on the trough bottom and had a "pinched" appearance in the abdominal region.

There was no evidence of anemia as determined by visual inspection of the gills. None of the above symptoms were observed in the group of fish receiving the salmon flesh diet. It is believed that the fingerling salmon were suffering from a thyamine deficiency directly caused by the inclusion of 30 percent carp flesh in their diet.

When the experiment was terminated, the affected fish were placed upon the production diet now in use (which contains 30 percent salmon viscera) to determine if this diet contains enough thyamine to permit the fish to recover from the deficiency.

Optimum Time for Initial Feeding of Chinook Fry

The experiment designed to establish the optimum time for the first feeding of chinook-salmon fry was concluded during the current quarter. Analysis of the data has not yet been completed but it appears quite evident that a sharply reduced growth rate and an increased mortality can be expected when chinook fry are retained on the trays for too long a period. It is obviously preferable to remove the fry from the trays before they are ready to feed rather than wait and risk misjudging the time at which the more advanced fish are ready to take food. Although the earliest fish in this experiment were removed from the trays one week earlier than "normal," no significant reduction in either growth rate or mortality subsequently could be found. This experiment did not indicate the earliest limit of fry removal but it probably would occur just after the fry reach the stage when they will not congregate in the corners and smother.

Effects from Feeding a Stored Mixed Diet to Chinook Fingerlings

An experiment was undertaken on May 5 to determine the adverse effects, if any, from feeding the Coleman production diet following storage after mixing. Feeding stored mixed diets, if found successful, would reduce the peaks of hatchery labor demands.

At the end of seven weeks, the fish fed the diets stored for varing periods up to seven days, show no significant difference in either growth rate or mortality in comparison with the control group receiving the same diet freshly prepared.

Causes of Coagulated Yolk in Chinook Fry

In an attempt to isolate the cause of a localized coagulation of yolk which sporadically constitutes a serious problem at the Coleman Station, seven groups of eggs were exposed to different treatments any of which might be responsible for the yolk abnormality.

Neither residual milt, shock, silt, nor pressure apparently are responsible for the localized yolk coagulation among the Coleman sac-fry.

Use of Circular Tanks as "Pilots" for Rearing Ponds

An experiment was undertaken on April 22 to determine if fingerling chinook salmon reared in 6-foot circular tanks would prove more representative "pilots" of comparable stock in the station rearing ponds than are those held in the deep troughs.

This experiment has not progressed to the point where tentative conclusions are warranted.

LEAVENWORTH LABORATORY

Diet Evaluations

The 1949 diet experiments were undertaken on April 6. Although these experiments have not progressed sufficiently to warrant any detailed reporting, certain interesting developments are becoming apparent. The inadvisability of including meals at water temperatures below 50 degrees F., reported last year, has been confirmed. A significant increase in mortality with no compensating accoleration in growth rate results when fish meals at the 10 percent level are incorporated in the diets of blueback salmon fingerlings at water temperatures below 50 degrees F.

Experimental groups of fish fed the isolated fractions of salmon viscera, including eggs, intestinal tract, liver, and milts, indicate that the growth factor of salmon viscera is contained principally in the eggs.

Hake, when substituted for hog spleen in the production diet, makes a significant contribution to the growth rate of fingerling blueback salmon. No anemia has developed in this diet to date.

Optimum Time for Initial Feeding of Blueback Salmon Fry

The experiment designed to determine the optimum time of first feeding of blueback salmon was concluded. The results indicate that optimum growth rates and low mortality can be obtained if the fry are removed from the trays as soon as the first fish swim in a normal upright position free from the bottom screen.

Frequency of Feeding

The results obtained to date from an experiment designed to determine the optimum frequency of feeding smaller blueback salmon fingerlings indicate that the frequent feeding of small stock is definitely advantageous. Fish fed eight times per day made significantly greater gains in weight than comparable groups fed the same quantity of food but less frequently. When the fish had attained a size of approximately 1,000 per pound, the growth rate among those fed eight times per day declined, whereas those on

five feedings per day showed a marked acceleration in growth rate. This phase of the experiment was discontinued and the experimental groups reset with comparable fish. The experiment will be continued using the same feeding frequencies to determine the optimum frequency of feeding as the size of the experimental stock increases.

Preservation of Hatchery Diets by Methods Other Than Freezing

A cooperative experiment with the Branch of Commercial Fisheries designed to determine the effect of different processing methods upon retention of the vitamin content of salmon viscera was concluded during the quarter.

Salmon viscera was converted into meal by lypholizing, vacuum, stream drying, and tunnel drying at 100 degrees F. These meals were bound by the addition of 10 percent gelatin to produce a particle size acceptable to the fish. The 100 degree salmon viscera meal diet produced a high mortality after four weeks of feeding. Some evidence of thyamine and pantothenic acid deficiency was found among these fish. The lypholized and vacuum dried products showed identical reactions. The mortalities became excessive after six weeks of feeding although the fish showed no evidence of an anemia or a nervous incoordination. They did exhibit definite symptoms of a pantothenic acid deficiency as evidenced by clubbed gill filaments. The closely parallel results between the lypholized and vacuum-dried products indicate that vacuum drying, which is much less costly than lypholizing, may produce a comparable product. The vacuum-dried meal was found definitely superior to the tunnel-dried product.

Use of "Disintegrator" for Hatchery Food Preparation

After considerable experimentation, the Rietz prebreaker-disintegrator has been adapted to the preparation of frozen fish-food products. Minor modifications in the design and the operation of the machine were required to overcome the various difficulties encountered. The machine, as now designed and operated, will reduce frozen blocks of beef liver, hog liver, or salmon viscera to a particle size suitable for feeding through a 3/32-inch hole diameter ricer at the rate of 100 pounds every four minutes. Hog spleen is reduced at the rate of 100 pounds in three minutes. A smaller particle size is produced at a slightly slower delivery rate.

EASTERN FISH CULTURAL INVESTIGATIONS

Eugene W. Surber, Chief.

FIELD STUDIES ON SMALLMOUTH BASS STREAMS

A cooperative agreement between the State of West Virginia Conservation Commission Department and the Fish and Wildlife Service was drawn up for field studies on smallmouth bass streams including creel census work, observations on growth rates of smallmouth bass and other species of fish in certain streams, results of stocking, and studies on natural propagation. During the fiscal year, 1949, the State of West Virginia appropriated $5,000 for the conduct of this work which was supervised jointly by Mr. Eugene W. Surber, Fish and Wildlife Service and Mr. E. A. Seaman, West Virginia Conservation Department. These field studies are a continuation of those begun in 1936 and discontinued during the war.

During the 1948 fishing season, test sections were reestablished on the South Branch of the Potomac River near Romney, West Virginia and on two sections of the Cacapon River. The upper section of the latter stream involved an intensive study of 5.9 miles of the upper Cacapon River at Cacapon Bridge, while creel census and other field data was collected on a 7.4 mile section of the Cacapon River at Largent, West Virginia. The primary objectives in the field studies of these streams were to determine the composition of the fisherman's catch, the quantity of fish removed from a given length of stream and how good the fishing is in these streams. A man was employed to patrol each of the three sections. Fishermen using the test sections were required to fill out a report showing the catches of each species of fish, the number of undersized bass caught and the number of hours fished each day. The test section on the South Branch of the Potomac was 4.1 miles in length. The average width of the stream was 154 feet in the section and the average flow was about 1600 cubic feet per second. The section of the South Branch involved in this study is regarded as a fine smallmouth bass stream. Catch records during 1948 showed that bass, both smallmouth and largemouth, were far outnumbered in the catch by yellow belly sunfish and rock bass. The total catch of legal fish was 2,105 during 1948. Of these, 357 were legal size smallmouth bass and 50 were legal size largemouth bass. The catch of smallmouth bass amounted to 17 per cent of the total catch and to 86 of the species per lineal mile of stream. Sunfish composed 43 percent and rock bass 25 percent of the total legal catch or about 12 sunfish and 8 rock bass percent. The average fisherman's day was 7.9 hours. The total number of hours spent fishing in the South Branch test section was 4,499 hours. The catch per fisherman hour was 0.51.

In 1940, a creel census had been taken in this section before the size limit on smallmouth bass was reduced in 1943 from a fork-length of 10 inches to a fork-lengh of 9 inches. Major changes took place in the composition of the fish population according to the creel census records. The catch of undersized smallmouth bass decreased from 940 in 1940 to 165 in 1948, indicating a 82.5 decrease in the population of small bass; and the catch of rock increased from 22 to 585, indicating a 2,660 percent increase in their population; and the catch of sunfish increased from 463 to 901, indicating a 195 percent increase in the sunfish population. It was concluded that smallmouth bass fishing in the South Branch was on the decline and likely to become worse as these species are replaced by rock bass and sunfish.

The situations in the upper and lower test sections on the Cacapon River are similar. The upper section, which averages 94 feet in width, flow 226 C.F.S., a catch of 2,021 legal fish of all kinds were reported by 294 fisherman in 1948. They fished 3,497 hours for a catch of 4.1 fish per angler, 0.6 fish per hour, and 343 fish per mile of stream. The average fisherman's day was 7 hours in length. For the 5.9 mile of stream in this section, the catch of fish represented 30 per acre and 33.5 legal smallmouth bass per lineal mile of stream. Rock bass and sunfish made up 43 and 37 percent respectively of the catch of legal fish, and smallmouth bass made up 9.8 percent of the total catch of legal fish.

Legal size smallmouth bass made up a larger percentage of the catch in the lower test section at Largent. The stream in this section averaged 109 feet in width and stream flow data show an average flow of 548 C.F.S. The total catch of 2,151 legal fish were reported caught in 2,476 hours of fishing. The catch per hour was 0.9 fish during an average fisherman's day of 6.7 hours. Legal smallmouth bass in 1940 represented only 8.1 percent of the total catch while in 1948, 15.3 percent of all legal fish taken were smallmouth bass, in 1940, however, legal size was 10 inches compared with 9 inches in 1948. Reduction of the size limit to 9 inches brought about a great reduction in the bass population since only 45 undersized smallmouth bass were reported caught in 1948 compared with 479 in 1940. In this section, rock bass increased from a catch of 270 in 1940 to 650 in 1948. There was a moderate increase in the total catch of sunfish from 805 to 959, but the take dropped from 0.7 fish per hours in 1940 to 0.4 in 1948. Growth rates of smallmouth bass in these sections, as revealed by scales collected in 1947 and 1948, were compared with growth rates recorded in the period prior to reduction in the legal size length from 10 inches to 9 inches. It was apparent from the studies in the South Branch and the upper Cacapon test sections that growth rates had not increased significantly as a result of the reduction in the size limit. Rock bass and sunfish increased in numbers to compete with the smallmouth bass to such an extent that an increase in growth rate was not brought about by the reduction of legal size limits.

A detailed report entitled "The Catches of Fish in Two Smallmouth Bass Streams in West Virginia," is to be published by the West Virginia Conservation Commission.

EFFECTS OF INSECTICIDES AND CHEMICALS ON FISH

During the year, the toxicity of the following insecticides to fish were tested in laboratory experiments: Parathion, rothane, methoxychlor and rotenone in its several forms. Toxicity of 25 percent wettable parathion was tested on small fingerling bluegill sunfish about two inches in length in aquaria. Nearly all fish were killed at the last level used (0.05 part per million), and nearly all were killed at 0.04 part per million. At 0.03 part per million, or less, few or no fish died. It was concluded that about 0.04 part per million of wettable parathion represents approximately the threshold level. The experiments was carried out in aquaria containing 20 liters of water stocked with three or four bluegill sunfish each. All experiments were performed in triplicate. Rothane, or DDD was tested on two inch bluegills in the same manner with concentrations ranging from 0.05 to 0.2 part per million. At 0.05 part per million of the pure chemical, all fish were affected and 20 percent died. No fish died at 0.025 part per million and 0.0125 part per million. Methoxychlor in acetone solutions were added to aquaria containing bluegill fingerlings at rates ranging from 0.025 to 0.10 part per million with the following results. All fish were killed at the rate of 0.15, 0.10, and 0.05 parts per million. A few fish survived at the 0.025 part per million level. It was concluded that about 0.02 part per million methoxychlor was near the toxicity threshold for small fingerling bluegills.

ROTENONE EXPERIMENTS

Extensive tests were made with several forms of rotenone. A rotenone paste developed in the West was compared with emulsifiable rotenone, 5 percent. Quantities of the paste, of unknown content, except that it contained rotenone and acetone, ranging from 2 parts per million to 0.063 part per million were tested against emulsifiable rotenone of a known 5 percent content. The tests showed that the rotenone content of the wettable paste was about 2.5 percent. At about 70°F, and after 22 hours, the paste was approximately half as effective as emulsifiable rotenone, 5 percent. At four hours the paste was about 1/3 as effective as emulsifiable rotenone indicating that it was slower in its action per unit of rotenone than the emulsion. During October and November, 1948, a series of experiments were performed to determine the rate of penetration of different formulations of rotenone into the water. Abandoned quarry holes in the vicinity of the Leetown, West Virginia Station, which had filled with water to depths of 40 feet or more were used in the study. Emulsifiable rotenone was tried in three quarry holes while wettable paste was tried in two others. In one quarry hole with a maximum depth of 42 feet, emulsifiable rotenone was applied at the rate of 1.36 pounds per acre foot or 0.5 part per million. One hour after treatment the water was toxic at 20 feet, but non-toxic at 30 and 40 feet. Two and four days after treatment the

water was toxic at the surface and at 25 feet, but non-toxic at 30 and 40 feet. Complete details on this work have not been assembled, but in general, it can be said that emulsifiable rotenone, applied at 0.5 part per million to the water in these quarry holes, failed to penetrate beyond a depth of about 30 feet. Experimental evidence regarding the rate of settling of different formulations of rotenone was obtained in a tube or pipe, 3 inches in inside diameter and 10 feet long, with a wide-mouthed quart fruit jar attached to the bottom of the pipe and a screen at the top of the jar to prevent bluegill sunfish, which were used in tests, from escaping from the jar, where they could be readily observed, to the interior of the tube above. Different rotenone materials were introduced at the top of the column of water, and the time it took for the rotenone materials to settle down and kill the fish at the bottom of the ten-foot pipe were recorded. In this way, it was possible to demonstrate that emulsifiable rotenone, 5 percent, settled more rapidly in soft water than in hard water. It was also possible to demonstrate that 3 percent wettable rotenone paste settled in hard water faster than emulsifiable rotenone, 5 percent, even though the wettable rotenone paste was not as rapid in its lethal action in aquarium experiments.

The rate of penetration of emulsifiable rotenone is of particular interest because of the possible use of this form of rotenone in airplane spraying.

EXPERIMENTS WITH OTHER CHEMICAL CONTROL AGENTS IN THE FIELD OF WEED CONTROL

A number of organic compounds have come into use recently in the control of submerged aquatic plants. Among these are benoclor 3 C, orthodichlorbenzene, and naptha. These compounds were found to be toxic to fish at concentrations required to kill plants. Experiments at Lectown showed that soluble benochlor at a concentration of 20 parts per million was required to kill aquatic vegetation. At this concentration, nearly all aquatic organisms, including fish, are killed. The use of orthodichlorbenzene in ponds and lakes to control submerged aquatic plants, has been recommended. The recommended rate of application is 40 gallons per acre. Studies of the effects of this hydrocarbon on fish were therefore, based on this rate. Orthodichlorbenzene, at the rate of 40 gallons per acre, three feet deep, which would include depths existing in most hatchery ponds, is equivalent to a concentration of 57 parts per million if thoroughly dispersed. In aquarium experiments orthodichlorbenzene killed fingerling bluegill sunfish 2.4 inches in lengh at 3.2 parts per million which is much below the concentration required to kill aquatic plants at ordinary depths.

Naptha is used in irrigation ditches at a concentration of 185 parts per million for one hour to control submersed aquatic plants. Naptha compounds consisting of equal parts of Socal solvent No. 2 and emulsifier, killed bluegill sunfish quickly at rates of 26 to 88 parts per million. Some fish were killed at a rate of 8.8 parts per million, and bluegill sunfish were affected but not killed at a rate of 2.2 parts per million. Early experiments with nigrosine at rates of 10 and 20 pounds per acre

showed no ill effects on fish. One largemouth bass pond, treated on three occasions with nigrosine, at ten pounds per acre, produced over 7,000 largemouth bass.

A number of experiments were conducted with 2,4-D to determine how the cost of using 2,4-D on emergent aquatic plants might be reduced. With good coverage or complete wetting, it was found that 2,4-D in tributylphosphate and kerosene or fuel oil was still effective at a 0.5 percent level of 2,4-D.

The sodium salt 2,4-D is ideal for use on broad-leafed plants without thick waxy coats. This highly soluble form, at a one percent equivalent level, was tried on a variety of plants, which included smart weeds, marigolds, burreed, and water cress. The sodium salt dissolved in water at a strength of 1.0 percent (acid equivalent) had little effect on cattails and soft stem bulrushes.

PROPAGATION OF POND FISHES

During the Spring of 1949, the following fertilizers were tested in the larger warm-water hatchery ponds of the Station; 10-6-4 inorganic fertilizer alone and in combination with 0.1 part per million manganese, barnyard manure at three tons per acre, bluegrass plus phosphorus plus nitrogen, and Vigoro, a commercial inorganic fertilizer. All experiments were performed in triplicate as in previous years. These ponds were stocked with either largemouth bass fry or smallmouth bass fry as they were available. Beginning April 28, water samples were collected at ten-day intervals from 15 of these ponds for analysis. The following elements or compounds were determined: Ammonia nitrogen, nitrate nitrogen, organic nitrogen, soluble phosphorus, calcium, magnesium, sulfates, iron, manganese, boron and copper. In addition, dissolved oxygen content, free carbon dioxide, methyl orange alkalinity and turbidity were determined. The final series of water analyses were taken on June 21 and the draining of the ponds was begun on June 29, 1949. Data for these experiments have not yet been compiled, but results will be combined with data for several seasons dating back to 1941, for a publication on the fertilization of hatchery ponds.

The goal of our fertilization experiments has been to consistently produce water blooms in hardwater ponds since maximum fish production can be obtained under those conditions. The 1949 schedule as in previous years failed to produce water blooms, except in those ponds which possessed them last year. However, better understanding of the conditions under which water bloom form have been obtained over a period of several years. It is known that water blooms can be artificially produced by killing coarse weeds with sodium arsenite or the destruction of Chara in ponds containing this coarse alga with copper sulfate. Future experiments will incorporate absolute control of pond scums and coarse vegetation with chemicals, either sodium arsenite, copper sulfate, or nigrosine. It is now known that heavy applications of inorganic fertilizer at rates up to 300 pounds per acre per application is not the answer to the problem.

STUDIES ON THE POLLUTION OF THE SHENANDOAH RIVER

Physical and chemical analyses were continued at eleven Stations from above the Merck Company plant to the mouth of the Shenandoah River. Prior to October 1, 1948 very little change was evident in river conditions. Dissolved oxygen, pH, and carbon dioxide were well within limits to support fish life. However, 0.2 to 0.6 parts per million zinc were present in the river. On October 1, the American Viscose Corporation, Front Royal, Virginia, instituted full time treatment of its effluents and improvement in river conditions was found by quantitive studies after that time. Quantitative bottom samples were taken when possible to determine the effects of pollution on fish organisms. Laboratory toxicity experiments were also performed to determine the toxicity of zinc to fish, snails, and helgrammites. Largemouth bass and bluegill tolerated 10.0 parts per million of zinc for thirty days; snails were killed in 5.0 parts per million of zinc in 24 hours; helgrammites tolerated 100 parts per million of zinc for thirty days. Mayfly nymphs tolerated 10 to 20 parts per million of zinc and caddis fly larvae were able to tolerate 100 parts per million. Snails (Nitocris) were able to survive in water containing not more than 0.5 part per million of zinc, and daphnia only 0.2 parts per million. Fish were placed in liveboxes at the various Stations along the river to determine whether they would live continously in the river water. In general, the fish were able to live in the live boxes below the Viscose plant, but they failed to grow in them. On the other hand, fish in a live box one mile above the Viscose plant not only maintained themselves in good condition, from food passing through the screen enclosure, but actually increased in size and weight.

Studies so far during the year, point to considerable improvement in the lower Shenandoah River. Bottom animals of the better fish food types are beginning to appear in limited numbers at all Stations. However, there remains a noticeable absence of mayfly nymphs and snails. Minnows reappeared in considerable numbers and have almost regained their former abundance. Since full time treatment was started, zinc seems to have been reduced to a staisfactory level and other physical and chemical conditions appear satisfactory for supporting aquatic life.

Fishing on the river has increased considerably during the past year. It is reported that quite a number of fish (mostly rough fish such as suckers, catfish, and carp, but only a few bass, sunfish, and crappies) have been caught by fishermen from Morgans Ford Bridge to Millville, West Virginia.

In June, 1949 there appeared to be enough food, principally small minnows, caddis fly and midge fly larvae, to support a considerable number of bass.

MICROBIOLOGICAL LABORATORY
S. F. Snieszko, Chief.

GENERAL

In repeated trials at Leetown, small brown trout (fingerlings and small yearlings) have shown a marked dislike for rations containing sulfamerazine, as evidenced by very poor growth. With such fish, treatment of furunculosis with sulfamerazine is difficult. In January and February, 1949, in an experiment, small brown trout fingerlings grew sensibly as well on rations continging a large dose of sulfamethazine as on the rations without any drug. This means that they took the drug readily and that this rather new sulfonamide is especially worthy of trial in the treatment of furunculosis in brown trout. It also should have further trial with brook trout, in conjunction with sulfamerazine. A report on this experiment has been prepared and submitted for publication.

An apparently new method of preparing graphs for publication was found and a brief account sent to Science. (J. S. Gutsell)

PROPHYLACTIC TREATMENT OF TROUT DISEASES

During this fiscal year was completed the second and started the third series of tests on the prophylaxis of furunculosis, gill disease, and external parasitic infestations. The results completed during the calendar year of 1948 indicated that: Roccal reduced the incidence of outbreaks of gill disease; sulfamerazine reduced the outbreaks of furunculosis, and oral immunization against furunculosis was not effective. Results obtained with the new lots of trout during the first two quarters of 1949 indicated the pyridylmercuric acetate is very promising as a prophylactic agent against gill disease and external protozoan infections.

ULCER DISEASE

A complete study was made on the characteristics and pathogenicity of a bacterium isolated from outbreaks of ulcer disease among brook trout. The suggested name for this bacterium is Hemophilus piscium. One paper on the early studies of this disease is in press in the Transactions of the American Fisheries Society, Vol. 78, and another is about ready for publication in the Journal of Bacteriology.

TASTE TEST OF TROUT TREATED WITH SULFAMERAZINE

Rainbow Trout yearlings were fed for 10 days food containing sulfamerazine. At the end of this period trout were distributed for tasting among the personnel of the Station. No difference in taste had been detected between the treated and control trout. (S. F. Snieszko).

FISH NUTRITION INVESTIGATIONS

A. M. Phillips, Jr., Chief.

THE NUTRITIONAL REQUIREMENT OF FISHES

The Vitamin Requirement of Trout

By methods previously described, the requirements of three species of trout (brook, brown and rainbow) for folic acid were studied. It was found that even though levels as high as 175.2 micrograms per kilogram of trout were fed daily, maximum storage was not reached. The curve of liver storage versus dietary level of folic acid did not level off even at this level of the vitamin. It was concluded that at least this amount of folic acid must be fed to trout. The level represents the amount found in a 100 percent beef liver diet.

The amount of folic acid stored in the liver was found to be the same for all three species of trout. Temperature had no apparent effect on the requirement. No disease conditions were noted during the experiments.

At present a series of experiment are in progress to more precisely determine the role of biotin in the diet of trout. Although one series of analyses have been completed, there is not sufficient data to warrant conclusions at this time.

The Use of Dietary Supplements

Cod liver oil added to the standard diet of this hatchery (50 percent beef spleen; 25 percent each of wheat middlings and cottonseed meal; 24 percent fish meal; 2 percent salt) resulted in an increase rate of growth of these species of trout (brook, brown and rainbow). However, in the case of brown trout an increase in the rate of mortality was also obtained. Indirect evidence suggests that this mortality is connected with a vitamin deficiency and the so called "slime-patch" disease of brown trout.

Experiments are at present in progress to attempt to couple the "slime-patch" disease with a vitamin deficiency and the role of increased rate of growth. The latter controlled by the use of cod liver oil. Results to date would not warrant conclusions.

Anemia in Trout

During the summer of 1948, these experiments were greatly curtailed because of a shortage of laboratory assistance. However, the use of a commercial dog food over a 26 week period did prevent the appearance of anemic trout. The rate of growth was inferior to the standard diet of this hatchery.

At present several experiments are in progress to attempt to discover the cause of this anemia. Several liver extracts are being used together with crystalline vitamin B_{12}. No progress can be reported at this time.

The effect of Diet on the Body Composition of Trout.

Several diets, differing greatly in chemical composition, were fed to brook trout. Samples of trout were taken at two intervals, differing by about two months, and analyses were run on their bodies. It was shown that there was no difference in the water content of trout as influenced by age but a difference was caused by diet. The ash content varied with age, the larger and older fish showing a greater amount of minerals. Diet affected the ash content of the trout. The fat varied with the diet fed and the older and larger fish contained more fat than the younger ones. The character of the fat, as determined by iodine number, was altered by diet. The amount of protein in the body was dependent upon the diet but it was independent of the age-size factor of the experiments.

Current experiments are under way to determine what changes occur in the chemical composition of hatchery fish after stocking. These experiments are only just started and no results are available at this time.

Development and Testing of Practical Diets

During the summer several practical diets were tested. A commercial dog food fed on a 100 percent basis prevented anemia in brook trout but did not produce good growth. When substituted for one half the meat portion of our standard hatchery diet, the commercial dog food again did not produce growth equal to the control fish. Cooked pinto beans used as a substitute for the dry portion of our standard diet resulted in inferior rate of growth. A commercial by-product was found to be a satisfactory substitute for dry skim milk often used in trout diets.

At present several experiments are under way testing the value of several commercial fish foods as diets for trout. Several new ingredients are also being tested for possible incorporation in the standard dry feed mixtures used in many fish hatcheries.

STUDIES UPON TROUT PHYSIOLOGY

The Effect of Metabolic Products on the Carrying Capacity of Ponds and Troughs

The studies of the effect of metabolic products were continued. The data previously reported from a series of closed container experiments were applied to ponds. It was found that the accumulation of ammonia was directly proportional to the weight of fish per cubic foot of water and temperature and inversely proportional to the number of water changes per hour. The ammonia concentration builds up to near accepted pollution levels in ponds in series.

At present a series of experiments are under way to determine the effect of these products upon the blood of trout, thus permitting a more exact measurement of the harm such products may do even though an actual loss is not experienced. These experiments have not progressed to a point where conclusions may be drawn.

COOPERATIVE FIELD PROGRAM WITH CORNELL UNIVERSITY AND THE STATE OF NEW YORK

Brown trout were reared under two conditions, rapid and slow growth. A portion of these have been stocked and survival studies will be made to determine the effect of rate of growth on stream survival. Chemical analyses have been made upon the bodies of the fish before stocking and this will be correlated with samples taken at intervals after planting to note any changes that may occur.

The study of rainbow stocking in Cayuga Lake, New York has been continued and fish have been furnished for additional plantings.

FEDERAL RESERVOIR INVESTIGATIONS

T. K. Chamberlain, Chief

Visits to various Oklahoma reservoirs, and reservoir feeding streams, have been made by T. K. Chamberlain during the period. At intervals experimental fishing in Canton Reservoir was carried out during April, May and the first half of June, in association with D. Homer Buck, Frank H. Cross, using gill nets and hoop nets. Buck and Cross are graduate students of Oklahoma A. and M. College, temporarily employed as fishery biologists by the Corps of Engineers. Intensive experimental fishing started about the middle of June. The gill nets used were of one, one and one-half, and two inch mesh, and were uniformly 175 feet long by 8 feet depth. The maximum amount of equipment put into operation at one time consisted of five gill nets and four hoop nets. Seining in shallow water was done with small mesh seins.

Some thousands of individual fish of 13 species have been taken. Total catches on specific days amounted to the neighborhood of a thousand fish. Members of the more important species were measured, weighed, sexed and, in the case of scaled species, scales collected. Changes were noted in the species composition of the catches, due to season, parts of lakes fished and fishing gear used. While the bulk of the catches was composed of carp, carp-sucker, buffalo, bullhead and gar, an occasional bass of legal length, or fair size white crappie, was taken, and where condition permitted was tagged and released. Sunfish entered extensively into hoop net catches and several times a school of small crappie appeared to have run into a gill net --- one gill net taking 225 at one time.

Catches by sport fishermen were checked whenever possible, and scales from bass and crappie in the catches collected. In this creel census work the Corps of Engineers has cooperated by loaning a man to assist in it one day a week. Probably due to the wheat harvesting (but also due to the poor showing of the reservoir at time of the fishing derby), fishing has been light in Canton Reservoir since the middle of May. An intelligent guess may be made that since that time the total daily catch in the reservoir has amounted to an average of two legal sized bass, two channel catfish and one fair sized crappie. In addition, small catches of sunfish, bullheads, carp and small crappie have been noted.

Plans call for a continuation of intensive fishing through the summer with the equipment mentioned, with the possible addition of fish poison, an electric fish shocking device and Florida type fish traps, and for the collection of essential limnological data.

SECTION OF MARINE FISHERIES

SOUTH PACIFIC FISHERY INVESTIGATIONS

John C. Marr, Chief

GENERAL

The continued relatively low level of sardine landings has caused considerable action to be undertaken with the hope of conserving and building up the resource. The thought processes involved seem to entail considerable confusion in that the stabilization of the fishery at some economically desirable level is often considered to be synonymous with maintaining an adequate stock of breeding fish. Information on what constitutes an adequate breeding stock is not presently available.

In connection with routine survey work at sea, Messrs. Ahlstrom, Cox and Eckles were on Scripps Institution of Oceanography vessels for one cruise.

Activities connected with getting the Black Douglas ready to go to sea have taken a great deal of time. A plankton winch and overboard work platform have been installed on the starboard side, aft. A portion of the galley adjacent to the work platform has been converted to a wet laboratory. Chemical determinations are made in the laboratory on the second deck. A bathythermograph winch is located on the port side, aft.

Under our cooperative program with the Scripps Institution of Oceanography and the California Fish and Game, the Black Douglas is to run, once a month, four station lines running off-shore between Cape Mendocino and the Columbia River. On the first cruise, starting the end of May, only four stations were occupied, due to mechanical failure of both generating units. The Black Douglas put to sea again on June 30. Mr. Eckles is in charge of the work at sea; also aboard are Messrs. Cox, Paya, Wallis and Widrig.

Visitors during the quarter included Messrs. Cottam (Fish and Wildlife Service), Anderson, LaFond (Navy Electronics Laboratory), Thorsen (Zoologisko Museum, Copenhagen), Phillips, Cox (California Fish and Game), Hiatt (University of Hawaii), and Burnette.

REPORTS

The following manuscripts were completed during the last quarter:

Felin, Frances E.

> An application of Walford's method of describing growth characteristics to a study of the effect of temperature on growth in Platypoecilus maculatus.

Schaefer, M. B., O. E. Sette, and J. C. Marr

> Growth of the pilchard fishing industry of the Pacific Coast of North America to 1942, with an Appendix on a Survey of the legal regulation of the Pacific Coast pilchard processing industry, 1917-1942.

The following manuscript was submitted for approval for publication:

Marr, John C.

Apparent abundance of the pilchard (Sardinops caerulea) off the coasts of Oregon and Washington, 1935-1943, as measured by catch per boat.

DETERMINATION OF THE RATE OF PILCHARD RECRUITMENT AND THE CAUSES FOR FLUCTUATIONS THEREIN. (Ahlstrom, Eckles, Calderwood).

Owing to the short period of time in which the expanded field program has been in operation and to staff vacancies, it is impossible to report upon the several subprojects of this project.

Thus far, four crusies (three ships on each cruise) have been completed; the fifth has just started. The southern section, lying between San Diego and Cedros Island, has been covered completely on every cruise. The central section, lying between Pt. Conception and Cape Mendocino, has been less adequately covered. The northern section, lying between Cape Mendocino and the Columbia River, has been the least well covered area. This is owing to the weather and mechanical failures.

Fish eggs and larvae have now been sorted from the plankton collections made in March and April. Pilchard eggs and larvae have, in general, been found only in the southern inshore (up to about 120 miles off-shore) collections. The plankton haul at one inshore station contained over 25,000 eggs, but the numbers contained in other hauls have not been outstanding.

In addition to pilchard larvae, 23 other larval forms have been identified at least to genus and their numbers are being routinely tabulated. Of particular interest in this connection are larval jack mackerel (Trachurus symmetricus) taken in the southern section, and hake (Merluccius productus) taken in the southern and central sections.

DETERMINATION OF THE CHARACTERISTICS OF THE ADULT (COMMERCIAL SIZED) STOCK AS IT IS AFFECTED BY RECRUITMENT AND BY THE FISHER. (FELIN, WIDRIG).

Studies to determine the size and the age composition of the adult stock and the mortality rates of pilchards in the adult stock.

A small 1949 interseason fishery at Monterey was sampled during May. Scale samples sent to this laboratory were taken from the catches of 10 boats, mostly lamparas, fishing within Monterey Bay. From March 1 to May 31 Monterey received 1,686 tons and southern California 496 tons of pilchard.

Further interseason fishing will be discontinued in accordance with new regulation of the fishery.

Mr. Bradford Mishler is calculating the fish lengths of individuals of all year-classes sampled for scales, both currently and for past seasons in which the calculations are not completed. He will summarize the lengths at the time of formation of the first annual ring, computing the means for each year-class at each port and for all ports combined. The deviations of these first growth increments from a norm will be estimated for seasons 1942-43 to the present in order to follow up the correlation of these with other deviations of environmental factors shown for seasons 1939-40 through 1941-42 by Walford and Mosher (Spec. Sci. Rept. No. 21, 1943.)

Preliminary application of a technique described by William E. Ricker, "A method of estimating minimum size limits for obtaining maximum yield" (Copeia 1945, No. 2) was made by Widrig and Felin. The method is offered as a means of evaluating, at any given (existing) rate of fishing, the minimum size at which fish should be taken in order to attain maximum production. The method appears to be subject to modification and applicable to certain phases of pilchard study, different from that for which it was originally intended.

Studies to determine whether or not sub-populations exist within the adult stock and to define the relative importance of such populations, if present.

Mean growth curves for year-classes 1936 to 1944 have been constructed from data on average lengths of each age group present in the commercial catch from the 1941-42 through 1948-49 seasons. From estimates of the standard error of these mean sizes and the t value associated with each number of degrees of freedom, the confidence limits around each mean at the 5 percent level of probability indicate significant differences in the growth curves from north to south. Since mean lengths in these curves are derived from seasonal averages, the possibility exists that certain size differences in the stock might be obscured by seasonal summary of data.

Mr. Inocencio Ronquillo, Philippine fishery trainee, made a study of data in our files on length frequency distributions of samples of pilchards of the same age caught in different geographical regions during comparable monthly periods, as a further inquiry into whether sub-populations of pilchards are distinguishable by their growth types. His study covers the 1945-46 through 1947-48 seasons and has been submitted to Stanford University as a M.A. thesis.

Using the conventional tests for significance of difference, Ronquillo found consistent monthly difference between sizes at the same age in San Pedro and northern ports. Other significant differences were found among northern ports in certain months, especially in summer and early fall.

Ronquillo found the coefficient of variation to range from 2.10 to 11.70, most lying between 3 and 5 "as would be expected with linear measurements made on substantially homogeneous samples. It can be seen that this measure fluctuates more in the San Pedro region than in other localities."

Of interest also to us, in connection with the technique of age determination from scales, Ronquillo gave the calculated ratio of range to standard deviation ($\frac{r}{\sigma}$) as an observed and also as a theoretical value of this ratio for samples of the same size. He notes, "Close agreement between the computed and theoretical values indicates reliability and accuracy in the age determinations by scale reading in the pilchard."

EFFECTS OF ATOMIC EXPLOSIONS ON FISHES (Marr, Paya, Mead).

Studies to determine the relationships of the Marshall Island stocks of pelagic fishes, especially five species of scombroids, with those of other regions.

Mr. Mead completed a trip to Central American waters on a bait boat, the M/V Alphecca. Fishing was confined to the month of May off El Salvador and Nicaragua, during which time 250 tons of yellowfin tuna and oceanic skipjack were taken. Morphometric data were secured for 40 yellowfin tuna, six oceanic skipjack, and one black skipjack. Scale samples were taken from the yellowfin, and observations were made on degree of maturity and stomach contents.

Night-light collections were made on fourteen occasions. These collections include good series of juvenile scombroids, which have not yet been identified.

NORTH ATLANTIC FISHERY INVESTIGATIONS

William F. Royce, Chief

GENERAL

The work of most of the people in this project has centered around the operation of the Albatross III during its first year of use. All of the scientific staff have participated in the operations which have contributed more or less to every sub-project. The Albatross III completed 23 cruises although it was laid up from January to May because of a shortage of operating funds.

The cooperative effort among our own scientists has been extended to include the Branch of Commercial Fisheries which undertook freezing experiments at sea, to the Woods Hole Oceanographic Institution which sent numerous scientists working on several oceanographic projects on our cruises, and to independent investigators working in various fields of marine biology or oceanography. This culminated in a study of North Carolina waters in cooperation with the Institute of Fisheries Research and the Woods Hole Oceanographic Institution which will be discussed at greater length in a later section. Other cooperative effort included several of the staff who assisted the Atlantic States Marine Fisheries Commission as advisors.

A major political event affecting this investigation was the successful completion of the Northwest Atlantic Fisheries Conference. Royce and Schuck participated in the conference and presented a summary of fishery research on the New England fisheries to the biologists at the conference.

THE HADDOCK AND HADDOCK FISHERY

The paper "Relationship of Catch to Changes in Population Size in New England Haddock" originally presented at the "Optimum Catch Symposium" at meetings of the American Society of Limnology and Oceanography, was accepted by the editors of "Biometrics". This paper, among other things, shows that fishing removals strongly affect the size and composition of the stock. A highly significant correlation was found between the number of fish that are caught in any year and the reduction in size of the stock. Some of these findings will be used as a basis for forecasts of future abundance.

Of a small group of haddock (94) tagged on Georges Bank after being taken by otter-trawl gear of the Albatross III, 6 were returned during the year. This is the first time that tagged haddock have been returned from otter-trawl-caught fish or from fish tagged on offshore banks. This limited success encouraged us to modify our techniques further and on a cruise of the Albatross III in June 1949, 1,228 more haddock were tagged on the offshore banks (Georges and Browns). Although indirect evidence, such as size-composition and growth rates, indicates that the Nova Scotian populations are probably largely independent of the Georges Bank stock, direct evidence from tagging is needed not only to determine this definitely, but also to determine seasonal movements within banks, and to gain information on mortality rates.

Some data on age at maturity were obtained on one trip of a commercial trawler to Georges Bank during the spawning season. Of the female haddock, 0 percent of 2-year-olds, about 75 percent of 3-year-olds, and 100 percent of all older ages were mature. All males two years and older were mature.

The destruction of baby seed on Georges Bank in the calendar year 1948 was estimated at only 44 percent of that of the large-scale destruction of 1947: i.e. about 7,500,000 fish as compared to 17,000,000 fish. This reduction is not believed to be due to a change in fishing methods or gear, but to the fact that there were many less baby fish on the banks: i.e. the 1946 year class was smaller than the 1945 year class.

During the 4th quarter, editing of the translation of Baerend's paper "The Rational Exploration of the Sea Fisheries with Particular Reference to the Fish Stock of the North Sea" was completed and was sent to Washington.

Back-calculations for each of the years 1931 to 1949 by subareas, year classes, ages, etc. were completed. In all, about 4,500 fish were represented. A paper on growth will be prepared at the earliest possible time.

Work continued on a manuscript which will present the catch of New England haddock, by seasons, from 1931-48 in terms of pounds, number of fish, length frequency, age composition, contribution of year classes, etc.

THE FLOUNDERS AND THE FLOUNDER FISHERY

The flounder research staff, restricted by the diversion and curtailment of personnel, reduced the collection of basic data and concentrated on preparation of important phases of the study for publication. During the year, all of the scale samples collected from the commercial catch of the principal stock of yellowtail flounders during the six-year period 1942-47 were read for age composition and growth rate studies. This is currently being analyzed by subarea, year, season, sex, etc., in preparation for a manuscript on the composition of the catch.

Briefly summarized, this analysis indicates that: (1) yellowtail flounders become commercially important as 2-year olds; (2) females are faster growing than males and this growth rate differential becomes more pronounced with age; (3) during the 5-year period 1943-47, 3-year old fish predominated the commercial catch from subarea XXII-Q while 2-year old fish dominated the catch from subarea XXII-O; (4) sex composition of the catch is extremely variable from season to season and year to year; and (5) the phenomenon of apparent decrease in the measured length from Season A to Season B of the various age groups which exists in the data collected from subarea XXII-Q is not present in collections from subarea XXII-O.

CENSUS OF TOTAL FISH POPULATIONS

Much of the work of the Albatross III was devoted to the project. A commercial net was modified with the addition of fine-mesh liners and the omission of Vigneron Dahl gear; a scheme of operating it in a standard manner was developed; and a system of trawl stations was laid out to sample representatively the entire New England banks. Over 170 trawl stations were occupied and complete data on the operations of the gear, the number and size of fish caught, and the temperature were obtained at each station.

The analysis of these data proceeded through the winter. Summaries were made of the catch by subarea, depth, temperature, and direction of tow. Haddock data were further analysed by age.

No conclusions can be drawn yet from these data. It is expected that they will form a basis for predicting the abundance of haddock and for determining the size of the populations of all demersal fish on the banks.

Raymond J. Buller was transferred from the Flounder Investigation to take charge of this project. He will soon commence a more detailed analysis of the data.

HYDROGRAPHY OF THE FISHING BANKS

Temperature data were collected on all trawl stations made by Albatross III as well as on many other occasions. Preliminary analysis indicated that bottom temperatures on Georges Bank during the summer of 1948 varied from 40° F., at the 75-fathom depth to about 50° F., in the central shoals area. Correlation of these data with distribution of fish is reported on elsewhere.

TESTING OF SAVINGS GEAR

Investigations on the action of larger than commercial size mesh or savings gear on the survival and escapement of fish was resumed during the fiscal year. A considerable period has elapsed since Herrington's first experiments in 1931 and extensive background research was necessary to bring the program up to date. With the commissioning of a research vessel, investigations again were possible. A new program on savings gear was outlined and experiments begun.

Two problems seemed foremost. First, tests to determine the rate of survival of fish, especially haddock, that escape through the meshes of the savings gear. Second, the size of the commercial species, other than haddock, which escape.

Determination of the rate of survival posed several problems. Haddock, the principal species needing protection, is a very delicate fish. This species, caught by otter trawl, had never been tagged successfully. Tagging seemed the only practical method to study survival, since it has not been possible to keep haddock in an aquarium at Woods Hole. During the spring of 1948, 357 haddock were tagged on Georges Bank. Of these, 257 were fish that had escaped through the savings mesh. To date 6 tags have been returned, only one of which was from a fish which escaped through the meshes. Although not very valuable for studying survival these returns are encouraging because they are the first from otter-trawl-caught fish.

During June 1949, 1,228 haddock were tagged on Georges and Browns Banks to continue the survival studies. All of these fish had escaped through the meshes. As a result of last year's experience, the tagging technique was improved greatly and the fish were released in much better condition. Results from this experiment will not be conclusive for at least one year.

During the fall of 1948 a net with four cod ends was designed to test the escapement of fish. This was tested on three short cruises during October and January. This net proved to be very bulky, hard to handle, and very sensitive to methods of setting and towing. Fish did not distribute themselves in the four cod ends as was expected, and too few small fish were found to give any significant results.

THE ROSEFISH AND THE ROSEFISH FISHERY

Dr. Alfred Perlmutter from the Gloucester office transferred to the Great Lakes Investigation in December. This vacancy, has not yet been filled.

One publication of the Rosefish Investigation has since been printed "Age and Growth of Immature Rosefish (Sebastes marinus) in the Gulf of Maine and off Western Nova Scotia" by Alfred Perlmutter and George M. Clarke, appeared as Fishery Bulletin 46 in June 1949.

It has been agreed that Dr. Perlmutter will complete three other papers as time permits:

1. The abundance of rosefish for the years 1942-48, with an outline of the method.
2. The populations of rosefish.
3. The spawning season of rosefish, the size at spawning, and miscellaneous biological data.

Since December, the collection of certain rosefish data has been continued by Messrs. Clarke and Booken. These collections include data on the total catch, abundance and size composition of rosefish, by areas of capture. In addition, scales and records of parasitic infections continue to be collected. The collection of data on length-weight, time of spawning, size at maturity, and distribution of larval rosefish, has been discontinued, as sufficient information on these points has been obtained.

Data on landings and location of capture of all species other than rosefish in the port of Gloucester has continued as usual.

HERRING OF MAINE

This investigation, financed by the Service, the Marine Sardine Packers' Association and the Maine Department of Sea and Shore Fisheries, was continued during 1948 at the request of the latter two agencies. The objective of the study has been to determine the cause of the fungus epidemics among herring. During periods of high incidence of fungus infection, the herring are not considered to be suitable for processing and the sardine industry suffers accordingly.

An increasing amount of our efforts is being devoted to accumulating information on the life history and abundance of the Atlantic herring. Unfortunately little is known about the species and this lack of knowledge precludes an accurate analysis of the factors which might influence the susceptibility of the herring to the fungus infections. The collection of statistics on the herring catch was continued in 1948 and punch cards were designed to facilitate future analyses of the catches. Scale samples from the various places in the Gulf of Maine have been obtained and await further study.

STUDIES OF OFFSHORE POLLUTION

This study is being conducted under the auspices of the National Research Council and in cooperation with the Woods Hole Oceanographic Institution. The latter is studying the oceanographic conditions off New York City while the Service is investigating other phases. During the year, the Service completed a survey of the sport fisheries of the area to show size of fleet, catch, and fishing localities. A preliminary report was prepared and the survey will be repeated this year. A photographic census of the larger bottom animals was completed which showed that starfish and other forms survived immediately under the point where sulphuric acid waste was dumped for eight months. A third study, which will be continued this year, used drift bottles to determine the drift of floating objects. It indicated that from certain points in the area objects drifted for weeks and many miles before reaching shore.

MIDDLE AND SOUTH ATLANTIC INVESTIGATIONS

Clinton E. Atkinson, Chief

GENERAL

The most significant development during the fiscal year was the reactivation of the Beaufort, North Carolina laboratory, with facilities for private investigators to work on marine problems. Headquarters for the Middle Atlantic Investigations have been established there.

Manuscripts prepared included "The Importance of Catch Records in the Management of the Fisheries of Virginia and Recommendations for a Statistical Laboratory" by C. E. Atkinson, R. C. Hammer and W. A. Van Engel, which was submitted as a progress report to the Virginia Research Committee. Also prepared was "A Survey of the Shad Fisheries of Virginia" by L. E. Cable and E. H. Hollis.

NORTH CAROLINA SURVEY

In April 1949 a cooperative agreement with the Institute of Fisheries Research was drawn up because: (1) the Institute and Service had common interests in studies pertaining to the biology of fish and invertebrates and their environment in the coastal waters of North Carolina; (2) the Service has the research vessel Albatross III designed and equipped for research at sea, and has personnel familiar with the oceanographic and biological phases of such work; (3) the Institute has personnel familiar with oceanographic and biological phases of such work and especially acquainted with problems characteristic of North Carolina waters; and (4) such a cooperative program involving the collection and processing of the data would be mutually beneficial.

The objectives of the survey were to:

1. Determine the distribution and abundance of fish and invertebrates and the possibilities of a trawl fishery in waters from 20 to 200 fathoms between Oregon Inlet and Cape Fear.
2. Determine the distribution of temperatures, salinities, and densities between Cape Hatteras and Cape Fear and out from shore into the Gulf Stream.
3. Determine the distribution of eggs and larvae of shrimp and fish between Oregon Inlet and Cape Fear.
4. Determine the depth and accurate positions on all courses run in order to provide additional data on bottom hydrography.

The Institute of Fisheries Research contributed $4,000 toward operating expenses of the Albatross III. The Woods Hole Oceanographic Institution agreed to send two men to collect oceanographic data and to be responsible for the preparation of a report on the oceanographic survey, which would include data from other Institution vessels operating in the area.

During the survey, a total of 26 trawl and 32 oceanographic stations (which were visited twice) were completed. Vertical plankton tows were made at every trawl station. Several plankton stations were also made in the vicinity of inlets and the mouths of rivers and in the Gulf Stream. Results from a preliminary analysis of the data collected indicate that: (1) trawling is possible in most of the coastal waters out to and including the 200-fathom depth; (2) even at this season (May and June) some species are commercially abundant in the greater depths; (3) by modifying their gear North Carolina fishermen will be able to fish the area covered by the survey. The survey made possible the collection of the first comprehensive data on the hydrographic conditions and distribution of plankton in both the Gulf Stream and inshore waters in the vicinity. In addition, data on the distribution and life history of certain pelagic sport fish were collected.

MIGRATION OF ALEWIVES

Mr. Collins conducted an experiment on alewives (Pomolobus pseudoharengus and Pomolobus aestivalis) ascending a small tributary of the Bournedale Ship Canal (Massachusetts) from April to June. A former State of Massachusetts egg taking station was used where the channel of the creek was already confined within a wooden trough. The trough was divided into two channels - using alternately one as a control and one for the experiment.

The experimental procedure was to first use both channels as controls, counting about 30 fish through each, in order to make sure that light, current, or other factors would not favor one channel over the other. Then a control (left) - Test (right) was run for about 30 fish followed by reverse procedure of a Test (left) - Control (right).

Efforts to measure the response of fish to temperature were unsuccessful probably because of the odor imparted to the water by the composition lining of the tank. The fish refused to enter into the water coming from the portable tank, dashed wildly about, attempted to go past the screen, and some jumped clear of the trough. The water supply, heated slowly by portable immersion heaters, was quickly dissipated. This phase of the experiment was abandoned after three weeks of unsuccessful attempts.

The tests with CO_2 progressed more satisfactorily. In 2,224 tests where CO_2 was bubbled directly into the water 70.9% of the fish chose the lower CO_2 tension as measured by pH. However, using only the fish that had previously chosen the control, 25.6% chose the CO_2 channel while 74.4 again chose the control. Similarly, using only the fish that had previously chosen the CO_2 channel, only 28.6 chose again the CO_2 while 71.4 used the control. Further experimental work is necessary to explain the reaction of fish to dissolved CO_2.

It is of interest to note that the alewives seemed to prefer more alkaline water; avoiding the channel to which H_3PO_4 or H_2SO_4 had been added to lower the pH from .15 to .4 and ascending the channel in which the pH had been raised from .25 to .1 by the addition of NaOH or KOH.

Acknowledgements are made to other cooperating agencies: - the salary of Mr. Collins for two months was paid by the Massachusetts Conservation Department, Division of Marine Fisheries, and Woods Hole Oceanographic Institute had awarded a scholarship to Mr. Collins to assist in this experiment. The Service has arranged for the loan of pumps, heaters, and current meters and the maintenance crew from the Woods Hole station repaired the existing facilities at egg-taking station.

PRIVATE INVESTIGATORS

In June laboratory facilities were extended to two researchers to work on the ecology of the Beaufort region. Dr. A. S. Pearse, professor emeritus, Duke University will study the fauna of the region while Dr. Louis G. Williams, Associate Professor of Biology, Furman University will study the flora of the region. Their particular interest lies in the ecology of the reefs.

The station was established, at Beaufort on June 1, 1899, with the purpose of observing and studying the fish and related marine conditions in the area. This use of the laboratory by summer investigators will again be encouraged.

CRABS

Between February 28 and March 4, 1949, 330 Blue Crabs were tagged in the Rappahannock estuary, as a cooperative project between the Chesapeake Biological Laboratory (Maryland), the Virginia Fisheries Laboratory, and the Fish and Wildlife Service, U. S. Department of the Interior. By June 30, 62 tags had been returned.

In agreement with previous observations, the returns from male crabs were entirely within the Rappahannock estuary, while the predominant number of returns from female crabs were from the main Cheaspeake Bay and south of their area of release. It is of interest to note that a slightly higher portion of males were taken by the fishing.

SHAD INVESTIGATIONS

TRENDS OF ABUNDANCE Miss Cable found that the upward trend noted last year in the catch of shad in the Hudson River was not continued this season. Receipts on Fulton Market amounted to 1,706,099 pounds, of which 744,639 pounds were taken in New York waters and 961,460 pounds were taken in

New Jersey waters. Although the total catch is much lower than last year and even lower than in 1947, the catch in the New York section, the upper part of the river where the spawning grounds are located, shows little change in spite of an increase in the number of licenses issued. However, it may be because of the increase in the number of nets that the catch has been maintained in the face of a decline in abundance. The number of licenses issued is not an accurate measure of fishing effort because very few of the nets are fished full time.

MIGRATION AND MORTALITY OF SHAD

This spring Mr. Hollis attempted to pond-rear shad for subsequent tagging as juveniles at hatcheries located at Edenton, North Carolina, and Orangeburg, South Carolina. At Edenton, survival of young has been far short of expectations, only 675 surviving out of an estimated 28,000 in one nursery pond and only 14 from another pond stocked with 22,400. These fish were held over a 7-week period.

At Orangeburg, ponds are now being drained preparatory to transferring young shad from nursery to growing ponds. Survival is yet unknown, but trial seinings indicate better survival here than at Edenton.

During the last week of May several lots of shad eggs were transported from the Potomac River to the Eastern Fish Cultural Experimental Station at Leetown, West Virginia. Shad will be stocked in ponds here to afford experimental material for working out improved methods of handling and tagging the juveniles. It is hoped results of this work will be available by fall.

There were 4 returns this spring from the shad tagged last August and September from herring wiers along the coast of Maine. It would appear from this year's returns that many of the shad found inshore in this area are immature. Sizes of shad tagged ranged from 41 to 94 half-centimeters (fork length). The shad returned this year were from the upper frequencies.

SCALE ANALYSIS A large collection of scales from the 1949 run of shad in the Hudson River was received by Miss Cable from New York and New Jersey Departments of Conservation. Samples of scales from the current runs in the Delaware and rivers in the Chesapeake Bay regions were obtained by Albert E. Sanderson, Jr., cooperating with the state conservation departments of Delaware, Maryland and Virginia.

Miss Cable and Mr. Sanderson visited the Chesapeake Biological Laboratory where they transcribed the list of licensed nets operated in Maryland tide water with lengths and locations. The daily catch records for 1946-7 and 1948 were brought to the laboratory for tabulation and analysis.

SHRIMP INVESTIGATIONS

On April 11, 1949, an agreement was concluded between the Institute of Fisheries Research, University of North Carolina and the Service whereby the status of the North Carolina shrimp fishery would be examined and recommendations would be submitted to the Institute to assist in the formulation of their future studies of shrimp.

Mr. Atkinson was detailed to the Institute from April 1 to June 30 to study the records collected by that organization and to analyze the results. Some evidence was found of overfishing during the years when the catch exceeded 6,000,000 pounds. A report is being prepared with recommendations for submission to the Institute of Fisheries Research.

STRIPED BASS INVESTIGATIONS

DELAWARE In cooperation with the State of Delaware, an investigation was made by Mr. De Courcey of Indian Bay to confirm reports that considerable numbers of striped bass were spawning each year in this area.

Beginning April 8, ovaries, lengths, scales and other information were collected from striped bass taken by anglers at Inlet, Delaware. The ovaries were kept frozen until an examination could be made to determine the stage of maturity of the fish. From the series of ovaries collected, it has been possible to follow the development of the eggs until time of spawning, about May 15.

SANTEE - COOPER About 10 years ago, the waters of the Santee and Cooper rivers, in South Carolina, were impounded to supply hydro-electric power, assist navigation, and control flood waters. Soon afterwards, there appeared in these rivers a phenomenal run of striped bass. A tagging program was undertaken by Mr. Hollis in cooperation with Mr. John Sutherlin, Refuge Manager. From April 28 to June 16, 1949, 220 striped bass were tagged in the Santee River and 20 were tagged in the Cooper. The returns will provide information on their migration and especially, if any are able to ascend the dam by use of the locks to the waters above. We know little of the runs of striped bass in southern rivers, and the information gained by this experiment will be most valuable.

The project was undertaken in cooperation with the State of South Carolina, Department of Inland Fisheries, and the Santee-Cooper authority.

GULF FISHERY INVESTIGATIONS
William W. Anderson, Chief

GENERAL

In the shallow waters off the west coast of Florida there appears quite suddenly at irregular intervals a peculiar discoloration of these waters known as "red tide". The last occurrences of this "red tide" were observed during the fall and winter of 1946 - 1947 and the summer of 1947. Associated with these outbreaks are the death of millions of pounds of fish, many of which are valuable food fish, and the contamination of the beaches by the decaying fish which are washed ashore.

The immediate cause of "red tide" has been ascribed to a tremendous abundance of the dinoflagellate Gymnodinium brevis which may be found in numbers up to 60,000,000 per quart of water in the more heavily affected areas. The death of fish is evidently caused by a toxic substance or poison of unknown nature which is associated with the occurrence of great numbers of Gymnodinium brevis.

The Fish and Wildlife Service was authorized by Congress to undertake a study of the "red tide" phenomena and the Gulf Fishery Investigations was assigned the task. After a thorough survey of possible locations for a laboratory on the Florida West Coast, Sarasota, Florida was chosen as the location for headquarters of the studies. The move from New Orleans, Louisiana to Sarasota was accomplished during October 1948.

Early in December, representatives from interested agencies and institutions in the State of Florida met at the Service's Laboratory at Sarasota to discuss possible cooperation in the "red tide" studies. Attending were representatives of the University of Florida, University of Miami, University of Tampa, The Florida Department of Conservation, and Commissioners of Pinellas County, Florida. As a result of this meeting it is believed that all interested agencies have a better concept of the problem and of what each hopes to accomplish.

Only one agency entered into an active cooperative part of the program. The Marine Laboratory of the University of Miami assigned Dr. Gladys King to a study of the nutritional requirements of Gymnodinium brevis and related organisms -- Dr. King is stationed at the Service's Sarasota Laboratory as a Collaborator.

OCEANOGRAPHIC WORK

The vessel Pompano, a 60 foot former Army "9" boat, was partially reconditioned by a shipyard during the second quarter and early part of the third. After delivery to Sarasota late in January our own crew began the task of refitting the sleeping quarters, installing laboratory facilities, winch gear and the many other items necessary.

Active field work was begun in May and has continued during June. Eight fixed stations, ranging from the mouths of fresh water rivers out to the 100 fathom line (approximately 110 miles offshore) have been established and are visited at regular intervals. A series of data relating to oceanography, planktology, chemical constituents of the water and general observations are obtained at each station. The accumulation of data for a longer period of time will be necessary before comparisons of the data obtained can be made or their significance determined.

Delay in securing major pieces of equipment such as a bathythermograph and a current meter have held up observations to be made with these instruments.

STUDIES ON NUTRITION OF ORGANISMS RELATED TO RED TIDE

Dr. Gladys King has continued her studies on the nutritional requirements of Gymnodinium simplex and Plagrocampa marina since we have been unable to secure Gymnodinium brevis. As a result of an extended study Dr. King has concluded that apparently these two organisms will not grow in an inorganic medium even when supplied wide ranges in amounts of available inorganic phosphorus and nitrogen. However, she has had success in culturing the organisms in a sea water-yeast nutrient, and studies are now in progress to identify the constituents of yeast which are essential for continued growth of the dinoflagellate and ciliate species under investigation.

PACIFIC OCEANIC FISHERY INVESTIGATIONS
SECTION OF BIOLOGY AND OCEANOGRAPHY
Milner B. Schaefer, Chief

GENERAL

As the first year of existence of POFI draws to a close, we find our operations somewhat behind the original schedule, particularly as to the instituting of sea going studies which were contemplated for May 1, but which will probably not get under way until October as a result of delays in vessel conversion.

The projects undertaken during fiscal 1949 consisted largely of necessary preliminary work antecedent to the institution of research projects, including the assembling of equipment and facilities wherewith to work, and study of background information for the efficient planning of our operations. This preliminary work, as described below, is completed or well on the way to completion. A new program will be submitted for fiscal 1950 describing research projects to be undertaken, in addition to the 1949 projects to be continued into the next year.

A report by Mr. Schaefer "The Federal Program with Relation to the Future Development of Pacific Fisheries" was read at the Seventh Pacific Science Congress in New Zealand.

CONVERSION AND OUTFITTING OF VESSELS

At the end of the fiscal year, the research vessel "Hugh M. Smith" (Ex-YP635) is in the Tacoma, Washington yard of the Tacoma Boatbuilding Company undergoing conversion. Delivery of the ship by the contractor to the Department of the Interior is expected to take place in September 1949. This will be the culmination of extensive planning for the repair and conversion of the ship. Rehabilitation of the hull and machinery was completed at Honolulu in early February and the ship was returned to the Service. Shortly thereafter, bid invitations were issued for the conversion. After a disappointing delay during which all bids were rejected, the contract was awarded on April 29.

A good deal of the scientific equipment required aboard the "Smith" and the two exploratory vessels has been obtained or ordered, and preparations have been made to procure the remainder early in fiscal 1950. The current Hawaiian waterfront strike, if it long continues, as it threatens to do, may, however, delay delivery of equipment and materials sufficiently to cause further delay in the institution of full scale work at sea.

SURVEY OF JAPANESE TUNA RESEARCH ACCOMPLISHMENTS AND STUDY OF JAPANESE FISHING AND RESEARCH METHODS

Procurement of Japanese Literature and Bibliographic Material Available in the United States.

This project has been largely completed. The bibliography compiled by the Pacific Oceanic Biology Project has been catalogued and is available for use. Microfilm copies have been made of nearly all pertinent Japanese papers

available in the Fish and Wildlife Service library. This work has been extended to Japan and it is believed that the collection of Japanese scientific papers on tuna biology and related subjects is reasonably complete.

Bibiographic work yet to be completed is the compilation of references which deal with tunas from other portions of the Pacific Ocean and assembling of these into a completed bibliography.

Study of Japanese Fishing and Research Methods and Procurement of Literature and Data from Japan

The procurement of material for this project is largely completed. Sufficient data have been accumulated to provide a clear picture of Japanese tuna fishing methods. Specimens of gear, or plans in the case of the more complex units have been procured. These include long lines and samples of the component parts, skipjack hooks, jigs, leader, a lift net for catching bait, and plans for line pullers as well as other gear. Moving picture coverage of both slipjack and long line tuna fishing has been made, although in the latter case there are still some arrangements to be made before copies of the pictures which were taken by the Army at our request may be delivered.

This information is to be divided into sections for analysis and publication. At the present time a paper dealing with the areas and methods of long line fishing is nearly complete for submission to SCAP in Japan to be published by them or the Fish and Wildlife Service as may seem most advisable.

Collection of research papers has been finished for practical purposes. While there are a few of value which could not be obtained, the great majority were either purchased or borrowed by our Japanese reconnaissance team to be microfilmed. As a consequence POFI probably has the most complete coverage of Japanese tuna publications outside of Japan. As an expedient, translations were secured of a number of manuscripts which could not be photographed.

Because the translations contain knowledge of considerable value to other governmental and research agencies engaged in studies of the Pacific tuna fisheries, and yet it is not feasible to make enough typewritten copies, they will be duplicated by a hectograph process for very limited distribution. The reproduction of the first of this series is about one-half completed. It is anticipated that the Branch of Fishery Biology or the Branch of Commercial Fisheries will reproduce for wider distribution those translations of sufficient general interest to warrant their further dissemination.

It has been possible to meet with most of the research workers engaged in tuna studies in Japan and to discuss their methods and results. A large number of useful ideas were so gained. Most of the Japanese scientists were quite candid, and discussed not only their successful ventures, but

also the weakness and failures to be encountered. Discussions of esperiments on tuna tagging, which are mainly unpublished were of particular value. A rather extensive series of tagging studies on skipjack was undertaken by means of a band about the caudal peduncle. A total of approximately 8,000 tagged fish released yielded returns of roughly two-tenths of one percent, and these shortly after tagging. Conversely, opercle tags applied to black tuna yielded a high rate of return for the few fish which were tagged.

Problems of age determination of tunas were investigated through interviews with a number of scientists. Dr. Aikawa who has been particularly outstanding among Japanese workers in this field was questioned extensively on the various phases of his research. Although large numbers of specimens were never used, about 150 fish in the case of the skipjack (K. pelamis) and fewer than 50 for the remainder of the so called "Scombroids", most of these species were examined by him. Dr. Aikawa found all of them to contain on the centra of the vertebrae markings which were assumed to be related to the age of the fish. Scales were used for age determination of the yellowfin (N. macropterus) and black tuna (T. orientalis) by other workers, but in no case did there seem to have been a thorough and extensive investigation of the problem.

Racial investigations have been largely confined to studies of the condition factor (Factor = $\frac{1000\ W}{L^3}$). Attempts have been made to divide the skipjack populations into "migratory" and "non-migratory" groups on this basis. More recently there have been several projects initiated which are aimed at racial studies through the use of morphometrics. A large quantity of these data (500 sets) were loaned to POFI by Dr. K. Kuronuma of the Central Fisheries Experimental Station of Japan for study but not for separate publication.

In general, research on the tunas in Japan has been primarily directed to expanding the exploitation of these fish rather than to discovering the facts governing their existence to serve as a basis of management. As a consequence, great emphasis has been placed on the study of some of the physical features of the environment which are related to the appearance and movements of tunas. For example, various water temperatures in which the several species of tunas will be found is known quite precisely, and this information is used by the fishermen in making their catch. In the fisheries of the former Mandated Islands area, water with a surface temperature within a few degrees of 28° centigrade was found to produce the best catches. Skipjack required similar temperatures, while those for albacore and black tuna are considerably lower.

Translation and study of data gathered under this project will continue through fiscal 1950 and into fiscal 1951.

Procurement and evaluation of Oceanographic Data Available for the Region to be Investigated

Because of the failure to recruit an oceanographer during fiscal 1949 progress on this project has been very meagre.

We have obtained from the Hydrographic Office copies of Japanese hydrographic data from some 700 stations in our general region of authorized study and have arranged to procure the data from a remaining 2800 stations. It appears that the most efficient method of handling these data will be by means of punch cards, we will therefore obtain duplicates of the Hydrographic Office's IBM cards as they become available. No analysis of any of these Japanese data has been possible during 1949 and with our greatly curtailed program in 1950 it is doubtful whether any work in this direction will be possible next year either.

PRELIMINARY SURVEY OF HAWAIIAN-LINE ISLANDS AREA

Data have been compiled on seasons, places of occurrence, abundance, and possible methods of capture of tunas and tuna bait fishes. These data were gathered by tudying the landings of local Hawaiian fishing vessels, by interviews with fishermen, and by field trips in local waters, plus visits to French Frigate Shoals, Palmyra, and Canton Island.

Commercial tuna fisheries in the Hawaiian-Line Islands exist only in Hawaiian Islands proper. In addition to diverse minor fisheries which use such gear as small surround nets and hand lines, important local tuna fisheries are conducted here. These tuna fisheries utilize two methods of capture--pole and line for live bait surface fishing and long line for subsurface fishing. It has been possible to examine the long line catches landed at the local market and obtain information on area of catch, time of catch, type of gear used, amount of gear used, etc. Thus, an opportunity to sample the yield from a small section of the Hawaiian archipelago has been present. From the detailed data recorded on the catches of 91 vessels, an analysis of the Hawaiian long line fishery for the six-month period from January through June is possible regarding:

(1) The species composition of the catches taken by vessels operating the long line gear and seasons of abundance for tunas and marlins taken by subsurface long line fishing. Yellowfin tuna, big-eyed tuna, striped marlin, black marlin, white marlin, and albacore compose the bulk of the catch landed.

(2) The efficiency of the long line gear as determined from the number of hours the gear has fished, the amount of gear fished, and the amount of catch.

(3) The fishing ground producing the major catches, and the related conditions of surface current and water depths under which they are produced.

(4) Construction and operation of the long-line gear.

The availability of live bait in the Hawaiian-Line Islands area appears to be a limiting factor in the development of a fishery where large tuna clippers can be operated. It has only been possible for us to survey briefly the live bait situation at a few outlying islands in the Hawaiian-Line region. Year-round studies should be carried out to show the seasonal abundance of the various small fishes that can be utilized for live bait. Japanese experience in the southwest Pacific has shown that live bait has also been a limiting factor in developing large vessel operations in that region.

At present a report is being assembled which will describe the findings of the survey team through June for use by POFI in planning its fishing and research operations. This report will include:

(1) An account of the history and present status of tuna fishing in Hawaiian and adjacent waters, including catch records to indicate the scope of the fishery.

(2) Methods and gear used in the Hawaiian tuna fisheries.

(3) The diagnostic characteristics, geographic distribution, length frequencies, and length weight relationship of Hawaiian tunas. If time permits, data will be presented on the marlins.

(4) The diagnostic characteristics, availability, localities of occurrence, and methods of capture of bait fishes in the Hawaiian-Line Islands area.

(5) The physical characteristics of the Hawaiian-Line Islands region (topography of ocean bottom, surface currents, surface water temperatures).

(6) The possibilities of the Hawaiian-Line Islands region as a major tuna producing area.

PRELIMINARY STUDY OF THE BIOLOGY OF CENTRAL PACIFIC TUNAS

Analysis of Data and Materials Taken on Cruises of the "Oregon" in 1948

A preliminary study of baththermograms taken along a section transverse to the equatorial current, from French Frigate Shoals to Jarvis Island, during February 1948 shows the effect of the divergence in the region of 10°N latitude on the subsurface temperatures as a result of upwelling, and suggests that in the region from about 7° to 13° N the tunas may be confined to the upper 300 feet, if credence may be placed in the statements of Japanese researchers that the subtropical tunas do not inhabit temperatures below 20° C.

Racial Analysis of Tunas by Morphometric Characters

The assembling of series of morphometric measurements of tunas from the adjacent waters of the Hawaiian Islands to form a basis of comparison with other regions was started in late February and is well on the way to completion. Data are being gathered from specimens at the wholesale fresh fish market and at the cannery at Kewalo Basin. Sets of measurements

have been obtained (as of June 13) from 126 big eyed tuna, Parathunnus sibi, 79 yellowfin, Neothunnus macropterus, and 124 skipjack, Katsuwonus pelamis, and 25 cava cava, Euthynnus yaito. In addition 25 sets of data have been taken from albacore, T. germo; these will be made available to scientists on the West Coast for comparison with data from albacore landed there. Our objective is to obtain from Hawaiian waters sets of measurements from 200 specimens of each species selected by length to cover as evenly as practicable the entire range of sizes encountered. This project is in cooperation with the Territorial Division of Fish and Game to the extent that we expect to pool our data and data already gathered by that organization and to conduct certain of the analyses on a joint basis.

In mid-April a vessel landed at Honolulu with a load of yellowfin and skipjack from the Society and Marquesas Islands. A joint operation by personnel of this Section and of the Territorial Division of Fish and Game resulted in the gathering of morphometric data from 99 skipjack and 47 yellowfin during the unloading and processing of these fish. Mr. Yee is in process of computing regression statistics for these samples.

Some morphometric data were obtained by our reconnaissance team in Japan during the winterfrom tuna specimens taken in the winter offshore fishery and landed at Tokyo. The very poor condition of most of the fish, however, precluded the assembling of very extensive data by this means. During May and June, Mr. Shimada has made several trips to fishing ports in southern Japan for the purpose of gathering morphometric and other biological data. Because of the lateness of appearance of the fish this year and bad weather there has been less material available than had been expected. However, sufficient data will probably be available for reliably comparing Japanese tunas with those from other areas; totals to date are not available as this is written. Specimens of each species have also been preserved for our reference collection and are being shipped to Honolulu. Dr. Kuronuma has made available to us some 5000 length-weight measurements on skipjack and 500 sets of measurements of a limited number of morphometric characters. The reliability of these data are in some doubt; a preliminary study of the length-weight data is being made now to (1) examine the question of reliability and (2) to determine the equation of length-weight relationship in order to form a basis of judgement of the value of the extensive racial studies now being conducted by Japanese scientists based on "condition factor" $C = \frac{1000\ W}{L^3}$

COOPERATION WITH NAVAL GOVERNMENT IN THE DEVELOPMENT OF FISHERIES IN THE TRUST TERRITORIES OF THE PACIFIC

In mid-October 1948 the policy for opening the Trust Territories to commercial fishing was promulgated by an order under the provisions of which the Fish and Wildlife Service was designated to advise the Navy on various matters affecting the conservation and regulation of the fisheries. These duties were assigned to the Director, POFI, who delegated the operational aspects to this Section.

At a conference in Washington, D. C. in late October various recommendations were made to the Naval Office of Island Governments as to the sort of statistical reports that should be required of commercial fishing operators. Conferences were held by the Navy at Pearl Harbor on November 5, 9, and 10 and on November 23, 24 and 25 at which recommendations were prepared for the conditions under which commercial fishing by non-indigenous persons might be conducted in the Trust Territories. Mr. Schaefer attended these conferences as an advisor. As a result of the conferences at Pearl Harbor, there were promulgated by the Deputy High Commissioner of the Trust Territories in late January "Terms and conditions applicable to fishing operations in the Trust Territories of the Pacific Islands" which essentially followed the recommendations resulting from the November conferences.

SECTION OF SHELLFISHERIES

CLAM INVESTIGATIONS

John B. Glud, Chief

GENERAL

Public Law No. 556 authorizes and directs the Service to undertake a comprehensive and continuing study of the hard and soft-shell clam fisheries over a period of five years in order to stop the depletion of these valuable natural resources and to restore them to their maximum yield. Work on this project began in October, 1948 .

During October and November a survey of the clam problems in the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut and New Jersey was made.

The results of this survey were used to formulate a program for the investigation which was presented to the Clam Specialists Committee of the Atlantic States Marine Fisheries Commission on December 20.

The Clam Specialists Committee approved the program as presented.

The survey of clam problems along the Atlantic Coast was continued during January, February and March through conferences with industry, state conservation departments and universities in the states of Virginia, North Carolina, South Carolina and Florida. This preliminary survey indicated that development of the commercial fishery, improvement of marketing procedures, exploration of extent of clam beds and development of better fishing methods are important. Basic biological factors concerning clams, such as growth rate, fecundity versus age, salinity and temperature tolerance and effect of predators have never been determined for most of the south. This information must be obtained for efficient regulation of the fishery, especially if it expands greatly.

Four research projects have been established at strategic locations to attack the problems disclosed by the surveys described above. In each case the site was chosen to utilize existing facilities and minimize expenditures.

BOOTHBAY HARBOR, MAINE UNIT

The principal soft shell clam problem in Maine is the management of the commercial fishery to maintain the greatest production without depleting the supply.

Two representative bays have been chosen for pilot plant studies to develop methods for management of Maine's clam resources. The three biologists stationed at Boothbay Harbor have completed the first population

survey in each of these bays and this will be repeated semi-annually. Catch records per man day for the past three years have been obtained from local clam buyers and are being analyzed. Arrangements have been made for obtaining these records from now on from the buyers. Additional studies of growth rate, reproduction, natural and digging mortality have been initiated.

When enough information has been obtained an estimate will be made of the amount of clams which can be removed each year without depletion. This will be compared with actual production and correlated with population trends to establish validity of these methods. These studies will determine the relative effect on the population of natural fluctuations and digging.

Other cooperative projects with Maine Sea and Shore Fisheries Commission include:

(1) Thinning experiment: In many places clams are overcrowded and stunted. This experiment will check growth rates in plots which have been commercially dug to reduce the number of clams in comparison with control plots.

(2) Transplanting experiments will determine at which size clams can best be transplanted and at which time of the year.

(3) Seed gathering experiments. In some places in Maine soft clams set in great numbers with concentrations exceeding 600 per square foot. Various mechanical methods are being tried to remove these one-quarter inch to one inch clams from the ground for transplanting.

(4) Exposure experiments will determine the mortality of clams left on the surface after commercial digging during each part of the year.

(5) Adaptation of clams to laboratory conditions. These tests indicate that clams can be successfully held in tanks at Boothbay Harbor for experimentation.

NEWBURYPORT, MASSACHSETTS UNIT

In Massachusetts soft clams have become so scarce that the usual methods of controlling seasons and catch seem ineffectual in restoring their abundance. Three approaches to this problem are being taken.

(1) Developing methods of private clam farming.
(2) Developing methods of town plantings.
(3) Determining reasons for the present decline in abundance and recommending measures for restoring the fishery.

Parker River Wildlife Refuge has been chosen as a base for soft clam investigations in Massachusetts and New Hampshire and three biologists have been stationed at Newburyport, Massachusetts. Flats have been surveyed to locate areas which will be suitable for experimental clam farming. Three experimental plantings of seed from Sam's Cove, Maine, have been made and winter survival has been satisfactory.

(a) Farming. Seed clams about 1 1/4" in length were obtained from Quincy flats in May and June and planted in twelve experimental beds on Newbury flats. These seed clams were planted by three methods.

(1) Plowing in with a hand plow.
(2) Broadcasting over a bottom previously plowed.
(3) Broadcasting over untouched bottom.

Preliminary observations of clams holes indicate method 3 is just as successful as the other two and is much cheaper.

Various concentrations from 10 to 50 clams per square foot were tried and the effect on growth and production will be determined by future digging.

Cost records of each operation are being kept and will be used to determine the commercial practicability of clam farming.

(b) Town planting methods are being developed through the experiments at Newburyport. Accurate records of cost, survival, and growth of transplanted clams will assist the towns in evaluating their own planting efforts. This part of the work is in close cooperation with the Marine Fisheries Division of the Massachusetts Department of Conservation.

(c) Program for determining reasons for the present decline in abundance. A sampling program has been started to determine clam population by age groups for the flats in Plum Island Sound. Last year's good set will be compared with the extremely low concentration of adult clams to indicate how many spawning clams are required to seed the flats adequately.

Commercial catch records are being obtained to determine production trends as a clue to the reasons for the present scarcity of clams.

Biological investigations of natural mortality, effect and control of predators and diseases, spawning and setting are being undertaken in cooperation with Woods Hole Oceanographic Institution which is conducting similar studies at Barnstable, Massachusetts.

NARRAGANSETT BAY, RHODE ISLAND UNIT

Narragansett Bay has been selected for hard-shell or quahaug investigations in cooperation with Rhode Island State College. Two biologists have been stationed at the State lobster hatchery at Wickford, Rhode Island and are working on the following phases of the problem:

(A) Effect of raking versus power dredging on adult and young quahaugs, setting, and related bottom forms. A serious controversy now exists among the fishermen using each method and between dredgers and the State Conservation Department.

(1) A survey of the bay to select a representative area for test plots has been completed.

(2) Conferences have been held with rakers, dredgers and State Conservation officials and all approve the choice of this location. Rakers are being employed to fish one part of the area. Another part will be dredged with a standard commercial dredge and the third part will be kept as a control plot. Fishing will continue through July, August and part of September and the relative effect of each method will be determined.

(B) Management of the Commercial fishery. It is planned that a portion of Narragansett Bay will be established as a management study area this summer to develop methods for use by the various State Conservation Departments. This project will be similar to the two soft clam management studies in Maine.

(C) Seed quahaugs from natural reporduction. Spawning and setting are being followed to develop methods of catching seed quahaugs which might be used for farming or reseeding of depleted areas.

(D) Quahaug farming will be attempted in experimental areas set aside by the State to develop methods and to determine commercial practicability.

NEW JERSEY UNIT

Through a cooperative agreement two biologists have been employed for the summer to work with Dr. Thurlow Nelson of Rutgers University who is conducting a quahaug investigation on a grant from a commercial company.

One biologist is stationed at Tuckerton, New Jersey where he is exploring methods of obtaining seed quahaugs from natural reproduction.

The other man is located near Cape May, New Jersey and is attempting to determine the food organisms utilized by hard-shell clams.

MILFORD LABORATORY

Part of the clam appropriation was allocated to the Milford Laboratory for studies of artificial propagation of hard and soft clams to supply seed for farming or stocking depleted areas. The progress in this work is described in Dr. Loosanoff's report.

Additional studies of physiological requirements of clam larvae are also under way at this station.

WOODS HOLE, MASSACHUSETTS

Headquarters of the Clam Investigations have been located at Woods Hole pending transfer to Boothbay Harbor, Maine.

Observations on the feeding of soft shell clams has been continued at Woods Hole Oceanographic Institution by John Barlow as a cooperative project with Harvard University. During the summer Mr. Barlow is investigating the effect of different types of bottoms upon setting and early growth of soft shell clams in Barnstable Harbor.

MILFORD SHELLFISH INVESTIGATIONS

V. L. Loosanoff, Chief

STUDIES OF PROPAGATION, GROWTH AND PHYSIOLOGY OF OYSTERS

Gonad Development, Spawning and Setting of Oysters in Long Island Sound

Observations on the gonad development, spawning and setting of oysters in Long Island Sound were carried on throughout the summer of 1948. The results of these observations can be summarized as follows:

The setting season continued from about July 21 to September 22. There were two distinct waves of setting - the first, ending about August 14, had its peak on August 4. The second wave began September 4 and ended September 22 with its peak near September 12. No set was recorded between August 14 and September 4. The second wave was somewhat heavier than the first. In general, the set of 1948 was the second lightest since 1937, being only slightly heavier than that of 1943, which was almost a complete failure.

In addition to the observations in Long Island Sound proper extensive studies on the ecological conditions, spawning of oysters and behavior of their larvae are also conducted in the Thimble Islands region.

Laboratory experiments on inducing gonad development and spawning of oysters in the winter time continued throughout the winter. This work was facilitated to a large extent by installing in the laboratory a warm sea water system which provides the investigators with a supply of water of the temperature needed for condit oning oysters. Oysters in spawning condition were available throughout the winter providing a supply of eggs and sperm when needed.

Studies of Oyster Larvae

Observations on the occurrence and distribution of oyster larvae in Long Island Sound were continued by Loosanoff and Nomejko. The larvae in 1948 were very few in number and those found were mostly in the straight hinge stage. Larvae of early umbo or late umbo stage were virtually absent in the plankton samples. Plankton samples collected over the beds throughout the tidal cycle showed that larvae were always present at all depths showing no tendency to congregate at any definite level.

In the summer of 1949 similar studies have already begun and will be continued throughout the summer at several stations of Long Island Sound and the Thimble Islands.

Cultivation of Oyster Larvae

O. virginica - Development of methods for the cultivation of oyster larvae was continued by Harry C. Davis throughout the entire year. The chief problem was to grow cultures of micro-organisms which could be utilized by larvae of O. virginica as food. Several different organisms, that were small enough to be considered as food of larvae, were isolated in persistent cultures and fed to the larvae but the results were unsatisfactory. Eventually a mixed plankton culture consisting largely of small green forms gave consistently good results and is now used successfully. Larvae receiving this culture grew to the setting stage.

Some cultures of oyster larvae were carried to setting in the middle of winter. At present culturing of oyster larvae to the setting stage is a relatively easy task.

Experiments conducted gave no evidence that light or darkness affected either the rate of growth or intensity of setting of larvae of O. virginica.

O. lurida - A number of cultures of larvae of O. lurida were run to determine whether these larvae are as selective as those of O. virginica in the type of food utilized, and to develop methods of obtaining, handling and feeding of larvae of one of the larviparous oysters preparatory to Dr. Loosanoff's experiments with O. edulis, which will be imported to New England on an experimental basis.

Many cultures of O. lurida larvae were carried to the setting stage. Comparative feeding experiments showed that O. lurida larvae can utilize food that larvae of our oysters cannot. Nevertheless, there is some evidence to show that O. lurida does better on food that is also utilizable by larvae of O. virginica.

While not all of the darkened culture jars gave good set, nevertheless, all the good sets were in darkened jars. In no case did cultures in jars exposed to light give more than comparatively few spat. Additional experiments will be needed, however, to prove definitely that strong light is deleterious to larvae of O. lurida.

Preliminary experiments were also conducted on the effect of temperature on growth and survival of larvae of O. lurida. A culture kept at 21.0°C. set in 10 days from the time of swarming. Most of the cultures kept at 19.0 and 20.0°C. required 12 to 20 days to set. Cultures kept at 17.0 to 18.0°C. did grow and some eyed larvae of 275-300 were seen. However, no set has been observed so far. It is thought that under more favorable conditions set at this temperature will also occur. Larvae kept at 15.0°C. did not show any appreciable growth and were all dead in 20 days.

O. gigas and hybrids of O. gigas and O. virginica - Numerous attempts to cross O. virginica with O. gigas have been made. Hybrid larvae developed quite normally to the straight hinge stage and in some cultures grew a little past that stage. In no case, however, did they reach more than

very early umbo stages. The hybrid cultures generally show very little mortality until the 4th to 6th days at which time the death rate becomes very high and almost all the larvae die in a few days, mortality being complete by the 10th day. Death seems to be due to a combination of inherited factors that prove lethal at this stage of development. Controlled cultures of pure O. gigas and O. virginica kept under the same conditions as hybrid cultures survived and grew normally reaching the setting stage. The results seem to indicate clearly the non-viable nature of hybrid larvae of the two above mentioned species. It is interesting that hybrids of the cross of gigas female and virginica male live usually 2 or 4 days longer than reciprocal growth.

Thus, during the year three species of oysters, O. virginica, O. lurida and O. gigas, were successfully cultured to the setting stage. Of these, cultivation of O. lurida was found to be the easiest. At present cultures of O. virginica are being grown in the large, outdoor concrete tanks.

Growth of Oysters

Studies of the rate of growth and mortality of oysters of the 1945 set brought early in 1946 from the upper region of Chesapeake Bay and grown in Milford Harbor were completed by Loosanoff and Nomejko. These oysters were compared annually against the control consisting of Long Island Sound set of the same age. The final examination of the two groups made at the end of three years, in November 1948, showed that the Chesapeake oysters gave a lower mortality than the Long Island Sound Group. However, the Long Island Sound oysters were somewhat larger than those from Maryland waters. This difference, however, was small. The Chesapeake oysters developed gonads and spawned normally. In general, this experiment showed that Maryland set may be profitably planted in some waters of New England.

A new experiment along the same lines was begun in the fall of 1948. It consists in comparing the rate of survival and rate of growth of oyster set of the same age collected from different geographical regions of the Atlantic Coast to be grown under identical conditions in Milford Harbor. Long Island Sound set of the same age serves as the control. The samples came from Pensacola, Florida, Pamlico Sound, North Carolina, James River, Virginia, Seaside of Virginia, upper section of Chesapeake Bay, Maryland, Cape May, New Jersey, and Wareham River, Massachusetts. The purpose of this experiment is to determine what section along the Atlantic Coast could supply the oyster growers of Long Island Sound with the best seed oysters.

In addition to the purely practical purposes mentioned above this experiment will help determine whether the oysters comprising the different geographical groups are really members of the same or of different races. Thus, besides observations on the growth and mortality of these oysters experiments are conducted to determine some of their important physiological requirements, such as lowest temperature at which they will spawn, and also to find out whether the oysters of different groups could be cross bred with equal ease.

An examination made in the spring of 1949 showed an extremely heavy mortality among the Florida, Carolina and James River oysters. The New Jersey and Massachusetts set, however, survived as well as the Long Island Sound set.

Experiments conducted by Loosanoff and Nomejko during the summer of 1948 showed once more that if the edges of the shells of oysters are broken off, the rate of shell growth of such oysters is more rapid than that of the control. These observations are of practical significance because they indicate that if the shells of the oysters are broken off during dredging or planting operations early in the spring or even in the middle of the summer, the overall size of the oysters may be, at the end of the growing season, just as large as that of the uninjured ones.

Another series of studies was conducted to determine the rate of growth of oysters exposed to different but quite constant temperatures. This was done in the winter time because it is easier then to maintain in the laboratory the desired temperatures merely by mixing definite quantities of cold and warm running sea water. At present, owing to the installation of a warm sea water system in our laboratory, it is possible to obtain in the winter time running sea water within the range from about 0.0 to 35.0°C.

In the middle of February a shipment of 4-year-old oysters, consisting of individuals of approximately the same size, was brought from Long Island Sound and divided at random into four groups each containing 105 oysters. The average length and width of each group was determined and the oysters were then placed in trays with running water the temperature of which was brought up and then steadily maintained at approximately 10.0, 15.0, 20.0, 25.0°C. All the trays received the same quantity of water. Measurements made one month later showed that the 15.0°C. group gave the most rapid growth showing at the end of the month an increase of 9.2 percent in length and 10.8 percent in width. The growth of the oysters kept at 20.0°C. was almost as fast as that of the 15.0°C. group. However, the 25.0°C. group showed a much slower growth than the two above mentioned and the 10.0°C. group showed only a slight increase. The experiments indicate that the optimum range for oyster growth was either confined between 15.0 and 20.0°C. or, what is more probable, extended a degree or two outside these two limits giving a range from approximately 13.0 to 22.0°C.

Another experiment on growth consisted in keeping oysters steadily at a temperature of 25.0°C. At first these oysters grew quite well but later on the growth stopped and they remained in poor condition unable to grow, accumulate glycogen or redevelop gonads, which were discharged during the first month of exposure to the high temperature. This experiment will be continued for several more months.

Behavior of Oysters in Low Salinities

Experiments on behavior of oysters in low salinities were continued by Dr. Loosanoff and Miss Smith. Experiments on the survival in such salinities during periods of high temperature were repeated and corroborated previous observations that at high temperature oysters die much quicker than when the temperature is relatively low (8.0-12.0°). In the winter time some of the oysters exposed to 3.0 p.p.t. and fresh water lived as long as 73 days.

Observations on the growth of oysters in water of different salinities ranging from 3.0 to 27.0 p.p.t. were also repeated. They showed that no growth occurred in salinities lower than 5.0 p.p.t. In 5.0 p.p.t. a slight growth was noticed in one or two individuals. In higher salinities, such as 7.5, 10.0, 12.0 and 15.0 p.p.t. the majority of the oysters grew showing a considerable increase in size.

Observations on gonad development and spawning of oysters in low salinities were completed. In addition to the results already reported it was established that oysters kept in low salinities for several weeks prior to spawning spawned heavily at 10.0, 12.0 and 15.0 p.p.t. and somewhat lighter at 5.0 and 7.5 p.p.t. Fertilization of eggs occurred in all instances.

In another experiment oysters nearing the spawning condition in Long Island Sound were placed in low salinities in the laboratory. Several days later spawning took place in 7.5, 10.0 and 12.0 p.p.t., as well as in higher salinities. During the course of this and the previous experiment the oysters spawned repeatedly. In several instances spawning in low salinity was induced by the addition of sex products.

In still another experiment partially spawned oysters were brought from Long Island Sound and placed in low salinities. They soon began to spawn even in a salinity of 5.0 p.p.t. Both males and females spawned in apparently the normal way. Eggs discharged by oysters taken from different salinites in this and previous experiments were cultured not only in salinities where the eggs were discharged but also in normal sea water to observe their viability, rate of growth and some abnormalities.

Experiments were designed to determine whether oysters of different ages react differently to lower salinites. Running these experiments at a comparatively high temperature, over 20.0°., it was found that in fresh water and a salinity of 3.0 p.p.t. the mortality of oyster spat and adult 4-year-old oysters was about the same. In 5.0 p.p.t., however, more adult oysters survived. These experiments are now being repeated because of the inconclusive results so far obtained.

By using an apparatus devised at Milford Laboratory by means of which it is possible to change the salinity gradually, thus imitating changes in salinity occurring between high and low water stages in tidal basins, observations were made on the rate of pumping and shell movements of oys-

ters accustomed to different salinites. It has been found that oysters taken directly from Long Island Sound, where they are accustomed to a salinity of 27.0 p.p.t., close their shells when the salinity is reduced to about 13.0 p.p.t. and open them again when the salinity is increased from fresh water to about the same strength. On the other hand, oysters conditioned for about three months in 10.0 p.p.t. close their shells only when the salinity drops to 3.0 or 4.0 p.p.t. and open them again as soon as the salinity is increased from fresh water to about 4.0 p.p.t. Oysters conditioned in 7.5 p.p.t. open their shells and begin pumping even at lower salinities than those conditioned in 10.0 p.p.t. These experiments indicate that oysters can be acclimated to lower salinities.

An experiment was conducted to determine the changes in pH and in salinity of shell and body fluids of oysters taken from normal salinity of about 27.0 p.p.t. and then placed and kept during 30 days in running fresh water or in salinity of 3.0, 5.0 or 10.0 p.p.t. Controls were kept in normal sea water. These experiments were conducted at a temperature of about 10.0°C. Samples of shell and body fluids of the oysters from low salinities and those of the control taken at regular intervals showed no significant differences in the values of the pH. A decrease in salinity of the shell and body fluids was most pronounced in the groups kept at 5.0 and 10.0 p.p.t., while in the groups kept in fresh water and 3.0 p.p.t. the salinity of the fluids changed very little. A rapid decrease in salinity of the shell and body fluids of the oysters kept at 10.0 and 5.0 p.p.t. took place because these oysters opened their shells and attempted to feed soon after being placed in low salinities. However, the oysters placed in fresh water and 3.0 p.p.t. remained closed to the very end of the experiment and, therefore, lost very little salt. It is extremely interesting, from a physiological point of view, that the salinity of the shell fluid of the oysters was, as a rule, somewhat higher than that of the fluid obtained directly from the oyster bodies.

Another experiment was devised to determine the rate of increase in salinity of shell and body fluids of oysters kept for 20 days in fresh water, 3.0, 5.0 or 10.0 p.p.t. and then abruptly charged directly to sea water of 27.0 p.p.t. It again showed that at the end of 20 days' exposure of the oysters kept in 5.0 and 10.0 p.p.t. lost more salt than those kept in fresh water or 3.0 p.p.t. However, upon return to normal sea water the salinity of the shell and body fluids of the oysters of all groups returned to normal (that approaching control oysters in sea water) within 24 or 48 hours. These observations, conducted at a temperature of about 10.0°C., demonstrated the ability of oysters to recover rapidly from exposures to low salinities provided the temperature during these exposures is not high.

Another experiment consisted in determing the changes in chemical composition of the meats of oysters kept in different salinities for different periods of time. Samples of the dry meats of these oysters are chemically analyzed. The histological changes in the tissue of the oysters subjected to low salinities are also studied.

In still another experiment oyster spat of last year's set was placed in cold fresh water for periods of 5, 10, 15, 20, 25, 30, 35, 40 and 60 days and then returned directly to running sea water. Although some mortality was noticed after long exposure, probably mostly because of tissue starvation, some of the spat which was returned to normal sea water after 50 days began to feed normally within 20 hours after the transfer, thus indicating the remarkable ability of young oysters to survive under adverse salinity conditions.

An experiment was conducted to determine the effect of low salinities upon oysters which had part of their shells broken off so as to expose their meats directly to the surrounding medium. One group consisted of 50 oysters with broken shells, while the control group had the same number of oysters with whole shells. Both groups were exposed to cold running fresh water. Toward the end of the experiment which lasted 73 days the mortality of the oysters with shells broken off was somewhat higher than the unbroken ones. Nevertheless, the broken off oysters were able to block with their gills and mantles the holes in their shells thus preventing for a long time the entrance of sea water into their shell cavities.

In a recent experiment the oysters were exposed to a flow of water the salinity of which was reduced to approximately 2.0 p.p.t. every two hours. At the end of these intervals the salinity of the shell and body fluids was determined and the chemical composition of the meats analyzed. It was found that changes in the salinity of the shell and body fluids of the oysters very closely followed changes in the salinity of the sea water, thus indicating that such changes probably occur in nature in tidal basins where sharp changes in salinity between high and low water stages exist.

Additional experiments were conducted to determine the changes in the rate of water pumping of oysters when the salinity of the water is either slowly decreased or increased.

A comprehensive report describing the above mentioned observations is in preparation for publication.

NATURAL ENEMIES AND PARASITES OF OYSTERS

Spawning and Setting of Starfish

Observations on spawning and setting of starfish in the oyster-producing section of Long Island Sound conducted by Loosanoff and Nomejko showed that the first set of the season occurred on July 24, 1948 at the 10-foot station of the Milford area. Several days later scattered starfish set was also recorded from the 30-foot depth of the Bridgeport section. From that date light sets were recorded from other sections of the Bridgeport and Milford areas, while the New Haven section showed none. On August 16, however, a light set also took place in New Haven. In all instances the starfish set was extremely light and did not contribute significantly to the starfish population of Long Island Sound.

The semi-annual surveys of the distribution and occurrence of starfish on Connecticut oyster grounds were conducted by the laboratory personnel in October 1948 and in March and April 1949. The fall survey showed that although there were some minor regroupings, the distribution of starfish remained practically the same as in the spring of 1948. However, the number recorded was somewhat larger than last spring.

The spring survey of 1949 showed that the number of starfish found was considerably higher than that of last fall. The increase was due to the large number found along the deepest line of survey, which lies mostly outside the cultivated area. Bulletins were issued to the members of the industry calling their attention once more to the concentration of starfish in certain uncultivated areas which for years have remained the centers from which starfish spread to the cultivated beds. The bulletins also pointed out the practicability of well-conducted efforts in combatting starfish, as demonstrated in the New Haven area, where a well planned program of eradication resulted in either complete elimination or a great reduction in their numbers.

Boring Sponge

Work on the biology of the boring sponge of the genus Cliona is continued at Milford Laboratory by Willard Hartman of Yale University. At present the work largely consists in studying the effect of ecological factors in the propagation of Cliona. Other aspects of this study have already been reported.

Crabs

Once more it was found that many species of crabs living in our waters are serious enemies of our oysters, especially of young ones. It was observed that the rock crab, Cancer irroratus, and the green crab, Carcinides maenas, were cracking the shells and devouring oyster set measuring from 1 to 3 cms. in length.

COMMERCIAL MOLLUSKS OTHER THAN OYSTERS

Many groups of clams, Venus mercenaria, were conditioned by Loosanoff, Davis and Miller to spawn in the winter time under laboratory conditions. The method of conditioning has already been described in the report given at the last convention of the National Shellfisheries Association and, therefore, need not be repeated here.

Numerous cultures of Venus mercenaria, Mya arenaria and Mactra solidissima were grown to the setting stage. In general, cultivation of clam larvae was found to be easier than that of O. virginica, which is rather selective in its feeding habits being unable to assimilate many ultraplankton forms. A very complete series of microphotographs showing different stages of larval and post-larval development of these three species

of clams has been made, and some have already been distributed among the members of the group working on commercial species of clams. At present many thousands of Venus cultured in this laboratory from eggs are available and some will be sent to Dr. Thurlow Nelson of Rutgers University for growth studies of the early stages of Venus. Numerous observations were made on the physiological and ecological character in connection with cultivation of the larvae of the three species. Culturing of clam larvae in large, outdoor concrete tanks is now in progress.

The method developed makes cultivation of clam larvae to the setting stage a comparatively easy matter. By following a few simple principles mature sperm and eggs of V. mercenaria, and perhaps other clams, can now be obtained on almost a year-round basis and the resulting larvae can be grown to the setting stage even in the middle of winter.

REPORTS

The following papers were presented at the National Shellfisheries Association Convention:

DAVIS, H. C. On the culture of oyster larvae in the laboratory.

LOOSANOFF, V. L. Variations in intensity of setting of oysters in Long Island Sound.

LOOSANOFF, V. L. and H. C. DAVIS. Spawning of quahaugs in winter and culture of their larvae in the laboratory.

In addition to papers published during the fiscal year, the following were prepared for publication:

LOOSANOFF, V. L. On food selectivity of oysters. Accepted for publication.

LOOSANOFF, V. L. Method for supplying the laboratory with warm sea water in the winter time. Accepted for publication.

LOOSANOFF, V. L. and C. A. NOMEJKO. Growth of oysters, O. virginica, during different months. Accepted for publication.

The following manuscript has been submitted to Dr. Walford for criticism and suggestions:

LOOSANOFF, V. L. and C. A. NOMEJKO. Spawning and setting of American oyster O. virginica, in relation to lunar phases.

CHESAPEAKE BAY SHELLFISHERY INVESTIGATIONS

W. A. Chipman, Chief

GENERAL

A survey was made by Walter A. Chipman and Paul E. Thompson of the oysters and oyster resources of the Virgin Islands and of Puerto Rico. In the Virgin Islands all of the coastal areas of the islands of St. John, St. Croix, and St. Thomas were carefully surveyed and the most likely locations for oyster culture examined in considerable detail. Besides the coastal waters of Puerto Rico proper, the survey included the island of Vieques. Observations were made of the temperature, pH, and salinity of the water, the type and nature of the bottom, and the ecology of the shallow water areas with collection and study of the lamellibranch mollusks and the organisms directly associated with them.

The great majority of the oysters of the islands were found to be Ostrea rhizophorae Guilding. Many were found with characteristics which very closely resembled those of Ostrea virginica of the United States. The larviparous oyster, Ostrea cristata Born, is present and was collected in Hurricane Hole on St. John.

Some individuals of the common oyster were found with ripe gonads and there were oyster larvae in the water samples collected with the fine net. Other oysters were unripe, or partly ripe. There is no question but what individuals may be found throughout the year with ripe gonads and that spawning takes place at all months of the year.

There was no evidence of shell damage from the marine worm, Polydora. This may be explained by the attachment of the oysters to the vertical roots of the mangroves off the bottom. Examination of the mantle margin of fresh specimens microscopically for the presence of the encysted spores of the gregarine Nematopsis, showed that this parasite was absent in the oysters examined.

There is the possibility that the clam Chione pubera may be utilized as a shellfish food to a greater extent for it is plentiful in a number of localities.

Although the small oyster, Ostrea rhizophorae, is marketed to some extent in Puerto Rico, there is very little in the way of an oyster industry. The extremely high salinity of the water (33 to 38 parts per thousand) and the lack of suitable areas for oyster culture will necessarily limit the possibilities of production of oysters in any great amount. Examination of the waters and coastal areas allowed the formation of a plan for experimental oyster plantings with an introduced species which may lead to the development of a suitable market oyster in sufficient quantities to supply the needs of these islands.

Mr. Engle was assigned as technical advisor to the Commission of Conservation of Natural Resources appointed by the Governor of Maryland, and known as the Bowman Commission. The Commission reviewed the programs of the State departments concerned with conservation and proposed changes in the existing methods and procedures which, in its opinion, would protect and further conserve the State's natural resources. A report, embodying the Commission's recommendations, was submitted to the Governor of Maryland on December 1, 1948. Mr. Engle prepared a series of memoranda on oyster biology and management much of which was incorporated in the above report.

A similar service was rendered the Virginia Fishery Advisory Council by Mr. Engle in its program to improve and enlarge the oyster rehabilitation activities of the State of Virginia.

Dr. Chipman was detailed to Oak Ridge, Tennessee, for a month's schooling at the Oak Ridge Institute of Nuclear Studies. It is anticipated that the use of radioisotopes will be of great value in studying the biology of oysters and other marine invertebrates. Plans are being made for physiological studies using these isotopes as tracers.

At the invitation of the Government of Venezuela made through the Department of State the office of foreign activities of the Service detailed Dr. Galtsoff to Venezuela to make a survey of the pearl oyster grounds around Margarita Island, to advise the Government regarding the present status of the fishery and, if necessary, to suggest the changes in the present system of management of the fishery.

After visiting the principal pearl ground, inspecting the fishing methods and the sale of pearls P. S. Galtsoff summarized his observations in a report entitled "The Pearl Fishery in Venezuela" which was submitted to the Director of the Service in two authentic texts--English and Spanish. The report traces the history of pearl fishery in Venezuela from the beginning of the 16th century to present days. The present state of pearl oyster grounds indicates that under the existing control measures--i. e. closed season, system of licenses, and regulation of gear, the yield of the fishery may be indefinitely maintained on the existing low level. Frequent interruptions of fishery for one or more seasons, which are necessary to ensure a satisfactory recovery of pearl oyster population after a period of intensive fishing, constitute a serious drawback to Venezuelan pearl industry. Under such conditions oyster fishermen are forced to abandon their occupation and to make their living by some other means. Consequently the number of divers in Venezuela gradually decreases and young generation is reluctant to enter this field of endeavor. The report recommends an initiation of field and laboratory studies of the propagation, development, growth and ecology of oyster for the purpose of formulating a program of oyster farming which would permit more intensive exploitation of latent pearl oyster resources.

At the request of the Government of Panama, Dr. Galtsoff made in February-March, 1948, extensive explorations of the existing pearl oyster grounds along the Pacific coast of Panama. The expedition, organized by the Panamanian Government, covered over 1200 miles in the Gulf of Panama,

primarily around Pearl Islands, and in the Gulf of Chiriqui. Hydrographic and biological observations were made with the view of determining the cause of almost complete disappearance of pearl oysters from these waters.

By using scaphander divers, observations were made at 30 different places, at the depths varying from 4 to 16 fathoms. Shallow water and tidal zone were explored by using small dredges and by collecting the animals at low water. The number of pearl oysters at all stations was so small that no commercial pearl fishery is at present possible. Few live specimens of very young and adult oysters which were collected by divers were examined microscopically and found to be in every respect normal and healthy. There were no indications of depradation by oyster enemies which might have explained the depletion of oyster grounds. Likewise, no evidence was found that oysters perished because of the "red tide" or were killed by some unknown poison dumped into the water. From these observations, and from a study of the method of fishery and analysis of statistical records conclusion is drawn that the depletion of pearl oyster grounds is due to overfishing. For many years, the pearl fishery of Panama was conducted without any restrictions and supervision. As a matter of fact the first depletion of grounds occurred soon after the discovery of Pearl Islands by Balboa and the depleted grounds were abandoned by Spaniards as unprofitable to fish. Recovery was slow and required several decades. In view of the fact that at present live pearl oysters with ripe gonads can still be found in Panamanian waters, it is believed that the grounds may recover again if pearl fishing is completely prohibited for several years.

DISTRIBUTION OF NEMATOPSIS

Nematopsis is a protozoan parasite of the order Gregarina; its cysts are frequently found in the tissues of oysters growing in southern waters. In the majority of cases so far recorded, the number of cysts in the oyster is small but occasionally very heavily infected specimens are found containing many thousands of spores per each square centimeter of tissue. The occurrence of cysts in the oyster lead to belief, maintained by some investigators, that this protozoan parasite may cause heavy mortality among oysters. The work, carried out jointly by Dr. Galtsoff and Miss Helen Landau, consisted in making a careful check of the distribution of Nematopsis in the Chesapeake Bay with special reference to the conditions of oysters. Futhermore, other observations made by the Service and various State organizations in New York, Delaware, Virginia, Florida, Louisiana, and Texas were summarized. From all the data so far observed conclusion was drawn that the occurrence and the intensity of Nematopsis infection are not correlated with the conditions of oysters or their mortalities. A manuscript was submitted for publication.

ECOLOGY OF OYSTER BOTTOMS IN THE CHESAPEAKE BAY

Observations were made throughout the year of the salinity and temperature of the waters over the various oyster beds in the upper Chesapeake Bay area. The information obtained this year is part of a continuing program to explain the importance of these factors in

controlling the oyster populations of the upper Chesapeake Bay and the condition of the oysters for growth and reproduction and for marketing.

Correlation of the chemical and physical factors of the environment with the abundance of plankton, the chemical composition of the oyster meats, and the development of spawn and the distribution and survival of the oyster larvae will be made from the accumulated data.

A comparison of the seasonal cycle of accululated glycogen reserve in the oysters of different beds showed a slight but consistent difference between the oysters of two different locations. In the summer of 1948 the glycogen content of the oysters of one station, which had remained consistently lower than the other, was found to be higher. Measurement of the thickness of the gonads of the oysters showed that the oysters showing the greater decrease in glycogen had produced the greatest amount of spawn. The oysters having less glycogen during the winter produced less spawn and the decrease in their glycogen content was less marked. The greater drop in glycogen content of those oysters having originally a higher amount, which caused a crossing over of the curves of the seasonal glycogen content of the two groups of oysters, apparently can be directly correlated with the activities of spawn production.

Detailed observations on the effect of fishing intensity on the oyster population of an oyster bar has been made possible this year. An oyster bar, depleted by freshets in 1945 and 1946, was planted with seed oysters in 1947, 1948 and 1949. Those planted in 1947 were, in a large measure, harvested during the past oyster season (1948-49). Only small numbers of small oysters planted in 1947, culled to meet the three-inch size requirement of the law regulating the taking of market oysters, remained. The oysters of the 1948 and 1949 plantings, many of them approaching marketable size, will be gathered and culled for market oysters in the season 1949-50. The population of oysters was surveyed in May of 1949. The harvesting record of this season will be gathered from the fishermen through special arrangements made possible this year. The natural replacement by reproduction, the normal mortality, and the increase by growth will be studied. The setting of oysters started in this area at the end of June. The increment added to the population by this natural reproduction will determine to a large extent the amount of replacement by seed planting necessary to maintain an oyster population sufficient to meet the needs of the industry of the area.

SPAWNING AND SETTING OF OYSTERS IN THE CHESAPEAKE BAY

In the spawning season of 1948, the first evidence of spawning of the oysters in the Chesapeake Bay was observed on June 8. The greatest activity occurred during the latter part of June. During the remainder of the season, only limited spawning of oysters was seen except for a minor increase the last week of August.

In the summer of 1948 the distribution of oyster larvae and oyster set in the Eastern Bay section of the Chesapeake Bay, one of the most important seed-producing areas, was not uniform. The pattern followed that observed in previous years. One section of this bay being developed by the State of Maryland as a seed-producing area is one of the locations consistently low in the number of oyster larvae and oyster set. Because of this fact, recommendation was made and followed that the State shift its seed-producing activities to areas consistent with the best setting potentialities. Studies were made of the relation of tidal currents in the movements and distribution of the oyster larvae.

Observations were made of the possibilities of using Lake Ogleton, an arm of the Chesapeake Bay that is nearly land-locked, as an oyster-seed producing area to supply the needs of the private oyster planters of Maryland. Spawning took place in the oysters planted for a spawning stock. There appeared to be no distinctive pattern of distribution of the oyster larvae in this body of water. Setting on the experimental shell bags placed throughout the area was irregular and light. The failure to secure a good oyster set may be indicative that this body of water does not have promise as a seed-producing area.

Observations on the extent of oyster setting at various depths of water were made at different locations in the Chesapeake Bay. The results, as observed on the spat collectors placed in Eastern Bay, showed the heaviest setting took place close to the bottom. In 15 feet of water there was an average on the bottom of 9.9 spat on 20 shells; at eight feet, 3.3; and close to the surface, 0.9.

During October and November of 1948, the investigators of the Service cooperated with the Department of Tidewater Fisheries and the Department of Research and Education of Maryland in a widespread survey of the oyster conditions throughout the tidewater section. Examination of the bars in the Bay proper, as well as some of the tributaries, such as Choptank, Chester, Potomac, and West River, showed a very limited set of oysters in 1948. Other areas, such as Tangier Sound, Pocomoke Sound, Fishing Bay, Eastern Bay, Broad Neck, Harris Creek, Miles River, Honga River, Little Choptank River, and some tributaries of the Potomac River, had adequate setting for replacement of the oysters taken in oystering activities.

Oysters of marketable size were scarce on most of the bars of the Bay proper. Tangier Sound, Fishing and Eastern Bays, and tributaries of the Potomac and Choptank River had the greater part of the market supply for the year, which should approximate the harvest of 1947. Scarcity of small oysters on most of the Maryland oyster bars may forecast a reduced harvest for 1949-50.

For the setting season of oysters in 1949, spat collectors were placed at various locations in the Chesapeake Bay and have been examined regularly since June 10, when the condition of the oysters indicated spawning had started and oyster larvae were present in the plankton samples. A small amount of setting was taking place at the end of June, but the peak of oyster setting should not be expected until the middle of July.

A heavy and unseasonal setting of barnacles was in progress in the Chesapeake Bay proper during the latter part of June. Normally this fouling organism has a setting period early in May in this area. This barnacle set may have considerable significance on the production of oyster seed in this area from fouling of the shell plantings of the State. Other fouling organisms, with the exception of Bryozoa, have been relatively scarce on the shells used for oyster spat collecting by the Service investigators.

IMPROVEMENT OF THE QUALITY OF OYSTERS GROWN

Since the quality of oysters depends to a great extent on the accumulation of reserve carbohydrate in the form of glycogen, observations were continued on the changes in this material as correlated with seasonal changes and with various physiological processes and conditions.

Utilization of glycogen reserves varied in rate in individual oysters and was definitely associated with the reproductive cycle. The two sexes showed no significant differences in the amount or time of depletion of this reserve material in the few samples examined.

Changes in the glycogen content of the various tissues of the oyster followed the same pattern as that of the total oyster meat. Depletion of the glycogen of the gonads, however, was seen to take place at a faster rate than in the other tissues which accumulate a significant carbohydrate reserve. Also, the accumulation of glycogen in the fall takes place earlier in the gonad tissue. There apparently is a direct connection between the amount of glycogen accumulated and utilized and the amount of gamete material formed.

Conversion of the glycogen to other materials was studied. Experiments were undertaken on the changes in the various carbohydrates and hexose sugars and of lipids in the oyster tissues.

EFFECTS OF POLLUTION ON SHELLFISH

Experiments were performed to ascertain the effects on the setting of oysters of treatment of oyster shells used as cultch with solutions of DDT. Untreated shells for a short time were relatively free of fouling organisms and caught a good set of oysters. Later, these shells became badly fouled and the catch was poor. Shells treated with DDT were less fouled than untreated shells even after long periods of exposure. Treated shells caught less oyster spat during the first three weeks but, after this time in the water, the treated shells equaled untreated shells and later surpassed them in ability to catch an oyster set.

The danger from fires that may occur when oil slicks are present in various harbors and ships and docks is very great. Numerous means of removal of such slicks have been tried and used; one of the most efficient, a method developed by the U. S. Navy at the Norfolk Shipyard, is the spraying of the oil slick with fine sand which has been previously coated with a layer of carbon. The oil immediately clumps around the sand and sinks to the bottom where it remains permanently anchored.

At the request of the U. S. Navy, numerous experiments were performed on the toxicity of the carbonized sand and oil combination for various aquatic animals. Observations were made also of the activities of oysters, particularly on the rate of pumping of water. It was determined that oil and oil mixed with carbonized sand and present in sea water in relatively strong concentrations reduced the water filtration rate of oysters. Long time exposure to weaker concentrations, tested at Woods Hole, also produced a reduction in the amount of water pumped by oysters.

The toxicity experiments performed at the Woods Hole laboratory using oils and oils mixed with carbonized sand were carried on with various species of animals that characteristically grow in environments in estuaries and harbors and around docks and structures where oil pollution is most apt to occur. These included the hydroid Tubularia, barnacles, hard-shell clams, oysters, and toad-fish embryos.

The results showed that oils added to sea water produced toxic environments to the animals tested. The toxicity varied with the nature of the oil used, its concentration, and the sensitiveness of the species of animal employed in the test. Oils anchored on the bottom by carbonized sand were slightly less injurious, but poisonous materials leached out of the anchored oil in considerable amount.

Although oil treated with carbonized sand continues to release toxic materials while anchored on the bottom, it is considered unlikely that concentrations dangerous to the aquatic life of estuaries and harbors may result from the normal operation of removal of oil slicks. In the few instances when great concentration may occur, the toxicity would be limited to relatively restricted areas of harbors where conditions of environment are such that very little aquatic life exists. Of value in preventing damage to animals in this method of removal of oil slicks is the anchoring of the oil permanently, or until destruction and disintegration is completed, in such biologically unimportant areas and preventing its movement to other places where great damage may occur.

GULF OYSTER INVESTIGATIONS
Philip A. Butler, Chief

INVESTIGATIONS CONCERNING BONNET CARRE SPILLWAY AREA

Mississippi Sound Area

During the period April-June, the field surveys to determine the present status of the oyster reefs in the west end of Mississippi Sound were completed. Until the third week in April, both top and bottom water samples at the established stations showed salinities of less than 1 ppt. Turbidity readings ranged from a low 23 percent transmission of light at the station nearest the entrance of the Pearl River into the Sound, to a maximum of 71 percent in one of the sheltered bays which is not exposed to wave action. Water samples ranged in pH from 6.9 to 7.1. At this time, none of the oysters examined was feeding, the meats were still transparent but in a few there were traces of gonad development. At each station there was still some recent mortality.

By the end of May, salinities at all stations had increased significantly and there was an accompanying decrease in turbidity. Oysters were feeding actively, showed an average of 5 mm of new shell and many contained some ripe spawn. Mortality in the experimental cages had decreased to less than 8 percent at all stations. Hydrographic conditions were suitable for normal growth of oysters and presumably will continue so during the summer months.

The survey was also completed on the more easterly located oyster reefs in Mississippi Sound. These beds were only partially destroyed during the floods of 1945 but were seriously damaged again in the hurricane of 1947. The spring intrusion of fresh water in this region had been dissipated by the end of May and salinities on the deeper bars approached 18 ppt. In two areas drills, Thais, and drill egg cases were recovered in the dredge sample. All bars having any cultch at all showed an extremely heavy spatfall, hundreds per shell, which apparently set in the period May 20-25.

Lake Mechant - Deer Bayou Area

The conditions for oyster growth in this area continued good and in April, oysters at the established stations had experienced a negligible mortality. The oysters showed moderate amounts of new shell and many contained ripe gonads. Salinities in the lake averaged 6.5 ppt but in the smaller bayous were still less than 1 ppt. Turbidity readings were highest in the areas of low salinity while the water was relatively clear in the lake proper.

The general picture obtained on these surveys in the period from November 1948 until May 1949 is a rather typical one which could have been predicted on the basis of our existing knowledge of oyster ecology. The mortality, poor growth, poor or retarded gonad development, high turbidity, low salinity, found on the various reefs are in all probability quite normal for the areas. The importance of these factors in so far as oyster production is concerned will depend from year to year on the magnitude and duration of the spring floods.

The analyses of the field data collected during the past seven months have been completed and the final report is now being prepared.

PARTICIPATION IN THE OYSTER PROGRAM OF THE GULF STATES

Alabama. Two survey trips were made in Alabama in the past quarter. The first one in April was done at the joint request of the Mobile County Wildlife and Conservation Association and the State Conservation Department. This survey was an attempt to estimate the possible harm being done to oyster reefs by the operation of commercial suction dredges which are removing buried shell from Mobile Bay. Public opinion had been aroused by the assumption that productive reefs were being destroyed. A report was made to the Conservation Department recommending that the dredging be allowed to continue because it was being done in an area of negligible oyster production. In addition, taxes on the operations were producing substantial revenues to the Conservation Department. These funds have made possible in the past two years a greatly expanded shellfish research and conservation program without imposing a tax on the citizens at large.

The second survey was undertaken to determine the condition of seed oysters which the state had transplanted two months earlier. On all of the plantings evidence of dredge damage was negligible, the seed oysters were growing well and accumulating spawn. There should be an excellent harvest from the state planted public reefs in Alabama during the next two years.

Florida. Preparations have been completed for the survey of East Bay at Pensacola, Florida. Spat collectors and trays of seed oysters are being located throughout this bay for the determination of possible seed and/or growing areas. Stations have been established for the regular collection of hydrographic and plankton samples, and it is planned that by next spring sufficient data will have been collected so that we may advise the state intelligently regarding its shell planting program in the bay.

Mississippi. One survey trip was made in May with members of the State Seafoods Commission. Six of the more important reefs were sampled for determinations of oyster quality, spat fall and harvesting possibilities. In general the bars are well populated with small oysters which may be harvested this fall and next spring. The percentage of marketable oysters

is small at present and much of the stock is so badly clustered that it will be suitable only for the steam oyster trade. The heavy and widespread spatfall which occurred in May was to a large extent wasted because of the small amount of suitable cultch present on the reefs.

In the past eight months of operation at the laboratory there has been an average of one field survey per month requested by the states of Louisiana, Mississippi, Alabama and Florida. In general all of these surveys were for the purpose of selecting seed areas, estimating spat fall and the effects of transplanting of seed oysters. This is indicative of the increasing trend along the Gulf Coast to emphasize the culturing of oysters and to place less reliance on the natural reproductivity of the oyster reefs.

PENSACOLA LABORATORY

A majority of the work in the past eight months has been concerned with field work in connection with the Bonnet Carre Spillway problem. However, certain basic investigations have been initiated and the collection of seasonal data on the ecology of oysters and the hydrography of this area has been systematized.

Oyster Parasites. In the course of investigations of oysters from various reefs along the Gulf Coast numerous instances of parasitism by a small astomatous ciliate have been found. In the Pensacola area heavy infestations of this ciliate appear to be correlated with a failure in shell growth on the part of the oyster. Histological examinations of oysters in conjunction with studies on growth rate have been carried on for the past three months in an attempt to determine whether or not this parasitism is the primary agent in inhibiting shell growth. Approximately five percent of the oysters held in trays at the laboratory fail to put on new growth. In the first series of twenty of these oysters which have been studied histologically, less than half were heavily infected with the ciliate parasite. The remainder, however, had significantly higher concentrations of spirochaetes and Nematopsis spores in the tissues than did oysters growing at the average rates. It is assumed that a combination of one or more of these parasites may be significant factor in low growth rates of a segment of the oyster population in this area at least. Efforts are being directed at the present time to reduce growth rates in oysters by experimental infection with the ciliate.

Mortalities in the trays of oysters suspended from the laboratory docks have been traced in numerous instances to the activities of mud crabs of the family Xanthidae. These mud crabs appear in the trays within a week following immersion of the trays in the water and at times they number as high as one per five oysters in the tray. They kill the oysters, primarily, by chipping away the soft new shell at the growing edge of the bill in the same manner as the large blue crab. Despite the small size of the crabs, mostly one-half inch in length, they are quite successful in killing the market size oysters.

Oyster Conch, Thais. Studies on the biology of this predator have been carried on during the winter months and the food requirements of mature conchs in terms of oyster meats have been ascertained. Under optimum conditions in the laboratory, mature conchs consumed an average of 5.4 market size oysters per thirty day period. In most instances, the greater the ratio of oysters to conchs in the aquarium, the more oysters were consumed. These conchs prefer barnacles and mussels of oysters and stopped feeding when water temperatures dropped below 12°C. At the present time observations are being made on the embryology and early development of the snails in an effort to devise methods of control. Egg cases were deposited in laboratory aquaria regularly in the period April through early June. Since the 25th of June when water temperatures were averaging 30°C or more, eggs have not been laid. No new egg cases have been found on the oyster reefs near Pensacola since the first week in June. Incubation period for the larvae varies 12 to 16 days at an average temperature of 25°C. Seven snails, whose egg capsules were identified and maintained until the hatching stage, produced in excess of 400,000 off-spring per snail in a two months period. This tremendous reproductivity indicates the desirability for instigating control measures in the period prior to egg deposition in order to be most effective.

Oyster Growth. Periodic measurements of the length and breadth of samples of oysters kept in trays suspended from the laboratory docks have been made since last October. It is hoped that these data will provide some of the background material for understanding the activity of oysters in this area. Approximately a thousand oysters divided into different size groups and collected from different geographic areas are included in this series. The linear growth data of one of the samples is given to show the average amount of shell deposition in the past eight months. This sample of 150 oysters, first measured October 22, 1948, has had a mortality of less than 10 percent to date. Some of this mortality was caused by mud crabs and it is believed that the remainder was due to internal parasites.

Linear Growth of 1948 Spat

Date Measured	Oct 22	Nov 29	Jan 14	Mar 2	May 6	June 7
Av. Length MMs	19.6	27.2	30.9	38.6	46.5	47.2
Av. Water T°C	-	-	16.5	17.4	26.6	28.8

A second series of growth measurements made on spat which set in a six hour period on May 20th is of interest in comparison with last year's spat shown above. This sample of 75 spat which measured slightly less than one-half mm in average length on May 20 had increased to an average length of 17 mm six weeks later and a maximum of 22 mm. During this same time interval, the average increase in length for the year old oysters had been approximately one mm.

Oyster Setting Rate. The seasonal distribution of oyster setting in the laboratory area is being recorded by the use of artifical collectors. These are made of thin asbestos cement squares having one hundred square centimeters of exposed surface on each side. One side is smooth and the

other is of a slightly waffled texture; the plates are held in the water in both horizontal and vertical positions. The regularity of the surfaces has permitted an analysis of the number of setting organisms in terms of square centimeters. Plates are exposed for seven day intervals and at the time of renewing them, one hundred liter water samples are filtered for plankton analyses. The fouling plates are now routinely suspended midway from the bottom in 12 feet water; plates located at the bottom, midway and at the surface on three weekly exposure periods showed no significant setting differential. Horizontally placed plates consistently attract more setting organisms than vertical plates, but there has been no consistent preference on the part of the organisms to set on either the smooth or textured surface of the plates. In preliminary exposures, these plates attracted approximately 10 percent more organisms than did clean oyster shells suspended at the same location.

Hydrographic Data. Through the efforts of station personnel and cooperating agencies, the following records are being maintained at the Pensacola Laboratory: tidal range, continuous water temperature, salinity at two hour intervals, daily phosphate and nitrate concentrations, pH and oxygen tension. One result of the regular collection of such data has been to demonstrate the wide daily fluctuations which may occur in the character of the laboratory water. The water system is of the continuous pumping type without a standing tank. Salinity at one time may be 25 ppt for example, and six hours later may have decreased to 13 ppt. Such radical changes are the exception, however, rather than the rule. The fluctuations in water quality while basically due to tidal flow are unpredictable because of the importance of the wind in regulating water movement in Santa Rosa Sound.

ICHTHYOLOGICAL LABORATORY

George S. Myers, Acting Chief

The routine duties of the laboratory, such as answering inquiries (or directing the inquiry to the proper source), keeping records, typing reports and correspondence, were attended to promptly by Mrs. Green and Mr. Ginsburg.

A drawing of Eucinostomus pallidus and two fingures of dorsal fins (enlarged), one of this species and one of E. argenteus, were completed by Mrs. Green. The entire manuscript on the supplement to "The Marine Fishes of Panama" was carefully looked over and put in systematic order. Lists of the families in the supplement and the illustrations to be used were compiled.

On May 23rd all the offices in the Division of Fishes were rearranged and now the Fishery Biology unit stationed in the Museum is located in one room (71). Several days were spent in putting our room in order.

The galley proof of a paper, "A Collection of Fishes from Talara, Peru" by Hildebrand and Barton, was received and proof read by Mrs. Green. This will appear in the Smithsonian Miscellaneous Collection.

Mr. Ginsburg spent two weeks on the Albatross III, which was making a survey off the coast of the Carolinas, for the purpose of identifying the fish taken in the trawls. Some interesting observations were made during this survey. A considerable number of large groupers were taken, averaging about 3 feet in length, most of which were the red grouper, Epinephelus morio. This would perhaps indicate the possibility of establishing a fishery for groupers in moderately deep water off the coast. Two large specimens of red snapper, Lutianus blackfordii were taken, and a number of specimens, averaging about a foot, of another snapper, Rhomboplites aurorubens, were also captured. Another surprising capture was some specimens of Scorpaena tertugae (tentative indentification) of about 20 inches in length. The latter species has been only recently described, was known from only a few specimens and was not known to reach that large a size.

A taxonomic study of the searobins, family Triglidae, was begun. The taxonomy of this family was found to be in a chaotic state, more so than that of other families of Gulf species heretofore studied. In order to place the Gulf species on a sound taxonomic basis, it was found necessary to revise all the species of this family that occur in the western Atlantic. So far 11 Gulf species have been tentatively distinguished. Two of these seem to differ subspecifically from the corresponding populations on the Atlantic coast of the United States. The study of this family is being continued.

PUBLICATIONS, FISCAL YEAR 1949

Articles published in outlets other than Bulletins, Special Scientific Reports, or Leaflets

Eicher, G. J., Jr.
1949. Localized weed control in management of game fish Trans. Am. Fish. Soc., Vol. 76, pp. 177-182.

Gjullin, C. M., O. B. Cope, B. F. Cuisenberry, and F. R. Duchanois
1949 "The effect of some insecticides on blackfly larvae in Alaskan streams." Journal of Economic Entomology, Vol. 42, No. 1, pp. 100-105.

Gutsell, J. S.
1948. The value of certain drugs, especially sulfa drugs in the treatment of furunculosis in brook trout, Salvelinus fontinalis. Trans. Amer. Fish. Soc., Vol. 75, pp. 186-199.

Gutsell, J. S. and S. F. Snieszko
1948. Furunculosis in fish; its diagnosis and treatment. Vet. Medicine, Vol. 43, pp. 484-486.

Gutsell, J. S. and S. F. Snieszko
1949. Dosage of sulfamerazine in the treatment of furunculosis in brook trout, Salvelinus fontinalis. Trans. Amer. Fish. Soc., Vol. 76, pp. 82-96.

Hile, Ralph
1948. Standardization of methods of expressing lengths and weights of fish. Trans. Am. Fish. Soc., Vol. 75. pp. 157-164.

Hile, Ralph
1949. Trends in the lake trout fishery of Lake Huron through 1946. Trans. Am. Fish. Soc., Vol. 76, pp 121-147.

Hoffman, C. H. and E. W. Surber
1948. Effects of an aerial application of wettable DDT on fish and fish-food organisms in Back Creek, West Virginia. Trans. Am. Fish. Soc., Vol. 75, pp. 48-58.

Jobes, F. W.
1949. The age, growth and bethymetric distribution of the bloater Leucichthys hoyi (Gill) in Lake Michigan. Pap. Mich. Acad. Sci. Art. & Lett, Vol. 33, pp. 135-172.

Jobes, F. W.
1949. The age, growth and distribution of the longjaw cisco, Leucichthys alpenae Koelz. in Lake Michigan. Trans. Am. Fish. Soc., Vol. 76, pp. 215-247.

Loosanoff, V. L.
1949. Survival, feeding and growth of oysters, O. virginica, in low salinities. Anat. Rec., Vol. 101, No. 4, p. 55.

Loosanoff, V. L.
1949. Gonad development and spawning of oysters, O. virginica, in low salinities. Anat. Rec., Vol. 101, No. 4, p. 55.

Moffett, James W.
1949. "The first four years of king salmon maintenance below Shasta Dam, Sacramento River, California." California Fish and Game, Vol. 35, No. 2, pp. 77-102.

Phillips, A. M., Jr.
1949. The vitamin B requirement of trout. Trans. Am. Fish. Soc., Vol. 76, pp. 34-45.

Royce, William F.
1949. The Albatross III. Official Year Book of the Fishing Masters' Associati n, 1948, pp. 13-19.

Rounsefell, G. A.
1949. Methods of estimating total runs and escapements of salmon. Biometrics, Vol. 5, No. 2, pp. 115-126.

Rounsefell, G. A. and L. H. Bond
1949. Salmon restoration in Maine. Atl. Sea-Run Sal. Comm., Res. Rept. No. 1, 52 pp.

Scattergood, Leslie W.
1949. Notes on the little piked whale. Murrelet, Vol. 30, No. 1, 1949, pp. 3-16.

1949. Notes on the Maine shark fisher. Copeia, 1949, No. 1, pp. 69-71.

Schaefer, M. B.
1948. Spawning of Pacific tunas and its implications to the welfare of the Pacific tuna fisheries. Trans. 13th N. A. Wildlife Conference pp. 365-371.

Schaefer, M. B.
1949. The employment of marked members in the estimation of animal populations. (Presented at Institute of Mathematical Statistics, Seattle, Nov. 27, 1948. Abstract published in Annals of Mathematical Statistics, Vol. 20)

Schaefer, M. B. and John C. Marr
1948. Juvenile Euthynnus lineatus and Auxis thazard from the Pacific Ocean off Central American. Pacific Science, Vol. 2, No. 4, pp. 262-271.

Schuck, Howard A.
1948. Current haddock situation on Georges Bank. U. S. Fish & Wildlife Service, Commercial Fisheries Review, Vol. 10, No. 10, pp. 1-6, Sep. No. 217.

Silliman, R. P.
1949. Some problems in fishery research to which statistical methods are applicable. (Presented at Institute of Mathematical Statistics, Seattle, Nov. 27, 1948. Abstract published in Annals of Mathematical Statistics, Vol. 20)

Snieszko, S. F.
1949. Experimental Fish troughs. The Progressive Fish-Culturist, Vol. 11, No. 1, pp. 79-81.

Snieszko, S. F.
1949. Pyridylmercuric acetate technical: Its use in control of gill disease and some external parasitic infestations. The Progressive Fish-Culturist, Vol. 11, No. 3, pp. 153-155.

Snieszko, S. F. and S. B. Friddle
1949. Prophylaxis of furunculosis in brook trout, Salvelinus fontinalis, by oral immunization and sulfamerazine. The Progressive Fish-Culturist, Vol. 11, No. 3, pp. 161-168.

Surber, E. W., and Dorothy D. Friddle
1949. Relative toxicity of suspension and oil formulations of DDT to native fishes in Back Creek, West Virginia. Trans. Am. Fish. Soc., Vol. 76, pp. 315-321.

Tiller, Richard E.
1948. Supplementary report on herring investigation from July to December 1948. 4 pp. (This is a mimeographed supplement to Spec. Sci. Rept. No. 58).

Van Oosten, John
1948. Turbidity as a factor in the decline of Great Lakes fishes with special reference to Lake Erie. Trans. Am. Fish. Soc., Vol. 75, pp. 281-322.

Van Oosten, John
1949. A definition of depletion of fish stocks. Trans. Am. Fish. Soc., Vol. 76, pp. 283-289.

Special Scientific Reports

55. A Report upon the Grand Coulee Fish-Maintenance Project 1939-1947. By Frederic F. Fish and Mitchell G. Hanavan. Issued November 1948.

56. Observations on the Horizontal Distribution and the Number of Eggs and Larvae of the Northern Anchovy (Engraulis Mordax) off California in 1940 and 1941. By John C. Marr and Elbert H. Ahlstrom. Issued October 1948.

58. A Report on the Appearance of the Fungus Ichthyosporidium Hoferi in the Herring of the Northwestern Atlantic. By Leslie W. Scattergood. Issued October 1948.

59. Investigations of the Oyster Reefs of Mississippi, Louisiana, and Alabama Following the Hurricane of September 19, 1947. By James B. Engle. Issued November 1948.

61. Conditions Affecting Shellfish Production in Lynnhaven Bay, Virginia, and the possibilities of Improving them by Increasing Tidal Flow. By Walter A. Chipman, Jr.. Issued December 1948.

62. A Survey of the Columbia River and Its Tirbutaries with Special Reference to its Fishery Resources. 2. Washington Streams from the mouth of the Columbia River to and including the Klickitat River (Area I). By Floyd G. Bryant. Issued January 1949.

63. Summary of Oyster Farming Experiments in South Carolina, 1939-1940. By R. O. Smith (With Off. For. Activities Since 1946)

64. A Bibliography of Lobster Culture. By Leslie W. Scattergood. Issued January 1949.

67. The Production and the Fishing Methods of the Maine Herring Industry with Notes on the 1947 Season. By Leslie W. Scattergood. Issued March 1949.

Bulletins

42. Effect of different concentrations of micro-organisms on the feeding of oysters (O. virginica), pp. 31-57, by V. L. Loosanoff and James B. Engle, 1947.

43. Ecological and Physiological Studies of the Effect of Sulfate Pulp Mill Wastes on Oysters in the York River, Virginia, pp. 59-174., by Paul S. Galtsoff, Walter A. Chipman, Jr., James B. Engle and Howard N. Calderwood, 1947.

44. Contributions to the biology of the Pacific Tunas. pp. 187-206, 1948. Includes the following three papers.

Spawning of yellowfin tuna (Neothunnus macropterus) and skipjack (Katsuwonus pelamis) in the Pacific Ocean off Central America, with descriptions of juveniles, pp. 187-196. By Milner B. Schaefer and John C. Marr.

Size composition of catches of yellowfin tuna (Neothunnus macropterus) from Central America, and their significance in the determination of growth, age, and schooling h bits, pp. 197-200. By Milner B. Schaefer.

Observations on the spawning of oceanic skipjack (Katsuwonus pelamis) and yellowfin tuna (Neothunnus macropterus) in the northern Marshall Island, pp. 201-206. By John C. Marr.

45. Age and Growth of Immature Rosefish (Sebastes marinus) in the Gulf of Maine and off Western Nova Scotia, pp. 207-228., by Alfred Perlmutter and George M. Clarke, 1949.

Fishery Leaflets

318 Notes on Shrimp Fishing Along the New England Coast, By Lionel A. Walford. Issued September 1948.

319 The Shrimp and the Shrimp Industry of the South Atlantic and Gulf of Mexico. September 1948. This leaflet supersedes I-107. Prepared in the Branch of Fishery Biology

331 Culture of Daphnia. By Eugene W. Surber, Chief, Eastern Fish-Cultural Investigations, Kearneysville, West Virginia. Issued January 1949.

337 Keeping Live Shrimp for Bait. Prepared in the Branch of Fishery Biology. Issued April 1949.

344 Contol of Aquatic Plants in Ponds and Lakes. By Eugene W. Surber. Issued July 1949.

350 The Use of Rotenone as a Fish Poison. Prepared in the Branches of Fishery Biology and Game-fish and Hatcheries. Issued August 1949.