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FISH AND WILDLIFE SERVICE
Albert M. Day, Director

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BRANCH OF FISHERY BIOLOGY
Lionel A. Walford, Chief
Paul E. Thompson, Assistant Chief

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CONTENTS

GREAT LAKES FISHERY INVESTIGATIONS

James W. Moffett, Ann Arbor, Michigan

SEA LAMPREYS

Major emphasis in the Great Lakes program continued to be placed on development of methods for controlling the parasitic sea lamprey. Activities consisted largely of further testing and refining of electrical barriers, completing certain researches on the biology of the lamprey, and continuing the survey of streams tributary to Lake Superior. This work is preliminary to the proposed establishment of a large-scale pilot control program, centered on Lake Superior, in 1953.

During the 1952 lamprey spawning run, field tests were made of the alternating-current barrier developed by Service employees and of a commercially-produced electric screen in six streams tributary to Lakes Huron, Michigan, and Superior. These practical experiments under a diversity of stream conditions led to substantial improvements in design and operation of the alternating-current barrier and provided a sounder basis for cost estimates on a large-scale program.

Although field tests proved that with proper installation of alternating-current barriers part of the useful fish migrating at the time could be trapped and passed upstream, possible damages to fish runs could be minimized if an efficient electrical leading device could be included as part of the installation. In an attempt to develop such equipment, numerous laboratory experiments were carried out on leading different species and sizes of fish with interrupted direct current. Results have not been encouraging because of wide variation of reactions according to species and size of fish. Currents that satisfactorily lead a particular fish may completely incapacitate individuals of a larger size or different species. Therefore, an unreasonably complicated and costly installation might be required to lead and trap all valuable fish moving upstream at the time of the lamprey spawning run. More work on this is planned.

Lamprey feeding experiments in which two successive broods of lampreys, recently transformed from the larval to the parasitic stage, were reared to sexual maturity in the laboratory have now been terminated. These studies have confirmed the belief (based on scattered measurements of specimens captured in the open lake) that length of the parasitic phase of the lamprey's life cycle in Lake Huron is one to one and a half years. They have also made it possible to estimate the pounds of fish a lamprey destroys during its parasitic existence and have provided extensive data on effects of lamprey attacks in relation to species and size of fish, size and age of lamprey, and location of attachment point. Included in this phase of the study has been a histological study of wounds and of blood of attacked fish.

Also terminated has been a laboratory screening study of chemicals made in an attempt to find a substance highly toxic to larval lampreys in concentrations harmless to fish. Several promising compounds have been uncovered, but field tests will be required to determine their practical value.

Data on occurence frequency of lamprey scars were compiled from examination of catches of shallow trap nets operated by staff members in northern Lake Huron and from inspection of commercial catches of lake trout in Lake Superior. In the white sucker, the principal species taken in trap nets, the percentage of scarred individuals rose rapidly with increased length of fish. The percentage of scarring of lake trout in Lake Superior has continued to increase, but has not approached levels of former years in Lakes Huron and Michigan.

LAKE TROUT

Researches on lake trout included further collection of data on abundance of small trout taken in chub nets in Lake Michigan (for comparison with earlier records available for 1930-1932); test of the validity of scale readings based on marked fish of known age; study of lake trout movements in Lake Superior (more than 1000 fish tagged during fiscal year 1952); and study of food habits of Lake Superior trout.

GREEN BAY FISHES

In Green Bay, a highly productive area in which the fishery is based on a wide variety of species, progress has been made on the study of the natural history of several of the commercially important species. In Lakes Erie and Huron and for species other than lake trout in Lakes Michigan and Superior, collections of biological data have been held to a minimum schedule sufficient only to provide continuity of observations for certain key species and areas.

WESTERN INLAND FISHERY INVESTIGATIONS

I. CALIFORNIA-NEVADA INLAND FISHERY INVESTIGATIONS

Reed S. Nielson, Reno, Nevada

GENERAL

To explain enormous overwinter trout losses in most streams in the United States, native and hatchery trout have been stocked in four experimental stream sections at Convict Creek Experimental Station in California. Water flow and fish movements in these sections, which total a mile in length, can be controlled. Experiments planned over several years propose complete draining of the sections and removing the fish for fall and spring counting, recording stream flow, air and water temperatures, velocity, snowfall, and ice formation, and observing the fish to determine the extent of their winter activity.

TROUT SURVIVAL

The second year of comparing stream-resident brown trout and hatchery-reared rainbow trout began April 1951 and concluded May 1952. Stocking of the four experimental stream sections followed the pattern of the previous year, one section containing browns, two sections rainbows, and one 50% each. At midyear check in November, growth and condition of survivors were satisfactory, but losses were higher than in the previous year; recoveries of rainbows were 37%, browns 39%. Beginning November 19, severe snow and windstorms, arriving almost weekly, kept Convict Creek under snow and ice varying from one to 12 feet in thickness until April 16, 1952. Observations during the critical period were impossible and efforts were necessarily confined to property protection and attempts at water control. The gross winter survival of browns was 16% greater than that of rainbows. Browns made small growth over winter and declined markedly in condition; remnants of rainbow groups were small and gave no reliable growth or condition change indications. Prolonged low water temperatures, absence of light, collapse of snow and ice with resulting back-up of water, insecure shelter, and partial or complete drying-and-freezing of stream bottom areas are important factors in the heavy winter losses experienced.

WINTER STREAM STUDY

Accomplishments have been negligible because of inacessibility of Convict Creek for observation and samples. Angling for specimens was unproductive when any water was open. Stream bottom samples, taken in the spring of 1952, indicated extreme food paucity. Experiment on low temperature digestion rates of various foods was abandoned because of lack of trout, food organisms and available water.

PRODUCTIVITY OF HIGH SIERRA LAKES

Convict Lake.--Weekly bottom samples, vertical plankton hauls and temperature gradients were taken. Ice covered the lake from December to May. The plankton crop had no significant seasonal changes. Ice fishing was unproductive, and winter feeding habits were undetermined. The trial trap on inlet stream operated through the brown trout spawning run; three and four-year fish predominated in the catch. Fish weighing over five pounds did not participate in stream spawning. Data were collected for extending the age-growth study.

Lakes of Upper Basin.--Barren Lake of 2.5 acres was mapped and sounded;

and in August stocked with brown trout; chemical and faunal characteristics were determined. Intensive bottom and plankton sampling was conducted on nine major lakes to analyze fish-food interrelationships. Fish were collected from those lakes where the previous year's samples of stomachs or scales were low; additional mid-depth water samples were taken for complete 1951 mineral analysis.

II. ROCKY MOUNTAIN FISHERY INVESTIGATIONS

Oliver B. Cope, Logan, Utah

The measurement of vital statistics of the trout population of Yellowstone Lake is the principal aim of this investigation. Adult trout tagged in previous years were recovered from the fishery, pelican roosts, and spawning runs. Four hundred and eight were recovered from 8,474 tagged in 1950 and 1951. Since heavy spawning mortalities and other losses occurred before the tagged fish entered the fishery, possibly 10% of those available in the fishery were recovered. Tagging is being done in the 1952 season to determine mortality rates, population sizes and fishery contributions.

Counting of spawners was continued in all streams previously worked. In June 1952, counts by means of portable traps was inaugurated so a measure of total spawning could be secured. In both the 1951 and 1952 runs, spawners ascended the tributaries in smaller than usual numbers at the beginnings of the seasons. In 1951, the counts picked up very well at the end of the season; it is too early to determine if this pattern will be repeated in 1952.

The sucker run into Pelican Creek in 1952 was the lowest on record. Recoveries of tagged suckers have been made in small numbers. Large numbers are being trapped in Yellowstone Lake.

Creel census work on Yellowstone Lake and River was carried through the end of the 1951 season. Analysis with methods developed by a statistician revealed 227,000 fish were taken in 1951. The 1952 season began with inclement weather, but catches per hour in the rowboat fishery at Fishing Bridge were above those for 1951 for June. Stream biology of Arnica Creek fish was studied in the autumn of 1951 until October, when bad weather forced termination of activities. In May 1952, studies were resumed in Arnica Creek at a new trap site. As of June 30, 2,834 adults had entered the stream, and 978 had returned to the lake. In addition, 349 fish of Age Group I had gone down to the lake. Tagged fish from previous years returned to the trap in the following numbers: 1950 - 7; 1951 - 9.

The office of Central Valley Fishery Investigations closed at Stanford University, Stanford, California, in April 1952. Salmon work, records, and property were transferred to the Pacific Salmon Investigations at Seattle.

III. COLORADO COOPERATIVE FISHERY RESEARCH UNIT

William C. Beckman, Fort Collins, Colorado

GENERAL

Warm-water irrigation reservoirs in Colorado are not producing satisfactory fish populations for the angler. Rough species, such as carp, suckers and bullheads and small perch predominate. Investigations have been set up to increase the scant amount of available data on factors which influence present populations, such as spawning times, food habits, food supplies, age, and growth.

Biological, chemical and physical inventory of Jackson Lake and Lone Tree Reservoirs.--Lone Tree Reservoir was mapped and sounded; physical and chemical data indicate it is suitable for rainbow trout, a cold-water species. Colorado laws forbid installing in irrigation projects brush shelters and other spawning devices. Improvement methods may, therefore, have to be limited to "balancing" existing populations by introducing new species to fill gaps in food chains.

Age and growth studies.--The following average lengths were determined from 2,365 yellow perch: Age group 0 - 4.5 inches; age group I - 5.9 inches; age group II - 6.7 inches; age group III - 7.2 inches; age group IV - 7.5 inches; age group V - 7.8 inches; age group VI - 10.6 inches; age group VII - 9.7 inches; age group VIII - 7.3 inches. Age groups 0, VII and VIII are unreliable because few fish were taken in these groups. Only the largest of the 0 group were taken in gill nets and too few old fish were taken. Remaining groups show good growth in early life and then a great slowdown. In Lonetree Reservoir, the black crappie averaged a length of 6.9 inches in their third summer, while in Jumbo Reservoir they averaged a length of 9 inches.

Parasites.--Eight species of parasites were found in several reservoirs but not in sufficient numbers to be harmful.

Food habits.--Carp do not prey on game or rough fishes but compete with perch and crappies for food.

Rough fish.--Colorado Game and Fish Department tabled the report on the "Selective Netting for Rough Species" because it felt the Unit's recommendations that a number of reservoirs be opened to public gill netting (in which gill nets with 1½-inch or larger bar measure mesh would be used) were too drastic.

Stream improvement.--Preliminary temperature records on the South branch of Poudre River in Pingree Park indicated a temperature too cool for optimum fish growth. A small dam is being constructed to create a pond and thus add more surface area with resultant warming of the water area to more optimum conditions.

The Rocky Mountain Experiment Station at Fraser, Colorado, and the Unit are studying effects of timber cutting on stream temperatures.

The United States Forest Service and the Unit made a preliminary survey in June 1952 on Trout Creek and Seven Mile Creek in San Isabel Forest.

Cooperating agencies of the Colorado Cooperative Fishery Research Unit, headquartered at Fort Collins, Colorado, are the Colorado Agricultural and Mechanical College, the Colorado Game and Fish Department, and the United States Fish and Wildlife Service.

FRESHWATER BIOLOGICAL LABORATORIES
I. FISH NUTRITION LABORATORY
Arthur M. Phillips, Jr., Cortland, New York

Vitamin requirement.--A relation was found between biotin level in brown trout liver and appearance of "blue-slime" disease. Both yeast and beef liver effectively reduced fish loss. Several commercial sources of yeast differed in ability to cause maximum storage of biotin in liver. No relation was found between pantothenic acid and "blue-slime" disease.

Wolf's synthetic diet fed to brook trout produced satisfactory results in mortality and growth. Deficiency studies have shown a high loss in absence of pyridoxine and typical lesions of dietary gill disease in absence of pantothenic acid. Several other vitamin omissions have resulted in reduced growth rates. No conclusions on these may be drawn now.

Use of dietary supplements.--Additions of fractions of cod liver oil to a corn oil base (Vitamins A, D, and an oil concentrate) failed to show effective fraction of cod liver oil in respect to growth. Chemical studies showed fat may be deposited at expense of true growth.

Yeast and beef liver in a diet containing cod liver oil produced maximum results in terms of growth and mortality of brook trout.

Practical diet development.--Whale liver proved satisfactory as a beef spleen substitute in the standard diet.

Preliminary studies with pellets as a food for hatchery fish have shown promise. Two types have been used, one a commercial product and the other an open formula. Comparable results were obtained with each.

Antibiotics added to the feed mixture increased brown trout growth rate. Effect of the antibiotic did not show until warmer water was experienced.

Radioactive isotopes.--Studies with radioactive calcium showed trout absorb this mineral from water. Evidence showed gills are an important entrance for calcium. After 48 hours little of the element had left the body.

A filter, recently developed at the laboratory, permits holding of fish for much longer than usual periods of time without water change. This permits longer studies on exposure to activity and retention. Studies are being made upon retention of calcium and effects of feeding upon both uptake and retention. All groups of fish are fed, one receiving radioactive calcium in food and another receiving its exposure in water. Studies are being made also upon phosphorus and magnesium balances in these trout.

Effect of metabolic products.--A study of the effect of metabolic products showed critical levels of oxygen and ammonia vary with temperatures. As temperature rises, the accompanying increase in metabolic rate not only quickens rate of oxygen consumption and ammonia production, but also makes trout more susceptible to both oxygen decreases and accumulation of metabolic products (as measured by ammonia).

Methods have been developed for fractional separation of components of metabolic products in an effort to discover the causative agent for symptoms. Added ammonia (free gas) has failed to shorten trout holding time.

Trout absorption of glucose.--Trout absorb glucose from water; great increases have been found in blood sugar of trout. There is also an increase in blood sugar of trout held under similar conditions, but without sugar in the water. This increase can be correlated with accumulation of metabolic products. Total rise in blood sugar is far below that shown when trout are exposed to glucose, but rise is significant.

Experimental results of this laboratory are described in detail in the annual report of the Cortland Hatchery which the New York State Conservation Department, Albany, New York, publishes. The United States Fish and Wildlife Service, Cornell University, and the New York Conservation Department do this work under a cooperative agreement.

II. SALMON NUTRITION LABORATORY

John E. Halver, Seattle, Washington

The new Fishery Biochemical Research Laboratory, near Willard, Washington, is nearly complete and will be occupied in the spring of 1953. Final equipment tests on the station will be completed before October 16, 1952, when the laboratory will be accepted from the contractor. Facilities will be available for research in the fields of protein, lipid, carbohydrate, inorganic, organic, vitamin and hormone chemistry, and for histopathology investigations.

Studies on chinook salmon included establishment of a vitamin-test diet, qualitative vitamin requirement, biotin requirement, correlation between hemoglobin content and total erythrocyte counts, and isolation, purification, identification and characterization of some tryptic enzymes.

Cooperative research problems were conducted with the Service's Western Fish Disease Investigations and the University of Washington Department of Microbiology on histo-pathology of various vitamin-deficient salmon. Other cooperative research problems are under way with the Service's Salmon Cultural Laboratory at Entiat, Washington, on qualitative fat-soluble vitamin requirement of chinook salmon, and with the Washington Department of Fisheries on correlation between hemoglobin content and total erythrocyte counts, and hematopoietic effect of various anti-anemic factors in chinook and silver salmon.

The vitamin-test diet consisted of a vitamin-free base supplemented with crystalline vitamins. Through use of this diet, the requirement of chinook salmon for thiamin, riboflavin, pyridoxine, niacin, pantothenic acid, inositol, biotin, folic acid, Vitamin B_{12} and choline was established, and lack of a requirement for vitamins C and para-amino benzoic acid demonstrated. Research on the fat-soluble vitamin requirement should be completed in the fall of 1952.

Data for correlating hemoglobin content and total erythrocyte counts are nearly complete; statistical analysis of this problem should be finished in the fall of 1952 or winter of 1953.

Materials for tryptic enzyme studies have been completed and extraction and isolation procedures are in process.

III. WESTERN FISHERY DISEASE LABORATORY

Robert R. Rucker, Seattle,Washington

Virus disease.--A virus has been demonstrated as the causative agent of a serious epidemic disease among blueback salmon fingerlings at Winthrop and Leavenworth, Washington, stations.

Gas-bubble disease.--The maximum amount of free nitrogen gas fish can tolerate is unknown. Analyses have been made at a number of hatcheries over the last few years to determine a level. A manuscript is in preparation.

White spot disease.--White spot disease of fish eggs is not understood. About 10% of a lot of chinook salmon eggs showed white spots. Five hundred eggs with white spots and 500 normal-appearing eggs were raised separately. There was no difference in mortality of appearance of fingerlings raised from these eggs.

IV. MICROBIOLOGICAL LABORATORY

Stanislas F. Snieszko, Leetown, West Virginia

Treatment of ulcer disease and furunculosis in trout.-- A large-scale experiment was carried out with fingerling brook trout during the summer and fall of 1951. Terramycin, at the dosage rate of 50 mg. per kg. of fish per day, stopped mortalities caused by both diseases. Aureomycin had no effect. After conclusion of treatment period, one part of the experimental fish was continued for another 10 days on terramycin and the other received chloramphenicol. This additional experiment indicated treatment with chloramphenicol produced more durable results than treatment with terramycin only. In addition to these experiments, various antibiotics were tried in vitro against pure cultures of Bacterium salmonicida and Hemophilus piscium. These in vitro experiments indicated chloramphenicol and terramycin were more effective in suppression of growth of H. piscium and B. salmonicida.

Nutritional effects of antibiotics on brook trout.--To fully utilize fish which were used in experiments on treatment of ulcer disease and furunculosis, nutritional observations were carried out and completed during the winter. A preliminary examination of results indicates addition of antibiotics to food of normal brook trout has a growth-promoting effect only if fish are fed at an excessive rate.

Physiology of Bacterium salmonicida.--Experiments on physiology of Bacterium salmonicida were carried out and their characteristics extensively studied. Up to this time there was not enough information available which would permit selection of correct taxonomic position for B. salmonicida. The organism has been successfully grown in a completely defined medium (chemically) of a complex nature. A study of some factors concerned in pigment production of B. salmonicida is nearing completion. Emphasis has been placed on relation of structural configuration of tyrosine molecule to general phenomenon of malanim formation. An important outgrowth of these studies has been development of a new color test reagent to be used in identifying B. salmonicida.

Study of bacteria belonging to genus Aeromonoas (Pseudomonas hydrophila and related species).-- Work has been done on isolation and identification of various bacteria obtained from outbreaks of diseases among fishes in many parts of the United States. Cultures have been collected and their characteristics determined. Information obtained shows certain similar types of bacteria can be repeatedly isolated from various outbreaks in different localities. A rod-shaped bacterium with a single polar flagellum which actively ferments various carbohydrates has been isolated frequently from many diseased fish. On the basis of its physiological characteristics, this bacterium closely resembles certain paracolons; however, on the basis of its morphology it should belong to the genus Pseudomonas. According to one group of bacteriologists, on the basis of its physiological properties, it should be clasified as a parscolobactrum; another school insists it should be classified as a Pseudomonas on the basis of its flagellation and shape. Kluyver in Holland and van Niel in the United States suggested a new genus should be created for bacteria with these characteristics. The name suggested for this genus is Aeromonas. The committee of editors of Bergey's Manual of Determative Bacteriology asked Dr. Snieszko to carry out a study of these bacteria and prepare a recommendation for their taxonomic position for the new edition of the manual. Dr. Snieszko was aked to work on this group of micro-organisms since they are considered as pathogens of fish and other cold-blooded animals; some are also pathogenic to higher vertebrates.

Bacteriological studies on fish ponds.--Experiments (accomplished by means of a method developed by Henrici (suspended slides))were carried out to determine effect of fertilization on bacterial population of warm water fish ponds. Since about 2000 slides had to be stained and examined, the work is still in progress.

Diagnostic service.--Diagnostic service was furnished to the Leetown Hatchery and many Federal, State and private hatcheries located east of the Mississippi River. Among the most interesting observations made as results of this diagnostic service was isolation of a number of cultures of a bacterium which should be classified as Aeromonas hydrophila. This represents the first outbreak of kidney disease reported in the eastern part of the United States; it seems identical or similar to that which is common among salmon in western hatcheries.

V. SALMON CULTURAL LABORATORY

Roger E. Burrows, Entiat, Washington

FEEDING TRIALS

The 1951 feeding trials resulted in development of three composite diets which are cheaper than the standard production diet and produce comparable growth rates. Two diets contain no beef liver. The toxic effect of high levels of vitamin A producing a hypervitaminosis was demonstrated in diets containing high levels of whale liver and tuna liver. The report on the 1951 trials is in press.

The 1952 feeding trials have been conducted for 10 weeks of the 24-week feeding period. It is too early to draw conclusions from these experiments.

Through use of controlled temperature units, experiments are being conducted to determine temperature effect on fish meal utilization. Temperature patterns of Leavenworth and Entiat, Washington, Stations, with accentuated rising and falling temperatures over a range of 40 to 50° F. are being reproduced. Resultant mortalities have not been analyzed, but temperature appears to be a mortality factor.

EGG AND FRY INCUBATION METHODS

Two methods of incubation, utilizing vertical rather than horizontal space, were tested last fall. One method consists of shallow pans, one above the other, in which water flows directly over a single layer of eggs or fry and is reused in pans beneath. The other method consists of deep pans fitted with screened compartments in which water flows upward through several layers of eggs or fry and is reused in successive pans below. Both methods have proved satisfactory for incubation of both eggs and fry. It is planned to test these incubators on full-scale production next fall.

The high-humidity cabinet again proved satisfactory for development of salmon eggs up to hatching.

PITUITIN EXPERIMENTS

Varied injections of pituitary material accelerated prespawning coloration but not actual maturation of blueback salmon eggs. An apparent antagonistic action to normal development was demonstrated when eggs and fry resulting from injected fish were compared with those from the control group. Pituitaries have been collected from chum salmon and segregated as to sex. In the 1951 tests no sex segregation was made. It is possible mixed sex hormones may have caused the antagonistic action encountered in 1951.

HOLDING POND EXPERIMENTS

The most successful retention of adult fish was experienced during the 1951 season. Holding facilities seem adequate, but further work is needed on trapping facilities.

REARING FACILITIES

Scale models of existing raceway and Foster-Lucas ponds are complete and materials assembled for completion of model circular pool, all one-tenth regular size. Evaluations of current and flow patterns and other hydraulic characteristics of prototype raceway, Foster-Lucas, and circular ponds have been made. Preliminary tests indicate it will be possible to reproduce hydraulic conditions which exist in prototype ponds in the models. Chemical determinations, including oxygen, carbon dioxide, and ammonia, were made in prototype ponds containing representative fish loads at time of evaluations.

Biological evaluations are continuing on growth rates and carrying capacities of circular pools. Circular pools of three-foot diameter or over have no deleterious effect on growth rate of chinook salmon. In chinook salmon, ranging from 330 to 100 fish per pound, the carrying capacity of circular pools is not correlated with fish size, but is a function of available water volume. In this size range, capacity of circular pools is 1.1 pounds per cubic foot of water.

SPECIAL INVESTIGATIONS

I. BIOLOGY OF GREAT LAKES FISHES
John Van Oosten, Ann Arbor, Michigan

Materials collected since 1923 on biology of Great Lakes fishes are being analyzed.

A study is being made of the effect of mesh size in chub nets on escape of young lake trout.

Since a method has been developed for obtaining accurate readings from lake trout scales, calculated fish length at the end of each year of life can be estimated.

II. DORENA DAM EXPERIMENTAL LABORATORY
Harlan E. Johnson, Dorena, Oregon

GENERAL

The Dorena Dam Experimental Laboratory, Dorena, Oregon, was established in the summer of 1950, in cooperation with the States of Oregon and Washington and the Corps of Engineers (U. S. Army), to determine if it is possible to incubate, hatch and rear salmon and trout in water obtained from Dorena Reservoir, a flood-control project of the Corps.

Water from three levels (765', 785' and 805' elevation) in the reservoir is available in the hatchery during the summer and early fall. For the remainder of the year water from only the lower intake is assured. During the summer and fall, fish of all species handled are reared in water from the lower and upper intakes and also in a mixed supply.

Laboratory equipment includes 22 deep troughs and 24 circular tanks, 6 feet in diameter, for rearing fish, a cold storage plant, feed preparation equipment, laboratory bench, office and storeroom, all in a building which the Corps of Engineers provided.

EXPERIMENTS

Eggs, fry and fingerlings of chinook and silver salmon and of cutthroat and rainbow trout were held in various water supplies available.

Results of the experiments have been generally satisfactory. Dorena Reservoir water appears suitable for hatchery use, although in some years, it may be too warm for satisfactory incubation of chinook salmon eggs.

During the summer of 1951 columnaris caused high mortalities in all species of fish reared in water supplies having daily maximum temperatures of 65 to 73° F. for several months. Treatments with sulfamerazine appeared to have beneficial effects in some instances. Fish reared in colder water were little affected by this disease. Kidney disease, which had previously caused some losses, was not identified in any species of fish.

Chinook salmon.--In the fall of 1951, an experiment demonstrated abnormal mortalities of spring and fall chinook salmon eggs were the result of high water temperatures during incubation period and that cooling the water used would reduce losses to normal. Fingerling spring chinook salmon were reared for 16 months with excellent results in both growth and survival. Fall chinook salmon were reared successfully for six months before release.

Silver salmon.--There was some mortality from undetermined causes of silver salmon eggs incubated at Dorena. Fingerlings made good growth with small mortalities during a 17-month rearing period.

Cutthroat and rainbow trout.--Losses of cutthroat and rainbow trout during the eyed egg and fry stages were much lower than in the previous year. Both species of trout made good growth and averaged over six inches in length when planted after a year of feeding.

SECTION OF MARINE FISHERIES — E. H. DAHLGREN, CHIEF

NORTH ATLANTIC FISHERY INVESTIGATIONS

Herbert W. Graham, Woods Hole, Massachusetts

Haddock.--In 1951 the Service recommended to the International Commission for the Northwest Atlantic Fisheries that large-meshed gear be required in haddock fishing on Georges Bank in order to eliminate waste of undersized fish and to conserve smaller fish for later capture. The Commission recommended selection of a size that would save most of the fish now discarded, but not affect materially present landings. United States and Canadian biologists formulated recommendations in accordance with this request.

On the basis of known mortality rates and growth rates of Georges Bank haddock it was determined these fish should not be taken until the end of their third year of life with present fishing pressure. An analysis of the effect such a practice would have on the fishery showed a serious reduction in landings might result during the first year or two of regulation if age of first capture were suddently increased to three years. It was computed that long-term beneficial results could be expected with only slight reduction in landings the first year by limting the haddock catch to fish over 2-1/2 years of age (40 cm. long).

It was decided to recommend a mesh which would release fish under 40 cm. in length (about 1-1/4 pounds) and, after about two years, to consider raising the minimum-sized mesh in order to increase age of first capture to three years. It was calculated that Georges Bank production could eventually be increased by about 50% if age at first capture were held at three years.

Certain discrepancies between results of various experiments and differences in methods of measuring size of mesh of American and British workers necessitated further experiments to determine exact mesh size required to give the desired effect. Accordingly, mesh selectivity experiments were conducted. Since large mesh of the type recommended was not available, experimental gear was ordered from usual suppliers so results from experimental nets would be directly comparable to nets which would be obtained after regulation becomes effective. These experiments were conducted on a commercial trawler on a regular fishing trip so results are directly applicable to commercial methods of fishing. Results of these experiments indicated it will be necessary to use a net having an inside stretched measurement of 4-1/2 inches in order to attain the desired result of protecting haddock under 2-1/2 years of age.

Great variations occur in haddock recruitment from year to year, so improved landings after regulation would not necessarily result from regulation. The ultimate test of management practice will be in quantity of fish landed from year classes of known size. Data collected on the haddock fishery over the past 20 years give a record of the contribution which each year class has made since 1931. Under the proposed regulation each year class should contribute more to landings than it would under the present fishing method. Plans to measure initial strength of year classes include licensing of a few commercial trawlers each year to fish with old type gear. This will provide an abundance index of each year class before it is heavily fished directly comparable to the index now used.

In a program of sampling haddock catches at sea, two men made 20 trips on regular commercial fishing trips on large trawlers of the Boston fleet. From this work accurate information is being obtained on numbers and sizes of fish being caught as well as on numbers and sizes of fish being discarded.

To properly manage the haddock fishery it is necessary to have accurate information on relative strengths of all year classes present in the population each year. To acquire this it is necessary to obtain pounds and numbers of each size and age of haddock landed. During the past year the 1948 haddock brood class dominated the Georges Bank fishery, contributing over 53% of the landings as opposed to 28% which is the average contribution of fish of this age (three-year olds).

Redfish (Ocean perch).--Data on time of fertilization of eggs, size at maturity of males and females, and fecundity of females of the same size, obtained from ovaries of redfish landed at Gloucester, Massachusetts, indicate fish stocks of different regions are distinct with little intermigration between them. The length of the incubation period appears to be 50-60 days in the Gulf of Maine and somewhat longer in eastward areas.

Reading otoliths has revealed redfish age. Preliminary studies indicate growth rate on different banks differs, thus further evidencing stock distinctness. Since commercial redfish stocks may be composed of more than one species or at least of several races, population racial studies have been started.

Records are being kept of relative redfish abundance from all areas fished by United States vessels. However, studies have not progressed sufficiently so management procedures can be recommended.

The effect on redfish of the ectoparasite *Sphyrion* is being studied and its value as a population tag considered.

Census on Georges Bank.--Although valuable information on distribution of various species has been obtained, accuracy of quantitative studies is not sufficient for estimating, for instance, relative strengths of incoming haddock year classes. Of recently devised sampling methods, one was tested on two cruises of the vessel *Delaware*.

Tuna.--By tagging Atlantic tunas the Woods Hole Oceanographic Institution, the University of Miami and the Service obtained information on their distribution but no conclusive evidence of the nature of their migrations.

Herring.--The life history of herring fungus and its effect on herring were studied. Observations on biology of herring included size at maturity, spawning season, length-weight relationships, and parasites.

Delaware Bay area.--The Service, with assistance from the University of Delaware and the New Jersey Division of Fish and Game, is considering possible effects of ocean waste disposal on marine fisheries off Delaware Bay.

Hydrography.--A study was made of the effect of wind and current on relative strengths of haddock year classes on Georges Bank. No definite correlations have been found partly because of inadequate data on physical factors in past years. Good correlations were found between distribution of ground fishes and type of bottom.

GULF FISHERY INVESTIGATIONS

W. W. Anderson, Galveston, Texas

General.--A comprehensive fishery and oceanographic survey of the Gulf of Mexico is being made. The vessel Alaska has been equipped and used for collecting water and plankton samples and physical data for the Gulf Fishery Investigations, the Department of Oceanography of Texas A. and M. College and the Geological Survey, Trace Elements Section. Investigators of Geological Survey were present on one cruise to take bottom cores. The collection of samples and data by the Gulf Fishery Investigations includes plankton, water for chemical analysis and bottom materials for pigment extraction, and bottom and water samples for the Geological Survey. Texas A. and M. collects water samples for determining chlorides, and records water temperatures and miscellaneous oceanographic and meteorological observations.

Plankton.--Plankton samples were collected to study distribution of fish eggs and larval and juvenile fishes. To discover zones of maximum plankton production, several approaches are being tested. Conventional half meter and one meter silk nets were used and are being tested against new types of plankton samplers. One of the new models, a simplified version of the high speed sampler, is an all-metal instrument designed to be towed at the full speed of the ship, and has produced some valuable material. The same can be said of an all-metal monel half meter net now being developed; it consists of a monel mesh cone encased in a monel sheet jacket. The jacket shields the wire mesh and carried the filtrate through the field of a measuring screw installed in its after section. Water entering the net is likewise measured by a measuring screw mounted in the net mouth.

The all-metal nets do not deteriorate as rapidly as the silk ones, and, because they can be towed at higher velocities, are more effective. Planned improvements and refinements of the quantitative effectiveness of these nets include a simple recording depth gauge capable of general application, an opening and closing device to operate without messengers, improved diving planes, and techniques for collecting through and below the photic zone at comparatively high speeds.

Statistical studies of Barnes and Marshall and others will be applied to these results; this approach can be probably apply only to passive plankton--diatoms, copepods, etc.--and not to larger and faster moving elements--active plankton. In active plankton, which includes juvenile fishes, the plankton net serves as a trap and not as a filter. A solution of this problem would permit a better estimation of abundance of active plankton.

Another type of plankton sampling gives a continuous picture of smaller planktonic elements as hourly components while the ship is under way. Water is pumped continuously to a circular trough rotated under the jet of the pump's discharge at the rate of one revolution in eight hours. This trough is divided into eight sections; each section is drained through a one-inch circle of bolting silk. At the end of each eight-hour period the silk circles are removed with their plankton and preserved individually. New silks are put in place and the apparatus is restarted.

Preliminary analysis of data from this sampler brings out what may be two daily vertical migrations of copepods, or a diurnal migration on the way up and then down. The latter would mean copepods concentrate in a depth of less than 10 feet. The sample captures greatest quantities at about $05^{h}00^{m}$ and again at about $20^{h}00^{m}$. Peaks at these hours are quite sharp and are found when all Gulf samples are combined, with depth and geographic position randomized.

A Foxboro Dynalog Multi-recorder, recently added to the apparatus for continuous recording of temperature and conductivity, will give a means of relating zooplankton to temperatures and salinities wherever the Alaska goes, regardless of inclement weather or other unfavorable circumstances.

Sediments.--A body of water such as the Gulf, though comparatively small, is divided into definite biological zones. Each zone probably has its characteristic level of bio-productivity which depends on the nature of water mass exchange. Certain residual pigments, which survive decomposition of plant and animal tissues, find their way to rest with bottom sediments. The general distribution of these pigments may be related to currents and productivity of the area in which they originate. For this reason, bottom samples are taken for pigment analysis with a Hayworth orange peel dredge wherever possible. Eventually a complete quantitative and qualitative picture of the distribution of mud pigments on the Gulf floor will be had.

Gulf Fishery Investigations and South Atlantic Fishery Investigations have worked out a standard technique for extracting total mud pigments--those soluble in petroleum ether.

Sound scattering.--Data for studying the deep scattering layer come from a recording fathometer which operates throughout each Alaska cruise.

Biological and chemical.--The most important part of the work centers around dissolved organic compounds found in sea water and relationships between these and various organisms that live in their presence. Ascorbic acid and a rhamnoside have been isolated from sea water and identified. An intensive study of the horizontal and vertical distribution of dissolved proteins (tyrosine-tryptophane method) and dissolved carbohydrates (N-ethyl carbazole method) is under way.

Isolation studies of organic compounds are being carried out by chromatographic methods. A bluish fluorescing compound outwardly similar to the description of such compounds extracted by Zechmeister from barnacles and from sea water by Kalle in Germany have been found in marsh muds and waters around Galveston, Texas, from sediments at 1700 fathoms in the Gulf, and from marsh water samples at Bermuda. Another unidentified compound which seems to correspond in many respects to an initial photosynthetic product mentioned by Loomis, Calvin and others is present. Work progresses on means of extracting and purifying these compounds in quantities sufficient for experimental investigations.

A combined biological and chemical attack on the problem of sound scattering layers is planned. Preliminary work on analysis of records obtained by N M C fathometer equipment on Alaska is practically complete. The biological attack consists of usual sampling by tow nets with exception of adaptations to permit higher towing speeds at lower levels. The chemical attack is based on the theory that the water matrix of any concentrated body of organisms, large or small, will contain detectable quantities of excretory products. Concentration of such products beyond boundaries of the matrix will rapidly diminish to near zero. If a sound scattering layer appears to be composed of marine animals, Nansen bottles can be cast to draw samples at the appropriate level. Samples would then be analyzed for ammonia, urea, and trimethylamine oxide, and/or trimethylamine, and appropriate interpretations made.

Effort expended in a new laboratory being set up for artificial culture of marine microorganisms will be directed toward understanding nutritional and environmental requirements for survival and multiplication of various organisms, particularly dinoflagellates. Results will be used in producing mass cultures to determine the role of various organisms in production and utilization of various organic compounds which are being isolated from sea water. These results, in turn, will be applied to studies on young fish survival.

Red tide research.--A theory has been formulated that "red water" depends on occurrence of isolated non-mixing water masses. A study of small-scale "red waters" in some inland bays and information from various other sources support this hypothesis.

ICHTHYOLOGY LABORATORY

Isaac Ginsburg, U. S. National Museum, Washington, D. C.

In continuing his study of western Atlantic fishes, particularly Gulf Coast species, Mr. Ginsburg concentrated on the families Carangidae, Scombridae, and Scorpaenidae. (See publications.)

SOUTH PACIFIC FISHERY INVESTIGATIONS

John C. Marr, Stanford, California

General.--The Service, the Scripps Institution of Oceanography, the California Division of Fish and Game, the California Academy of Sciences, and the Hopkins Marine Station of Stanford University, with the support of the Industry (through the California Marine Research Committee) are cooperating in a study of the Pacific sardine, the greatest contributor to the fish catch of the Nation until the sharp decline in abundance following the 1945-1946 season. The problem is to determine the size of the sardine population in various years and the causes of these fluctuations, by establishing variations in the amount and range of spawning, and relation between these fluctuations and prevailing current patterns and other characteristics of the marine climate off the west coast.

Sardine recruitment.--During the 1951 spawning season, sardine spawning occurred along the length of the Baja California coast and off southern California to Point Conception. To the north of Point Conception eggs or larvae were sparse. Within the spawning area there were two major centers of abundance, the more important center being located off central Baja California and the secondary one off southern California and adjacent northern Baja California.

Spawning occurred during all months of the year off central Baja California, while off southern California and adjacent northern Baja California eggs and larvae were present only from February through August. Not many eggs or larvae were obtained from waters off southern Baja California, surveyed on three cruises during March, June and September.

Off central Baja California spawning was most intense during March through May. March was the peak month for abundance of eggs, May for abundance of larvae. During the latter half of the year, spawning activity was centered in Sebastian Viscaino Bay. Upwards of 90% of all eggs and larvae obtained on survey cruises in 1951 were collected off central Baja California.

The bulk of spawning off southern California and adjacent northern Baja California occurred during April through June. About 95% of eggs and larvae collected in this area were obtained during this period.

There was considerably less spawning off southern California than during the 1950 season. Only about 10% of eggs and larvae collected during surveys of 1951 were obtained from the southern California-adjacent Baja California area, whereas about 25% of eggs and larvae collected during 1950 were obtained from this area.

Only about 20% as many eggs were taken off southern California during the 1950 season as during either 1940 or 1941, and only about 10%

as many during the 1951 season. Spawning also has occurred later in the year during the recent period, mostly during May and June, while during the earlier period there was abundant spawning during March through May, with April the peak month. Water temperatures in this area are colder during March and April than formerly, and this may account, in part, for the spawning time shift.

Other fishes.--Plankton hauls taken for sardine eggs and larvae contain eggs and larvae of other fishes spawning in the same area. Observations on kinds of fish that gather under work lights while hydrographic stations are being occupied at night have yielded information on many fishes in addition to the sardine. Trolling lines are kept out while traveling between stations. In this way considerable data have been accumulated on distribution and abundance of albacore, yellowtail, and other species.

Young of other fishes.--Information on eggs and larvae of other species is important because many of these compete with sardine larvae for available food or actually prey upon eggs and young of the sardine, and because some of these fishes are being exploited commercially while others constitute fishery resources of considerably protential value.

Larvae of several fishes, including northern anchovy, hake, jack mackerel and rockfish, were collected in greater abundance than sardine larvae during 1951. Their frequency occurrence in hauls containing sardine eggs or larvae shows the role these species could play as either competitors of or food for sardines. Rockfish appeared in 75% of the hauls containing sardine eggs or larvae during the period of widespread sardine spawning (January through July 1951), hake larvae in 67.5%, northern anchovy in 65.0%, and jack mackerel in 50.0%.

Northern anchovy.--During 1951 the largest concentrations of anchovy eggs and larvae were taken off central Baja California; an area of especially heavy concentration was found south of Pt. Abreojos. Although anchovies spawn every month, spawning was most abundant off central Baja California during February through May, and off southern California during April, May and June. At the spawning height eggs and larvae may be collected as far seaward as 250 to 300 miles; off-season spawning, however, is confined mostly to a coastal strip.

Hake.--Deepening of tows from 70 to 1940 meters probably explains why the hake was the most abundant larval fish taken in hauls in 1951. Hake larvae tend to be considerably deeper than those of other fishes mentioned in this series. Their abundance center occurred off southern California and adjacent northern Baja California. In 1951 most larvae were collected during February through April, with a marked peak in March. Of the latent fishery resources, the hake is almost certainly the largest.

Jack mackerel.--The larvae abundance center occurred well offshore off southern California; larvae are taken as far seaward as the survey cruises go--about 400 miles. Therefore, their offshore spawning range has not been delimited. During 1951, most of the larvae were collected during March through June, with April the peak month.

Saury.--During 1951 saury eggs were taken in nearly twice as many plankton hauls as were sardine eggs. They were commonly taken during February through July; however, a few were taken during the off-season. A newly hatched larva is much larger than an individual at this stage in the sardine and anchovy and much better able to fend for itself. Since the smallest of the larvae is an active swimmer, they are seldom taken in plankton hauls.

Rockfish.--The appearance of rockfish larvae in more hauls containing sardines than any other kind of larval fish indicates they may be the chief competitors of sardine larvae. Rockfish larvae were widely distributed every month; their persistent occurrence up to 300 miles suggests some species of rockfish may lead a pelagic existence.

Other food fish larvae.--The young of many other food fishes in addition to the anchovy, jack mackerel, hake, rockfish and saury of present or potential importance to the commercial fishery occur in collections made for the sardine study. Pacific mackerel larvae have been taken in moderate abundance, particularly in inshort hauls off central Baja California. Many flatfish larvae are taken, including larvae of rex sole, dover sole, slender sole, English sole, petrale sole, sand dabs (several species), most abundant and widely distributed of flatfish larvae, turbots (several species), and California halibut.

A few other food fishes in the material include larvae of barracuda, bonito, cabezone, flying fish, pompano, round herring, sablefish, sculpin and sea bass.

Adult albacore.--During the summer and fall, albacore have been taken on jiglines trolled from research vessels traveling between stations. When albacore start hitting bone-and-feather jigs, the vessels usually are slowed to half speed without altering the course. Since no attempt is made to stay with a school, catches represent only a fraction of what could be taken.

Rather complete records have been kept during a three-year period on the vessel which usually operated north of Pt. Conception. A few albacore were taken within 100 miles of the coast, but most were taken between 235 and 275 miles offshore. The area about 150 miles off Cape Mendocino has consistently had albacore in August and September during the past three years.

Adult sauries.--Since sauries are readily attracted to a light hung over the vessel side at night, a visual estimate of their abundance may be made at stations occupied during dark hours. When they are at all abundant, a considerable size range is usually represented, often including fish from about one or two inches to 12 or so long. Small fish dart along the water surface with a rapid, snake-like motion, often breaking the surface. Larger fish swim about individually or in small schools, usually staying a few feet below the surface, but at times leaping from the water.

Since the systematic recording of their abundance was begun, this species has been observed at about half of the night stations occupied. The largest numbers are within about 80 miles of the coast; occasionally very large schools are seen.

Sauries have been found the most important food item of the albacore caught by research vessels, comprising almost 50% of the total food volume. They comprised about 77% of the stomach contents of 29 marlin.

PACIFIC OCEANIC FISHERY INVESTIGATIONS
O. E. Sette, Honolulu, Hawaii

The rich zone along the Equator extends from 180° to 120° W. longitude. Six experimental fishing sections taken across this region during the past year indicate the zone of high abundance of yellowfin tuna may extend in a continuous 300 to 400-mile band for almost 4,000 miles. The measured abundance of yellowfin tuna was not as high, however, in the easterly portion as in the central portion of the area studied. It is unknown whether poor catches reflect a geographical or a seasonal low. Average catches of yellowfin per 100 hooks fishes in the general region of 140°, 150°, and 160° W. longitude were three times as great as postwar catches of the Japanese longline fishery in the western Pacific.

In consultation with East and West Coast oceanographers, POFI is developing a new theory to explain more adequately the equatorial current system in the Pacific than any now held. Existing theories do not adequately account for the persistent picture presented by POFI's hydrographic data. It has become more obvious from data collected during the past year that concentration of plankton, forage organisms, and tuna is a current system product. Presence of land has been proven of little consequence; yellowfin tuna in subsurface depths occur along the Equator at all longitudes examined regardless of land proximity. There may be seasonal variations in their abundance, however. Southeast trade winds, which prevail over the Equator from June to February, enhance yellowfin concentrations along the Equator, possibly by concentrating upwelling products to a higher degree than do winds which prevail over the Equator during March, April and May.

Equatorial region productivity is being measured in terms of plankton abundance. Zooplankton samples taken across the equatorial zone at various longitudes add to accumulating evidence of a continuous rich band along the Equator, with some indication of a seasonal variation. A zone of high zooplankton productivity was found in the Equator vicinity from about 6° N. latitude to about 5° S. latitude. Studies of tuna stomach contents indicate they feed mostly on fish, pelagic molluscs, and crustacea. Since abundance of these organisms depends largely upon plankton, a high degree of correlation was found among surface phosphate concentration, zooplankton, and tuna.

A comparison of yellowfin stocks from various Pacific areas suggests samples have been drawn from stocks which, except for a certain degree of intermingling between adjacent areas, are semi-independent. While yellowfin tuna are probably relatively localized, growing, spawning and dying within a number of hundreds of miles of rather than thousands of miles from their birthplace, the consistent gradation in various body proportions in samples taken along the Equator substantiates the hypothesis of a continuous band of yellowfin tuna long the Equator from Asia to America.

A Hawaiian program designed to discover potentialities for increasing skipjack (ahu) catches has been continued. Two hydrographic-plankton cruises, one made last summer during the skipjack season and the other during the fall after the season closed, are intended upon further study to give information on causes of seasonal fluctuations in the skipjack catch. Comparison of sea surface temperature records, published for the years 1944 to 1947, with monthly catches for the same years, suggests fishing success and fishing season length may depend upon high water temperatures.

Surveys of bait availability around islands in the central Pacific equatorial region disclosed small quantities of bait and fishable surface tuna schools. It is doubtful if any of this area would provide bait in quantities needed for extended tuna clipper operations. In general, bait quantity depends upon shore line length and shoal water extent; there are no extensive amounts of either in the central equatorial region. However, bait fish and surface tuna schools seem plentiful enough to support a limited commercial operation by small fishing boats similar to those employed in the Hawaiian live-bait skipjack fishery. The economic feasibility of maintaining shore bases for such fishing at outlying islands is questionable.

Gill net fishing offers little promise of capturing tuna in commercial quantities in the clear tropical waters around Hawaii. From July 2 to October 19, 1951, 24 sets made with surface gill nets from the Territorial Division of Fish and Game vessel Makua and the Service vessel John R. Manning caught only 28 fish, including six skipjack and a little tuna (*Euthynnus yaito*).

A two-year purse seine fishing trial in waters south of Hawaii was completed with an intensive test in the Hawaiian Islands vicinity during the skipjack season height in the summer of 1951. The study showed purse seining as conventionally carried out is not a satisfactory method of catching tuna in the central Pacific area. However, it was feasible to purse seine skipjack when they were concentrated by chumming with live bait from a sampan. Since this method requires both live bait and a large investment in vessel and gear, its advantage over conventional pole-and-line fishing directly from the sampan is dubious.

Longline fishing as developed by the Japanese in fishing the western Pacific for albacore, yellowfin, skipjack, big-eye and other tuna shows the best promise for commercial exploitation of tuna equatorial stocks. Japanese vessels with a crew of 25 men fish about 350 baskets of gear per day or about 2,000 hooks. Their daily catch south of the Carolines averages 4,000 pounds of yellowfin.

To test the economic feasibility of longline fishing from an American vessel, the chartered vessel Cavalieri made one trip to the Equator, but, after trying to fish for two days, with serious engine-room trouble, returned to Honolulu for repairs. Yellowfin were abundant during those two days; had the expected 100 baskets of gear been fished, a catch of three tons of fish per day would have resulted. The vessel will return to the Equator to resume her attempt to catch a commercial tuna load.

Studies have been continued on tuna life history and habits. Yellowfin in stages developing toward spawning occur through the year in the equatorial region south of Hawaii. No season or locality seems favored; more adequate coverage is needed for definite conclusions.

Yellowfin and little tuna were successfully maintained in captivity. They have a well-developed sense of smell or taste whereby they are attracted to certain food substances even when in the form of colorless liquid extracts. Extracts of bait fishes and squids did not attract, but extracts of tuna flesh evoked strong attraction. White light of moderate intensity (70-450 foot candles) exerts an attraction. There was an indication of sensitivity to complex sound in the range below the sensitivity of the human ear. Progress was made on the instrumental problem of electrical stimulation. These preliminary results suggest eventual success in devising bait substitutes.

ATLANTIC SALMON INVESTIGATIONS
James E. Mason, Orono, Maine

An agreement between the Service and several State of Maine agencies provides for research on Atlantic salmon. The Research Committee representing these agencies and the Atlantic Sea-Run Salmon Commission established a biological investigation program for Little Falls Stream and the Machias and Narraguagus Rivers. Little Falls Stream was biologically and economically unsuited for certain types of investigation, and operations on it were confined to testing experimental stocking procedures. Additional water storage facilities were provided at Hobart Bog on the stream to stablize minimum flows at or near 5 c.f.s.

Plans and materials have been assembled for installing an adult counting weir on the Narraguagus River. Methods of enumerating smolts on the Narraguagus River and of enumerating both smolts and adults on the Machias River are being considered; the practical methods will be tested.

Data on a preliminary experiment testing egg survival under different temperature conditions have been collected and are awaiting analysis.

MIDDLE ATLANTIC FISHERY INVESTIGATIONS
Gerald B. Talbot, Beaufort, North Carolina

SHAD INVESTIGATIONS

Hudson River.--The New York State Department of Health and the Service have completed their cooperative pollution study of the Hudson River. Major areas of critical oxygen levels (below 5 ppm) occur between Catskill and Albany and in the vicinity of Poughkeepsie. The egg sampling program revealed the major shad spawning area lies between Coxsackie and Kingston. Juvenile shad sampling showed no significant difference in relative abundance of young shad in 1950 and 1951. Scale samples were collected from the Hudson River commercial catch in the 1952 season; tag recovery information was gathered from fishermen.

Connecticut River.--Sizes of escapements in previous years affected the size of runs considerably more than factors such as rainfall, water temperature, hatchery plantings and dissolved oxygen levels. Fishing and natural mortalities outside the river in some years decrease shad populations almost as much as river fishing. This broadens the scope of any management program to rebuild the shad runs to their former abundance level in the river. Scale samples were collected from the commercial fishery in 1952 as part of a continuing study to determine total mortality rate and to divide this rate into component parts. Tag recovery data from tagging program were obtained.

The juvenile marking experiment in Windsor Locks Canal has been delayed until the fall of 1952 because high water over Enfield Dam in the fall of 1951 permitted seaward migrating young to pass over the dam instead of being directed into the canal as in years of lower water levels.

Delaware River.--Sampling of young shad indicated greatest relative abundance occurred between Port Jervis, New York, and Lackawaxen, Pennsylvania.

Chesapeake Bay.--The 1952 shad program centered on the Chesapeake Bay. Tagging studies were carried out at the mouth of the Bay, at the upper end of the Bay, and in the James and Potomac Rivers to follow migration routes and to determine populations at various Bay points. Log books were distributed to a sample of fishermen to obtain catch and effort records.

In cooperation with the State of Pennsylvania, adult shad were caught below Conowingo Dam, tagged and released below and above Conowingo Dam and above Safe Harbor Dam. About 30% of the adult shad transported above the dams died. Returns indicate some adults passed over spillways or through turbines on three dams. A check on mortality suffered by these fish will be made in 1953 when more returns are expected. Spawning success by shad planted above the dams will be measured when the areas are sampled for young shad in the summer of 1952.

PACIFIC SALMON INVESTIGATIONS

Clinton E. Atkinson, Seattle, Washington

GENERAL

Consolidation of the Central Valley, North Pacific and Alaska fishery investigations into Pacific Salmon Investigations became effective March 21, 1952.

RESEARCH PROJECTS

Seaward migrants are being systematically trapped at Bonneville, identified, measured and aged. Results indicate spawning success and can also be used to predict the return.

A net has been designed which leads into a 12-inch hose downstream to a holding trap in relatively quiet water. Mortality of young salmon in turbines will be studied at Bonneville by releasing them just above the turbines and recovering by net the live, dead or injured fish as discharged.

The effect on salmon runs of dams and other water-use projects continues to be a problem on the Columbia River. The answer lies in maintaining the yield of salmon fisheries despite ever-expanding water-use projects. This rests on the Service's ability to devise means of preventing or at least minimizing mortalities of seaward migrants as well as adults at each dam or diversion. Electrical guiding of fish shows most promise but the work is still confined to basic exploration on biological limits of the method.

The State of California and the Service are studying natural propagation of chinook salmon at Mill Creek.

Pink salmon in Southeastern Alaska.--Weir counts at Little Port Walter show that from about 4,062,000 eggs deposited, 379,585 fry were counted on their seaward way--a survival rate of 9.3% compared with the previous high of 6.4% in 1940 and a 12-year average of 2.5%. The comparative indices for the past four years show the same unusual fry abundance; 1948 brood 8.9; 1949 brood 17.6; 1950 brood 24.0; 1951 brood 49.5. The 1948 brood produced 533,000 cases in 1950; the 1949 brood 1,164,000 cases in 1951.

Isolation and evaluation of various factors influencing survival are basic. Competition for spawning area may be one factor. Where density in a pen was one pair of fish per square yard, 19.5% of eggs remained unspawned in the female; where two pairs per square yard, 31.2%. Salinity is believed another factor--at the plus six-foot tidal level where eggs experience ocean salinity for a third of their incubation history their survival was about 8%--only slight less than the 9.3% at Little Port Walter.

Returns from 16,195 salmon tagged in Sumner Straits in 1951 show those fish passing along the west shore were predominantly local races; those on the east shore came back from Clarence Strait, from Ernest Sound as well as local areas. The Icy Strait tagging of 1950 did not reveal such segregation.

Red salmon in Alaska.--The Institute of Fisheries Research and the Service have started a research program on Cook Inlet in an attempt to determine destination of red salmon stocks now being intensively exploited by the relatively new gill net fishery.

Since 1950 phosphates and nitrates, added as a fertilizer each summer in Bare Lake (Kodiak Island), have produced blooms of micro- and macro-plankton which are important fish food. It is too early to know the effect on production of young red salmon.

In 1951 the spring run of 257,000 reds to Karluk was 30% less than the five-year average. The 1952 spring run totaled 290,000. The escapement in the 1951 fall run was 431,000, almost twice the average for the past five years.

In Moraine Creek egg and fry survival is being tested of five troups of 20 egg cartridges each which have been buried in a randomized block pattern to allow for a rigorous statistical evaluation of the method.

Bristol Bay climate is important in ocean growth of red salmon. The warmer the weather, the faster the reds grow. The faster they grow during their first year in the ocean, the sooner they will mature and be available to the fishery. Only one year in 18 deviates from this pattern.

The signing of the North Pacific Treaty has made it necessary to define areas used by Alaskan and Siberian stocks of salmon. At the invitation of the Japanese government, a Service biologist accompanied the mothership, Tenyo Maru, to obtain preliminary information on characteristics of salmon from different areas east of Atka Island and related biological information.

Herring in Alaska.--The catch still fluctuates wildly from year to year for no apparent reason. In the 1951 season, the Herring Advisory Committee, composed of three members from the industry and two from the unions, found the fishing intensity did not increase. There were 12 boats in Southeastern District, 16 in Prince William Sound and 16 in Kodiak. Four plants operating in each district processed 85,216 barrels of herring in Southeastern District, 178,247 in Prince William Sound, 6,544 from Kodiak and 27,847 from Chignik. Catch per boat hour in Southeastern District was 7.1 barrels in 1950, 12.6 in 1951; Prince William Sound 28.4 in 1950, 14.1 in 1951; Kodiak 29.8 barrels in 1950, 0.7 in 1951.

SECTION OF SHELLFISHES

SHELLFISH LABORATORIES

I. WOODS HOLE SHELLFISH LABORATORY
Paul S. Galtsoff, Woods Hole, Massachusetts

Cape Code oyster culture.--To assist in reviving the declining Cape Cod oyster farming industry, surveys were made to determine latent oyster resources and development possibilities. Massachusetts oyster culture consists of planting in early spring in Cape bays and tidal rivers grown oysters from Narragansett Bay, Long Island Sound and New Jersey. Oyster growers, local shellfish wardens and the Service planted several thousands bushels of New Jersey oysters which spawned during the summer and produced a set offair commercial value. Efforts are being made to control drills and conchs, the greatest oyster menace.

A survey of local tidal waters found many excellent natural seed grounds. Restrictions imposed by villages and townships on use of shellfish grounds by nonresidents hamper their development and utilization.

II. MILFORD LABORATORY

Victor L. Loosanoff, Milford, Connecticut

Spawning and setting of oysters in Long Island Sound.--Studies conducted during the summer of 1951 to determine rate of gonad development, time of spawning and time and intensity of setting of oysters of Long Island Sound paralleled observations on physical and chemical conditions of environment.

A large-scale statistical analysis of data on spawning and setting of oysters in Long Island Sound for the last 15 years was begun to study variations in intensity of setting of oysters both from year to year and within a season and to determine which of many factors are associated with these variations.

The Milford Laboratory and Bingham Oceanographic Laboratory of Yale University began an investigation of the physical and chemical oceanography, phytoplankton and zooplankton of Long Island Sound, especially its oyster-producing section.

Techniques have been developed to follow quantitatively both growth rate and survival of oyster larvae, *Crassostrea virginica*, in laboratory cultures.

Results of experiments comparing Milford sea water with Thimble Islands sea water showed no significant difference in larval growth and in microplankton content.

Results of preliminary experiments show growth rate of oyster larvae is roughly inversely proportional to their concentration in laboratory cultures and that variation in growth rate is of sufficient magnitude to necessitate taking concentration of larvae into account in comparing cultures receiving different treatments (food, temperature, etc.).

Some 30 pure or nearly pure cultures of micro-organisms have been obtained and kept in pure culture for testing as foods for oyster larvae.

Nine species of bacteria isolated from Milford Harbor mud were not utilized as food by oyster larvae. Preliminary tests showed five of six flagellates obtained from the Plymouth Laboratory to be utilizable by oyster larvae. The sixth flagellate gave less growth of oyster larvae than was obtained in the unfed control. Subsequent tests on various combinations of usable flagellates have confirmed that Isochrysis galbana, particularly in combination with Dicrateria inornata or Chromulina pleiades, is a fairly good food. Preliminary tests of effects of various concentrations of these flagellates on larval growth indicate a concentration of 25,000 per cc. of Dicrateria inornata is not beyond the optimum and that the optimum concentration for Chromulina pleiades is probably between 15 and 20,000 per cc. Isochrysis galbana in varying concentrations has not been tested, but its optimum is certainly above 20,000 per cc. At low concentrations the value of these flagellates appears to be additive to the value of Chlorella. Chlorella, although it interferes slightly with early larval growth, significantly accelerates growth during later larval stages.

Experiments on culturing larvae of Japanese oysters, Crassostrea gigas, were resumed to obtain a complete series of microphotographs of the larvae and to establish the length-width relationship throughout the entire range of larval development. The same type of data was secured from cultures of Ostrea lurida which were grown during the year. Experimental evidence collected during this work showed larvae of Ostrea lurida do grow normally on a diet of a bacteria-free Chlorella, evidence directly contradictory to opinions of many European investigators that Chlorella and related species cannot be utilized by adult or larval oysters of the genus Ostrea.

Studies of enemies of commercial mollusks.—Observations on spawning and setting of starfish in the oyster-producing area of Long Island Sound found the extremely light starfish set of 1951 did not contribute significantly to the starfish population.

In screening and testing chemical compounds for control of enemies of oysters and other lamellibranchs, such as Venus and Mya, several promising compounds were discovered. Their addition to the water even in small concentrations affected shellfish enemies, such as Urosalpinx, Busycon, Polinices and Crepidula. Gastropods exposed to these compounds had their soft parts swollen distending far out of protecting shells. During this stage, which usually lasted from several hours to two days, gastropods were incapable of locomotion and were quickly eaten by crabs and other enemies. These substances which caused a relaxing action on gastropods caused no such effect on lamellibranch mollusks, such as clams, mussels, and oysters.

Some compounds were tried on other enemies of mollusks including starfish, boring sponges, true crabs and horseshoe crabs. Screening found at least 20 compounds which would act as good vital dyes.

Cultivation of lamellibranch larvae.—Three more species of larvae of lamellibranch mollusks, namely Pitar morrhuana, Ensis directus and Anomia simplex, were grown through metamorphosis. Series of microphotographs, as well as whole mounts of larvae of different stages, were prepared. Rate of growth, length-width relationship and, to some extent, food requirements of the larvae of these mollusks were studied. During the summer of 1951 several successful cultures of the European oysters, *O. edulis*, were grown in the laboratory and in outdoor tanks.

III. BEAUFORT LABORATORY (SPECIAL SHELLFISH INVESTIGATIONS)

Walter A. Chipman, Beaufort, North Carolina

Laboratory culture of marine plankton.--Laboratory cultures are maintained and studied of one or more species of *Skeletonema*, *Nitzschia*, *Chaetoceros*, *Chlamydomonas*, *Chlorella*, *Carteria* and *Oxyrrhis*. Also in culture are a filamentous blue-green alga, an unidentified Chlorophyceae, five species of nanno-plankton, and three species of protozoans, including *Plagiocampa marina*.

Large quantities of *Chlamydomonas*, *Carteria*, *Chlorella*, *Nitzschia*, *Plagiocampa*, and *Skeletonema* have been grown for feeding experiments with oysters or for chemical analysis.

To obtain new species having different nutrient requirements and to increase population sizes of those isolated and in culture, modifications of culture medium are continually made. Preliminary experiments indicate that when autoclaved sea water is used in preparing culture medium, larger population sizes are obtained than when sea water filtered through a bacteriological filter is used. A much simplified nutrient solution can serve in place of solutions now added to sea water in preparing culture medium without reducing population size of phytoplankton obtained.

A number of cultures were started from a species of Gonyaulax, which occurred on the Florida east coast during the fall of 1951. Tests were made of a great number of different media and cultures grown under various conditions. Many conditions of culture were unsatisfactory, but some cultures were maintained for six weeks.

Cultures of a species of *Oxyrrhis*, a dinoflagellate, are growing well in the laboratory in the presence of a small species of a Chlorophyceae. Experiments are in process on studies of the physiology of this form, particularly on conditions affecting multiplication and growth. These may shed light on environmental factors concerned with "blooming" of dinoflagellates.

Phosphorus uptake and exchange in marine plankton.--Experiments on uptake and exchange of phosphorus in marine phytoplankton have been completed. Cells grown in a medium containing radioactive phosphorus and a small amount of inorganic phosphorus rapidly absorb active phosphorus. In about four days cells convert most of the active phosphorus into the organic state; those prepared in this manner exchange little phosphorus with the medium. Since they tend to retain active phosphorus for long periods, they have been used in oyster feeding experiments.

Metabolism of metal ions in phytoplankton.--Inshore waters may contain more zinc (quantity varying with locality) than offshore waters in which only trace amounts occur. Many invertebrates accumulate large amounts, possibly in excess of metabolic needs, some of which may come from phytoplankton food. A small amount of zinc is probably necessary for phytoplankton cell growth, but the exact need for zinc is unknown.

Experiments, in which radioactive zinc was used, were made on uptake and exchange of zinc by phytoplankton. Cells grown in the presence of radioactive zinc rapidly take up this ion. For the most part, zinc taken up is exchangeable with that of the medium. When cells containing active zinc are filtered and washed with similar non-radioactive culture medium as that in which grown, radioactivity is rapidly lost by exchange. A small amount of zinc appears bound with protein. Only 2% or less of absorbed zinc remains in the fraction not extractable with trichloracetic acid.

Chemical constituents of phytoplankton.--Since marine animals use phytoplankton as food, studies are being made of nutrient materials of these forms. These plant cells vary in chemical composition, some storing more reserve material as lipids and others more as starch. At times, the nature of the stored material may vary in a single species. Plankton also varies in protein and other cellular constituents, such as pectins, celluloses, etc.

Studies of mineral content and total carbohydrate, protein, and lipid of one species each of *Nitzschia*, *Carteria*, and *Chlamydomonas* showed slight variations between species and of a single species when grown under varied culture conditions.

Evaluation of plankton as shellfish food.--Radioactive plankton was fed to oysters and different species were compared as to their acceptability by oysters. Some plankton forms settled more rapidly than others and fewer were in suspension and available to oysters. Results of a comparison of fed cells entering the digestive tract and those contained in the pseudofeces agree with previous work that sorting of particles for ingestion by the oyster depends in part on size, shape, and abundance at one time. Because of accurate quantitative measurements made possible by use of radioactive tracers, further work will give a more complete understanding of the sorting extent that takes place.

Experiments demonstrated digestion, absorption, and assimilation of plankton cells fed to oysters with exception of *Chlorella* cells. Despite large numbers of *Chlorella* cells in the digestive tract, the oyster utilized almost none as food. Phosphorus of plankton cells utilized by the oyster was assimilated and incorporated into organic phosphorus containing compounds of oyster tissues.

Phosphorus exchange and uptake by oysters.—Studies show oyster tissues have exchangeable phosphorus which is in equilibrium with that of surrounding sea water. The amount of exchangeable phosphorus in the oyster is small, however, and the greater amount is not exchangeable. Apparently there is a metabolic pool of phosphorus available to meet needs of tissues for phosphorus. Feeding plankton to oysters demonstrated phosphorus compounds of oyster food contribute the largest phosphorus amount to this metabolic pool.

Phosphorylations enter into the carbohydrate, lipid, and protein metabolism of the oyster. Phosphorus also is important in shell formation. Phosphorus of the gill tissue was 7.5 µg P/mg. on a dry weight basis; of this, the trichloracetic acid insoluble fraction, which included protein P and lipid P, amounted to 17.6%. Of the trichloracetic acid extractable fraction, 26.2% was in the form of inorganic P and 74.6% as organic P, chiefly ester P.

Experiments using radioactive phosphorus showed a rapid turnover of inorganic P, a moderate turnover of ester P, and a slow turnover of protein-bound P. Oysters placed in sea water containing radioactive phosphorus quickly became radioactive from uptake involving only the inorganic P fraction. When they were placed in ordinary sea water, they rapidly lost this radioactivity. Since the amount of inorganic P in oyster tissues is small, oysters accumulate little radioactivity from short exposures. Because the incoporation rate of P^{32} in organic fractions is slow, a long-continued exposure results in extremely radioactive oysters which retain their activity for long periods.

Role of metals in shellfish metabolism.—Oysters accumulate more zinc than other metal ions and accumulate it in great quantities. Undoubtedly small amounts are necessary in oyster metabolism; it probably is combined with proteins and forms parts of enzymes.

Through use of radioactive zinc, Zn^{65}, a sizable amount of zinc is exchangeable with zinc ion present in sea water. However, there is a continued uptake, the zinc entering and apparently being combined into compounds, perhaps loosely bound. These compounds are of such a nature that the zinc ion is readily exchangeable with zinc ions of the external medium.

Radioactive zinc accumulates in all oyster tissues. Gills have the greatest accumulation and hepatopancreas the second largest amount. This distribution was observed when radioactive zinc was injected into different parts of the oyster body and when oysters in another experiment were immersed in sea water containing radioactive zinc.

Exposure of oysters to sea water containing zinc for as long as 60 hours showed the zinc uptake continued rapidly. It is believed this uptake continues for long periods and that toxic amounts can be accumulated. Repeated extraction with 10% trichloracetic acid showed oyster tissues exposed to radioactive zinc for 60 hours contained 0.13% in the protein-bound fraction. Zinc excretion is being studied.

Studies of zinc metabolism are complicated by possibilities of a replacement of other ions within the body and chelation effects of many compounds, particularly adenosinetriphosphate.

Carbohydrate shellfish metabolism.—Investigation was made of so-called glycogen fractions of oyster tissues. Past investigators have described two glycogen fractions, desmoglycogen and lyoglycogen. This resulted from their comparison of amounts of glycogen measured after extraction with hot water or trichloracetic acid and amounts obtained after extraction with hot alkali. Investigators recently ascribed some physiological role to glycogen not extractable with trichloracetic acid but included in amount extracted with hot alkali.

Comparing amount of glycogen extracted by hot water, cold trichloracetic acid and hot potassium hydroxide, showed that if extracted glycogen were purified by redissolving in hot water and reprecipitating with 60% ethanol, no differences in glycogen amount in tissues could be measured. Without purification, a reducing material was included as glycogen. Previous investigators concerned with different "glycogens" failed to purify glycogen extracted and included certain reducing materials other than glycogen in their calculation, since their methods involved measurement of reducing materials after hydrolization of glycogen to sugars.

Studies on amounts of phosphatase enzymes in oyster tissues concerned with carbohydrate metabolism, including acid and alkaline phosphatases, have not progressed sufficiently to report.

IV. PENSACOLA LABORATORY
(GULF OYSTER INVESTIGATIONS)

Philip A. Butler, Pensacola, Florida

Oyster heredity investigations.—Initial successes attained in 1950 in raising offspring from single pairs of oysters has not been repeated in the two subsequent spawning seasons. Failure in 1951 was believed due to poor condition of the animals. Although many cultures were started in 1952 and various techniques employed, progeny of any single pair of oysters could not be carried through metamorphosis. Cultures in most cases failed to grow appreciably after the first few days and despite initial larvae concentration mortality rates were extreme. Larvae survival in many cases up to 25 days indicates food lack caused failure. Adding mixed plankton concentrates was valueless and cultures maintained in "live cars" with filter screen bottoms in the natural environment survived no better than laboratory cultures.

The single successful culture resulted from natural spawning of a group of 10 Chesapeake Bay oysters which had been maintained at Pensacola for over a year prior to this experiment and were isolated in a 3000-gallon tank of standing sea water. Spawn settled on scallop shells provided for the purpose although an unknown percentage of survivors set also on tank walls. These spat, which are about a half inch in diameter, will be reared in trays in the natural environment and used to determine whether there is any inheritance of the reported lower threshold temperature for spawning of northern oysters.

Stocks of fast and slow-growing oysters are maintained in an effort to overcome difficulties in raising their larvae. Data collected on these oysters continue to support the theory that growth rate, although easily modified by changing the environment, is basically an inherited characteristic.

Oyster growth investigations.--Work on growth of local oysters has been completed and data are being analyzed. Certain growth phases are being examined further, especially rates in successive year classes of spat, to determine whether there is any correlation with more obvious hydrographic factors. Puzzling results have been obtained in studying growth rates of Chesapeake Bay oysters brought to Pensacola as spat. These oysters, paired off with local oysters as controls, are maintained on either side of the laboratory island in presumably similar environments. After a year, differences in growth rates on either side of the island, are statistically more significant than are differences, which are also pronounced, between Chesapeake Bay and local oysters. A study of conditions on either side of the island will be required to resolve this problem.

Seasonal surveys of oyster larvae, spatfall and plankton.--Data collected from four years' surveys demonstrate inherent dangers in interpreting results of surveys conducted for short periods. In the past three summers, a close relation was observed between numbers of larvae in the water and spatfall on test plates and condition of gonads of adult animals. Identical techniques were used this summer and plankton samples have been almost negative in regard to oyster larvae--an extremely high spatfall on test plates resulted. Spatfall this summer reverses the progressive decline in setting rates the Pensacola area has been experiencing for the past three years. In contrast to past data, total plankton volume collected in weekly water samples averaged smaller.

Investigations of associated animals.--Collection of samples for studying cyclic changes in gonad of *Ostrea frons*, the tree oyster, and *Martesia smithii*, the boring clam, during a 12-month period, is nearly complete. Much information was gained early in the summer on reproductive habits of larviparous oysters frons and equestris which continue to set at Pensacola in moderate abundance along with commercial oyster spat.

New projects.--Data were obtained on effects of continuous artificial illumination on setting rates of oysters and other sedentary organisms; spatfall intensity at various levels in relation to mean low water; and effectiveness of scallop shells and palmetto leaves as cultch. During the pre-spawning season 200 oysters of all ages were sexed for studying sex reversal in southern oysters.

CHESAPEAKE BAY SHELLFISH INVESTIGATIONS

James B. Engle, Annapolis, Maryland

Seasonal spawning and setting of oysters.--Areas in upper Chesapeake Bay, where oysters set in sufficient quantity for seed use, are widely scattered and scarce. Eastern Bay, one of these areas, produced sets of commercial magnitude during seven of the last 10 years. Years of poor setting occurred when Bay water in late spring and early summer had salinities above a normal of about 10 parts per 1000.

Setting in 1951, a year of below normal salinity at the critical time, produced a commercial set of seed oysters. This set, while of commercial signficance, was not as good as it should have been because no clean cultch was placed on the seed area in 1951. Spat collectors designed to measure optimum setting caught many more oyster spat than old planted shells on the bottom. Eastern Bay stations show the following:

	Spat Collector Catch per bu.	Old Cultch Catch per bu.
Long Point (west)	33,300	400
Parsons Island	19,800	1,400
Bodkin Rock	12,750	900
Millhill (east)	6,650	400

A bag of clean shells placed in old cultch at Bodkin Rock caught 2587 spat per bushel from June 25 to September 10.

Gonad of oysters thicken rapidly during May and June. A drop in the progressive thickness curve of average gonad measurements indicates spawning. This technique established time of first spawning, a light one, about mid-June. A major discharge of gametes, however, occurred during the week of July 9. From this second spawning came the season's heaviest setting. Spawning continued from June 18 to the last September week.

Oyster larvae, about as numerous as in previous years, were in the water from mid-June to September 24. Metamorphosis, however, was unusually complete with a high setting rate. In 1949, when only .3 to .6%

of the larvae reached advanced development stages, setting virtually failed. Extent to which their development progresses largely determines setting amount.

Setting in upper Chesapeake Bay proper was light and scattered. Spat collectors caught 0.25 spat per shell at Tollys and 0.05 at Hacketts. Commercial significance of this limited setting was practically nil.

Oyster larvae in the Bay proper, as in other years, were scarce. Oyster replacement in most parts of upper Chesapeake Bay must be by transplanting from seed areas, such as Eastern Bay.

Condition of oysters.—Seasonal condition of oysters has a relation to marketable value and physiological processes. As gonads develop gametes, percent glycogen drops. During the summer while the oyster is spawning, glycogen remains low—about 7%. From November through May 1951-1952, the meats had a percent glycogen of about 35% which indicates a relatively "fat" or good oyster.

Total solids in general follow the glycogen cycle except development of gonads in June adds enough solid material to offset glycogen loss. After the first major spawning, total solids drop and remain low for summer and early fall. This was the 1951-1952 pattern. Recovery of total solids in fall and glycogen improvement were simultaneous.

Condition factor, a measure of yield in oyster meat per volume of whole oyster, again followed glycogen and total solids cycles. During winter the condition factor ratio was 10 and indicated good oysters; the lowest ration, 5, was reached in August.

Productivity measured by chlorophyll cycles and its relation to oyster condition.—Seasonal changes in total phytoplankton were observed during 1951 and the spring of 1952 at six stations in the upper Chesapeake Bay areas. Presence of chlorophyll showed phytoplankton was in the water. The fall of 1951 produced a heavy bloom of chlorophyll-bearing organisms in the open Chesapeake Bay and Eastern Bay, which lasted through August and September. Summer and winter quantities were low. The spring of 1952 produced a bloom of lesser magnitude than the fall of 1951. Phytoplankton was generally more abundant in Chesapeake Bay than in Eastern Bay.

Oysters at Tollys and Hacketts were higher in glycogen than those in Eastern Bay. The relation between phytoplankton and condition of oysters may be coincidence, but in areas examined oysters were better where more phytoplankton was produced.

Seasonal distribution of some phytoplankton organisms.—The diatom Coscinodiscus and several color-bearing dinoflagellates occur in quantity in upper Chesapeake Bay. These organisms collected from a hundred liters of water pumped through a No. 20 plankton net were examined under a magnification of 75X and numbers in the following genera recorded: Coscinodiscus (diatom), and Prorocentrum, Peridinium, Gymnodinium, Ceratium and Glenodinium (dinoflagellates). Seasonal peaks of abundance or blooms occurred at different times for some groups. July and August produced a bloom of most of the dinoflagellates. Prorocentrum was numerous in May, July and August, and Coscinodiscus in July, October and April.

Methods of determining oyster population changes.--Studies are continued on the 3,300 acres of Swan Point oyster bar in upper Chesapeake Bay to develop a method of estimating absolute numbers of oysters and to determine the abundance level which produces a sustained yield of satisfactory commercial magnitude. Successful results will have immediate and wide applications for good management. Two hundred and twenty dredge hauls on the 12 regular transect lines were made, with three major dredge modifications.

Analysis of current observations has not progressed enough to permit a statement. Data collected in previous years have been analyzed to the point where they can be used to establish indices of relative abundance. Data have been collected on natural recruitment, natural mortality, amount and location of seed plantings, oyster size range on various parts of the bar, commercial production statistics and fishing mortality.

In 1946, conditions associated with low salinity reduced the Swan Point bar oyster population to a low abundance level. A vigorous planting program subsequently undertaken by the State of Maryland has raised the abundance level.

Inventory survey of oyster resources in Maryland and Virginia.--In October, the Service and Maryland Departments of Research and Education and Tidewater Fisheries examined 141 samples of bottom material containing oysters from representative areas of Chesapeake Bay, Choptank River, Tangier Sound area and the Potomac River area. In December, they examined oyster bars of Eastern Bay and tributaries. Their findings show a favorable set and accumulation of good quality seed in upper St. Marys, Holland Straits and Punch Island seed areas. A somewhat better than usual set was on most bars along the lower western shore of Chesapeake Bay, in the lower Choptank River, portions of the Potomac River and the upper part of Tangier Sound. Setting was a failure along both shores of the upper Chesapeake Bay, upper Choptank River and lower Tangier Sound. Most Eastern Shore tributaries below Chester River received good sets of oysters which helped maintain satisfactory populations of small oysters. Eastern Bay seed area setting was sufficient on shell plantings to provide recruitment of commercial significance.

CLAM INVESTIGATIONS

John B. Glude, Boothbay Harbor, Maine

BOOTHBAY HARBOR, MAINE

Productivity studies, designed to determine bushels of soft clams removable yearly without causing depletion, were continued in Sagadahoc Bay and Robinhood Cove.

Plankton studies.--Semiweekly quantitative pump samples were taken at stations in Robinhood Cove in the summer of 1951 to follow seasonal larval variations. Periodic tidal and depth series followed Bay larvae movement. Larvae, showing extreme patchiness, oscillated with tide. Water masses containing many *Mya* larvae also contain many *Mytilus*, *Anomia* and *Saxicava* larvae; other masses contain few larvae of any species. This condition may indicate food or water quality variation.

Weekly sampling of Robinhood Cove found *Mya* larvae in 1951 from the first week in March to November 21; in 1952 first larvae were found June 5. Early larvae appearance in the spring of 1951 was believed correlated with high water temperature. In 1950 larvae appeared from autumn until December 31.

Setting studies.--Soil samples examined for newly set *Mya* down to 400 microns found great setting intensity variation. Movement of byssus stage clams complicated analysis.

Race-growth experiment.--Growth rate difference in Sagadahoc Bay Center (maximum size 123 mm.) and Sagadahoc Bay Bedroom Cove (maximum size 55 mm.) suggested different races. Monthly sampling through March 1952 for growth of cross plantings in both places, plus similar plots at Robinhood Cove, Plum Island Sound and Falls Cove, revealed introduced clams grew at nearly the same rate as native clams, a condition indicating environment was the cause rather than races.

Maine experimental clam farms.--Monthly sampling of farms established in April 1951 continued at Sagadahoc Bay, Jonesport and Wells. Green crab, *Carcinides maenas*, ate all clams at Love's Cove and Spurwink River. Since most clams are the legal size of two inches, their growth indicates two growing seasons will produce marketable clams from Western Beach seed. Predators limit commercial clam farming but are less important as clams approach legal size. The Service and the Maine Department of Sea and Shore Fisheries made a larger scale planting of 50 bushels of seed clams in May 1952 at Sagadahoc Bay because this area has a low green crab population.

Soft clam census.--Incompletely analyzed results of the fourth annual census in Sagadahoc Bay and Robinhood Cove indicate a population increase. The sampling plan has been changed from a regular grid to a stratified random to provide a better reliability check. Decreased fishing intensity during 1951 and 1952 correlated perfectly with new destroyer contracts at Bath Iron Works.

Green crab studies.--Green crab decimation in 1951 at Love's Cove clam farm in three weeks suggests importance of determining crab population extent. Few returns from over 1,200 crabs caught in modified lobster traps, tagged and released indicated 15,000 crabs in Cove. Catch of 60% males and 2% berried females suggests traps are selective, especially during the period females carry eggs.

Crab population moved from intertidal zone to 10'-25' depth during winter. Low salinity and low temperature reportedly kills them. They reappeared in clam flats the first of May and within two weeks had eaten all seed clams planted at monthly intervals during winter. Clam survival to this time had been excellent.

The apparent increase of crabs along the New England coast is believe associated with warm open winters--water temperature at Boothbay Harbor for last seven years has been above 40-year normal. This happened in Plum Island Sound, Massachusetts, from 1927-1933. Cold winters of 1934 and 1935 supposedly killed the crabs. Crab increase coincides with clam depletion in both cases. In the laboratory, crabs ate an average of 15 seed clams in 24 hours.

Digging mortality experiments.--Commercial catch is not a true measure of removal since many broken clams are left behind or buried too deeply to survive. Digging mortality is being determined for various soil types, different diggers and different weather conditions by the following procedure:

1. Measure and count catch removed from 4' x 4' plot by commercial digger.

2. Sieve 0"-2", 2"-4", 4"-6" layers of plot after digging. Count and measure clams from each depth and record breakage.

Following experiments are used to determine survival at each depth for different soil types and various breakage degrees:

1. Plant 50 clams each of 9-20 mm., 21-35 mm. and 36-50 mm. size groups at 1", 5", 9" depths; upright, horizontal and upside down; broken and unbroken; in sand, sandy-mud, and mud.

2. Dig after two weeks and record survival, position, depth and size.

Experiment completed for sandy area showed little survival at 9" depth for any size group; some survival at 5" for large but not for small clams; good survival at 1"; practically no survival for broken clams.

NEWBURYPORT, MASSACHUSETTS

Clam farming.--Monthly samplings were made for growth and survival data of three successful plots of transplanted clams in Plum Island Sound. Shifting sand destroyed three plots. On mud, growth and survival have been good where green crabs and horseshoe crabs were kept off by chicken wire staked down over clams. Predators took all clams from unprotected plots except one plot on a high flat where enemies are less abundant. Plots in Hampton River, New Hampshire, where horseshoe crabs are scarce but green crabs abundant, experienced similar results. Wire was removed from Hampton River plots and areas were subjected to uncontrolled digging in the fall because of changed State laws. Presence this spring of clams in parts once wire-covered indicates protection is important the first summer after transplanting.

Final return were secured in September 1951 from one small plot protected since November 1949. An average of eight samples showed a yield of 27 marketable clams per square foot. About one-third were planted, the rest native. Forty-eight square feet would produce one bushel; but protective wire cost $2.74 per bushel. Growth of planted clams was from 16 to 57 mm. in two summers. Natives, year class 1949, grew from about 7 mm. in April 1950 to 53 mm. in September 1951.

An important difference between survival of 1949-year class natives and subsequent year classes is that the 1949 year class survived and grew where protected. Subsequent year classes have not done this, though present in all samples, usually in greater numbers. Small clams moved from the plots.

Preliminary tabulations and graphs have been made of growth and survival data from transplanting experiments for completing this project in the summer of 1952.

A foot high fence, topped with a five-inch tin flange, only partially protected clams from green crabs.

Studies of clam movement.--Square foot trays, clamless mud (screened and replaced biweekly all year), indicate large-scale and continuous movement of byssus clams. Biweekly take of byssus clams 2 to 12 mm. closely correlated with same group in controls from surrounding flat. Natural flat had 20 to 40 per square foot in early summer, 400 to 460 in late summer, while biweekly collections were 11 to 20 and 118 to 150, respectively, for same periods. Since September 1951 numbers in both had declined to two or three by June 1952. These clam movements, also observed in the laboratory, may explain native clam behavior in protected farming plots mentioned above.

Limulus population and migration studies.--In upper Plum Island Sound *Limulus* was not as abundant in 1952 as in 1951. Of 914, marked by cutting tails and immovable spines in the summer of 1951, three were recovered in 1951 and two in 1952. Of 90 tagged with numbered discs, none had been recovered by June 30, 1952; 150 were examined and tabulated as to size, sex, maturity and appearance. Since mature specimens were much smaller than those reported in Barnstable, Massachusetts, regional race groups are suggested. One hermaphrodite was found, apparently the first one recorded.

Green crab investigation.--Crabs were dug from banks, trawled from channels and trapped at irregular intervals to determine seasonal distribution and movements. Size frequencies were taken in October, January, February, March and May. Crabs wintering in marsh banks were mostly males; a few small females were present. Apparently most females and larger males move to more saline waters. Few of either sex remain in channels. In spring, large males and females reappear and spend low tide in channels and banks. Egg-bearing females apparently winter in the ocean since significant numbers are found only on exposed beaches after storms.

Histological studies.--Histological examination was continued on clams collected biweekly for gonad development and parasite occurrence. Maturation of gonads came later in the 1952 season than in 1951 but then proceeded rapidly. Some were mature by the end of June and some spawned before July 7, 1952. Studies on 500 individuals in the Newburyport area collected in 1950, 1951 and 1952 indicate gametes produced most prolifically later in summer.

Frequent observations of clam parasites, *Trichodina* sp. and *Himasthla quissetensis* revealed no evidence of a serious pathological condition. No serious clam mortality was found.

KINGSTON, RHODE ISLAND

Productivity studies.--Bucket sampling at 600-foot intervals in July 1951 in Greenwich Bay showed areas of high and low abundance of *Venus mercenaria* similar to those found in the 1950 survey, but with specific differences. More information is needed on population distribution before it can be determined if the distribution was normal. This information will be obtained during the summer of 1952 by dividing the Bay into three parts and by sampling randomly in each part. A large number of samples will be taken in areas of high variation and a smaller number in areas of low variation. Numerous samples will be taken after the survey in several acre plots of high and low abundance.

In general, hard clam distribution is spotty with areas of high abundance adjacent to areas of low abundance. The extent of these areas is also variable and follows no pattern which can be connected with ecological or hydrographic causes. More of the smaller sizes up to 25 mm. were found in 1951 than in 1950.

Commercial digging was about the same in 1951 as in 1950. The Bay was generally fished except in the middle less productive section. The catch is three or four bushels daily, of which two bushels are "necks" (48-70 mm.). The number of boats reach a high point in July and fall off to almost zero in winter.

Larval and setting studies.--Plankton samples were taken at Wickford and Greenwich Bay during the 1951 spawning season. *Mya* larvae first appeared on April 16, 1951 but not in quantity until May 3. *Venus* larvae first appeared on May 23, 1951 with spawning peak on June 25. *Venus* spawning ceased about October 1 while *Mya* larvae were found occasionally in samples until well into the winter.

Mya larvae were more than twice as abundant in 1951 as in 1950. *Venus*, however, were noticeably less abundant. Larval studies continued in 1952 on a slightly reduced scale.

Attempts to induce *Venus* larvae setting by placing plastic screening and shells on the bottom obtained no measurable increase over untreated areas.

A census of about a half acre of tidal flat in Wickford was begun to follow each year class from its beginning until commercial fishing digs it out.

Densities in 1951 follows:

0 year class	=	$2.09/ft^2$
1 year class	=	$1.31/ft^2$
2 year class	=	$1.80/ft^2$
3 year class and up	=	$0.40/ft^2$
Total	=	$5.60/ft^2$

Entrance of *Venus* into the fishery between second and third year classes explains some of the difference between the two densities.

Age and growth.--Greenwich Bay growth plot was dug in November 1951. Only about half of the original planting of 4,500 was recovered. Growth in the year averaged 10 mm. No evidence was found of growth variation or increased mortality because of crowding.

Average annual growth of quahaugs on a plot dug in Wickford in December 1951 follows:

3-year olds 7 - 10 mm.
4-year olds 5 - 6 mm.
5-year olds 4 - 5 mm.

Shells from Venus caught during the 1951 Greenwich Bay survey were studied to determine growth. About 600 age measurements were made; these averaged about 10-15 mm. growth per year.

MILFORD, CONNECTICUT

Clam pathology studies.--Clam pathology studies, directed toward explaining mass mortality phenomena in Mya populations, have required a systematic examination of specimens of several shellfish species. A fundamental approach to this problem was needed because of lack of information regarding the character of mass mortalities, as reported in 1946 and 1949. Whether mortality was primarily due to pathogenic organisms or to temporary period of adverse ecological conditions is unknown. Mya arenaria, Venus mercenaria and Mytilus edulis have been studied in the belief pathogens or parasites lethal to one species may be relatively non-specific in host requirements and equally pathogenic in related form.

The following parasitic fauna have been identified in the above-named shellfish and host-parasite relations determined in most cases: Cercaria myae n. sp. (proposed), Paravortex n. sp. (proposed), Distomum somaterias, Himasthla quissetensis, Himasthla sp., Cercaria milfordensis n. sp. (proposed), and Trichodina n. sp. (proposed). Four other parasitic or commensal forms are being studied--copepods, ciliates, flagellate.

Secondary projects were initiated in the spring of 1952 to determine behavior characteristics and limitations of Mya arenaria as an experimental laboratory animal. Experimentation with this species requires a knowledge of the magnitude of casual mortality and growth rate over extended periods of time in relation to such factors as age, water temperature, food supply, and presence or absence of a burrowing substratum. Results of Mya 1951 year class indicate the species is exceptionally tolerant to sustained exposure to abnormally high temperatures and that growth cessation occurs only above 27.0° C. Over 30% of subjects survived 15 days' exposure to 30.0° water; removal to water of seasonal normal temperature was made without additional mortality and growth was resumed at a comparable rate with control groups held at 18.0° C. Casual mortality in control groups averaged 11% over a 30-day period with the greater part occurring shortly after initiation of experimentation. This recurrent mortality pattern suggests inclusion of numbers of indistinguishable moribund animals. A reasonable sustained isolation period might provide stocks for experimentation with a significantly lower casual mortality rate.

RUTGERS UNIVERSITY
NEW BRUNSWICK, NEW JERSEY

Extremely heavy set of *Mya* occurred along miles of New Jersey beach though adults are scarce--only 19 were found in the survey. This finding demonstrates that under ideal conditions few spawners are required for species which produce large quantities of eggs.

RESEARCH PERSONNEL

Name	Title	Investigation	Location
Abegglen, Carl E.	Fishery Aid	Pacific Salmon	Seattle, Wash.
Ahlstrom, Elbert H.	Fish. Biol.	South Pacific	La Jolla, Cal.
Allen, Donald M.	Fishery Aid	North Atlantic	Woods Hole, Mass.
Anas, Raymond E.	Fish. Biol.	South Pacific	Stanford, Cal.
Anderson, Wm. W.	Fish. Biol.	Gulf	Galveston, Texas
Applegate, Vernon C.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Arnold, Edgar L., Jr.	Fish. Biol.	Gulf	Galveston, Texas
Atkinson, Clinton E.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Attebery, Dorothy R.	Fishery Aid	South Pacific	La Jolla, Cal.
Austin, Thomas S.	Oceanographer	Marine Section	Washington, D. C.
Ball, Orville P., Jr.	Fish. Biol.	South Pacific	La Jolla, Cal.
Baptist, John P.	Fish. Biol.	Clams	Newburyport, Mass.
Barnes, Marylin B.	Fishery Aid	Beaufort Lab.	Beaufort, N. C.
Beckman, William C.	Fish. Biol.	Colo. Coop. Unit	Ft. Collins, Colo.
Belding, David L.	Collaborator	Clams	Woods Hole, Mass.
Beil, Joseph	Fishery Aid	Great Lakes	Marquette, Mich.
Bell, Joe O.	Fish. Biol.	Gulf	Galveston, Texas
Bennett, Alan C.	Fishery Aid	Great Lakes	Rogers City, Mich.
Bliss, Chester I.	Collaborator	North Atlantic	Milford, Conn.
Bocken, Claude	Fishery Aid	North Atlantic	Gloucester, Mass.
Bolin, Rolf L.	Fish. Biol.	Marine Section	Pacific Grove, Cal.
Braem, Robert A.	Fishery Aid	Great Lakes	Rogers City, Mich.
Brewington, Willard O.	Fishery Aid	Pacific Salmon	Seattle, Wash.
Broad, Robert D.	Stat. Clerk	Pacific Salmon	Seattle, Wash.
Brock, Vernon E.	Collaborator	POFI	Honolulu, T. H.
Brown, Wm. J.	Fishery Aid	Clams	Boothbay Harbor, Me.
Bryant, Floyd G.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Brynildson, Clifford L.	Fishery Aid	Great Lakes	Rogers City, Mich.
Buettner, Howard J.	Stat. Clerk	Great Lakes	Ann Arbor, Mich.
Burner, Clifford J.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Burrows, Roger E.	Fish. Biol.	Salmon Cult. Lab.	Entiat, Wash.
Butler, Philip A.	Fish. Biol.	Gulf Oysters	Pensacola, Fla.
Cable, Louella E.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Cangemi, Vito J.	Fishery Aid	Great Lakes	Ann Arbor, Mich.
Carbine, William F.	Fish. Biol.	Inland Section	Washington, D. C.
Casey, Harold D.	Fishery Aid	South Pacific	La Jolla, Cal.
Cating, James P.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Chanley, Paul E.	Fish. Biol.	Chesapeake	Annapolis, Md.
Chenoweth, Harry H.	Hydraul. Engr.	West. Fish Cult.	Seattle, Wash.
Ching, Donald K. F.	Phy. Sci. Aid	POFI	Honolulu, T. H.
Chipman, Walter A.	Fish. Biol.	Beaufort Lab.	Beaufort, N. C.
Clark, John R.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Clarke, George L.	Fish. Biol.	Marine Section	Cambridge, Mass.
Clarke, George M.	Fishery Aid	North Atlantic	Cloucester, Mass.
Coates, John A.	Fish Husbandman	West. Fish Nutr.	Seattle, Wash.

Name	Title	Investigation	Location
Coffin, Gareth W.	Fishery Aid	Clams	Boothbay Harbor, Me.
Cogswell, Sterling L.	Stat. Clerk	North Atlantic	Woods Hole, Mass.
Collier, Albert W., Jr.	Fish. Biol.	Gulf	Galveston, Texas
Collins, Gerald B.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Colton, John B., Jr.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Combs, Bobby D.	Fish. Biol.	Calif-Nev	Convict Creek, Cal.
Cope, Oliver B.	Fish. Biol.	Rocky Mountain	Logan, Utah
Counts, Robert C.	Fish. Biol.	South Pacific	La Jolla, Cal.
Craddock, Donovan R.	Fish. Biol.	Pacific Salmon	Bonneville Dam, Ore.
Cromwell, Townsend	Oceanographer	POFI	Honolulu, T. H.
Dahlgren, Edwin H.	Fish. Biol.	Marine Section	Washington, D. C.
Davis, Harry C.	Fish. Biol.	Milford Lab.	Milford, Conn.
Dinkel, Charles C.	Chemist	Gulf	Galveston, Texas
Dreyer, Frank A.	Stat. Clerk	North Atlantic	Woods Hole, Mass.
Dunbar, Clarence E.	Fish. Cult.	Micro. Lab.	Leetown, W. Va.
Dung, Dorothy I. Y.	Fishery Aid	POFI	Honolulu, T. H.
Eckles, Howard H.	Fish. Biol.	South Pacific	Stanford, Cal.
Edmondson, W. Thomas	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Eicher, George J., Jr.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Elling, Carl H.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Elliott, Oliver R.	Fishery Aid	Great Lakes	Rogers City, Mich.
Engle, James B.	Fish. Biol.	Chesapeake	Annapolis, Md.
Erkkila, Leo F.	Fish. Biol.	Great Lakes	Marquette, Mich.
Eschmeyer, Paul H.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Fast, Thomas N.	Collaborator	South Pacific	Pacific Grove, Cal.
Felin, Frances E.	Fish. Biol.	South Pacific	Stanford, Cal.
Feltham, Catherine B.	Fishery Aid	South Pacific	La Jolla, Cal.
Fredin, Reynold A.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Friddle, Saufley B.	Fishery Aid	Micro. Lab.	Leetown, W. Va.
Fulton, Leonard A.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Galtsoff, Paul S.	Fish. Biol.	Woods Hole Lab.	Woods Hole, Mass.
Gangmark, Harold A.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Garn, Daniel W.	Stat. Clerk	Great Lakes	Rogers City, Mich.
Gauley, Joseph R.	Fish. Biol.	Pacific Salmon	Bonneville Dam, Ore.
Gaylord, William E.	Fishery Aid	Great Lakes	Rogers City, Mich.
Gehringer, Jack W.	Fish. Biol.	Gulf	Galveston, Texas
Ginsburg, Isaac	Zoologist	Ichthy. Lab.	Washington, D. C.
Glidden, Willis S.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Glude, John B.	Fish. Biol.	Clams	Boothbay Harbor, Me.
Godfrey, Mary L.	Phy. Sci. Aid	POFI	Honolulu, T. H.
Gonzales, Robert S.	Fishery Aid	Gulf	Galveston, Texas
Gosline, William A.	Collaborator	POFI	Honolulu, T. H.
Graham, Herbert W.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Griffin, Philip J.	Bacteriologist	Micro. Lab.	Leetown, W. Va.
Hall, Albert E., Jr.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Halling, Jean	Fishery Aid	POFI	Honolulu, T. H.
Halver, John E.	Fish Husbandman	West. Fish Nutr.	Seattle, Wash.

Name	Title	Investigation	Location
Hammack, David F.	Fishery Aid	North Atlantic	Boston, Mass.
Hanavan, Mitchell G.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Hartt, Allan C.	Collaborator	Pacific Salmon	Seattle, Wash.
Hiatt, Robert W.	Fish. Biol.	Marine Section	Honolulu, T. H.
Hida, Thomas S.	Fishery Aid	POFI	Honolulu, T. H.
Higgins, Margaret D.	Stat. Clerk	South Pacific	La Jolla, Cal.
Hile, Ralph O.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Hollis, Edgar H.	Fish. Biol.	Middle Atlantic	Annapolis, Md.
Howell, John F.	Fish. Biol.	Gulf	Sarasota, Fla.
Hunter, Lois E.	Fishery Aid	South Pacific	La Jolla, Cal.
Ikehara, Isaac I.	Fishery Aid	POFI	Honolulu, T. H.
Jacoby, Carl	Fishery Aid	Great Lakes	Ann Arbor, Mich.
Joeris, Leonard S.	Fish. Biol.	Great Lakes	Sturgeon Bay, Wis.
Johnson, Harlan E.	Fish. Biol.	Dorena Exp. Lab.	Dorena, Ore.
June, Frederick C., Jr.	Fish. Biol.	North Atlantic	Newark, Del.
Kane, Thomas F., Jr.	Fishery Aid	Clams	Kingston, R. I.
Kelly, George F.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
King, Joseph E.	Fish. Biol.	POFI	Honolulu, T. H.
Kirkpatrick, Robert G.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Kolloen, Lawrence N.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Kramer, David	Fish. Biol.	South Pacific	La Jolla, Cal.
Landers, Warren S.	Fish. Biol.	Clams	Kingston, R. I.
Leap, Howard E., Jr.	Electron. Engr.	Gulf	Galveston, Texas
Lehman, Burton A.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Liscom, Kenneth L.	Fishery Aid	Pacific Salmon	Seattle, Wash.
Livingstone, Robert Jr.	Fish. Biol.	South Pacific	Stanford, Cal.
Loeb, Howard A.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Loosanoff, Victor L.	Fish. Biol.	Milford Lab.	Milford, Conn.
Lovelace, Floyd E.	Biochemist	Fish Nutrition	Cortland, N. Y.
Lucash, Joseph F.	Lab. Mechanic	Milford Lab.	Milford, Conn.
Lunger, George F.	Statistician	Great Lakes	Ann Arbor, Mich.
McKernan, Donald L.	Fish. Biol.	POFI	Honolulu, T. H.
McLain, Alberton L.	Fish. Biol.	Great Lakes	Rogers City, Mich.
McNamee, Zene M.	Stat. Clerk	Pacific Salmon	Seattle, Wash.
MacGregor, John S.	Fishery Aid	Gulf Oysters	Pensacola, Fla.
Macy, Paul T.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Mann, Herbert J.	Fish M E Spec.	POFI	Honolulu, T. H.
Marak, Robert R.	Fishery Aid	North Atlantic	Woods Hole, Mass.
Marr, John C.	Fish. Biol.	South Pacific	Stanford, Cal.
Marvin, Kenneth T.	Chemist	Gulf	Galveston, Texas
Mason, James E.	Fish. Biol.	Atlantic Salmon	Orono, Maine
Matsumoto, Walter M.	Fish. Biol.	POFI	Honolulu, T. H.
Mattson, George M.	Illustrator	South Pacific	La Jolla, Cal.
Maxfield, Galen H.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Miles, Ernest L.	Fishery Aid	Woods Hole Lab.	Woods Hole, Mass.
Moffett, James W.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.

Name	Title	Investigation	Location
Montgomery, Raymond B.	Collaborator	POFI	Barrington, R. I.
Moore, Harvey L.	Fish. Biol.	Rocky Mountain	Logan, Utah
Morris, Robert W.	Fish. Biol.	South Pacific	Pacific Grove, Cal.
Mosher, Kenneth H.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Murphy, Garth I.	Fish. Biol.	POFI	Honolulu, T. H.
Myers, George S.	Zoologist	Marine Section	Stanford, Cal.
Nelsen, William V.	Fish M E Spec.	POFI	Honolulu, T. H.
Nelson, Philip R.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Newman, H. Wm.	Fish. Biol.	Salmon Cult. Lab.	Entiat, Wash.
Nielson, Reed S.	Fish. Biol.	Calif-Nev	Reno, Nevada
Niska, Edwin L.	Fish M E Spec.	POFI	Honolulu, T. H.
Nomejko, Charles A.	Biol. Aid	Milford Lab.	Milford, Conn.
O'Connell, Charles P.	Fishery Aid	South Pacific	Stanford, Cal.
Olson, Jerrold M.	Fishery Aid	Pacific Salmon	Little Port Walter, Alaska
Ordal, Erling J.	Collaborator	West. Fish Cult.	Seattle, Wash.
Otsu, Tamio	Fish. Biol.	POFI	Honolulu, T. H.
Page, Robert M.	Collaborator	South Pacific	Stanford, Cal.
Palmer, David D.	Fish. Biol.	Salmon Cult. Lab.	Entiat, Wash.
Parker, Phillip S.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Penrod, Joan S.	Fishery Aid	South Pacific	La Jolla, Cal.
Peterson, Stanley R.	Fish M E Spec.	POFI	Honolulu, T. H.
Phillips, Arthur M., Jr.	Fish. Biol.	Fish Nutrition	Cortland, N. Y.
Premetz, Ernest D.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Price, Thomas J.	Fish. Biol.	Beaufort Lab.	Beaufort, N. C.
Reimers, Norman	Fish. Biol.	Calif-Nev	Convict Creek, Cal.
Reintjes, John W.	Fish. Biol.	North Atlantic	Newark, Del.
Rice, Theodore R.	Fish. Biol.	Beaufort Lab.	Beaufort, N. C.
Robertson, Oswald H.	Collaborator	West. Fish Cult.	Seattle, Wash.
Roseberry, Thomas J.	Fish M E Spec.	POFI	Honolulu, T. H.
Rounsefell, George A.	Fish. Biol.	Marine Section	Woods Hole, Mass.
Royce, William F.	Fish. Biol.	POFI	Honolulu, T. H.
Rucker, Robert R.	Fish. Biol.	West. Fish Dis.	Seattle, Wash.
Scattergood, Leslie W.	Fish. Biol.	North Atlantic	Boothbay Harbor, Me.
Schaedig, Earl J.	Fishery Aid	Great Lakes	Rogers City, Mich.
Schlotterbeck, Lewis C.	Fish. Biol.	Pacific Salmon	Bonneville Dam, Ore.
Sette, Oscar E.	Fish. Biol.	POFI	Honolulu, T. H.
Shea, John F.	Fishery Aid	North Atlantic	Woods Hole, Mass.
Shomura, Richard S.	Fishery Aid	POFI	Honolulu, T. H.
Silliman, Ralph P.	Fish. Biol.	Anadromous Sec.	Washington, D. C.
Simmons, George K.	Fishery Aid	Great Lakes	Rogers City, Mich.
Skud, Bernard E.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Slobodkin, L. Basil	Fish. Biol.	Gulf	Sarasota, Fla.
Smith, Bernard R.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Smith, James M.	Fishery Aid	South Pacific	La Jolla, Cal.
Smith, Osgood R.	Fish. Biol.	Clams	Newburyport, Mass.
Smith, Stanford H.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.

Name	Title	Investigation	Location
Snieszko, Stanislas F.	Bacteriologist	Micro. Lab.	Leetown, W.Va.
Spear, Harlan S.	Fish. Biol.	Clams	Boothbay Harbor, Me.
Stavenhagen, Lee	Fishery Aid	Gulf	Galveston, Tex.
Stringer, Louis D.	Fish. Biol.	Clams	Kingston, R. I.
Stroup, Edward D.	Fish. Aid	POFI	Honolulu, T.H.
Stunkard, Horace W.	Collaborator	Clams	New York, N.Y.
Sykes, James E.	Fish. Biol.	Middle Atlantic	Beaufort, N.C.
Talbot, Gerald B.	Fish. Biol.	Middle Atlantic	Beaufort, N.C.
Taylor, Clyde C.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Tetzloff, Clifford L.	Fishery Aid	Great Lakes	Marquette, Mich.
Thompson, Paul E.	Fish. Biol.	---	Washington, D.C.
Thompson, Robert R.	Biochemist	Beaufort Lab.	Beaufort, N.C.
Thrailkill, James R.	Fish. Biol.	South Pacific	La Jolla, Cal.
Trefethen, Parker S.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Uzmann, Joseph R.	Fish. Biol.	Clams	Milford, Conn.
Van Campen, Wilvan G.	Translator	POFI	Honolulu, T.H.
Van Cleve, Richard	Fish. Biol.	Marine Section	Seattle, Wash.
Van Oosten, John	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Vaughan, Elizabeth	Statisticisn	Pacific Salmon	Seattle, Wash.
Vieira, Manuel	Stat. Clerk	North Atlantic	Woods Hole, Mass.
Vlymen, Lillian L.	Fishery Aid	South Pacific	La Jolla, Cal.
Volz, Charles D.	Fishery Aid	Pacific Salmon	Seattle, Wash.
Walburg, Charles H.	Fish. Biol.	Middle Atlantic	Beaufort, N.C.
Walford, Lionel A.	Fish. Biol.	---	Washington, D.C.
Wangersky, Peter J.	Chemist	Gulf	Galveston, Texas
Weaver, Charles R.	Fishery Aid	Pacific Salmon	Seattle, Wash.
Weber, Kingsley G.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Webster, John R.	Fish. Biol.	Chesapeake	Annapolis, Md.
Welch, Walter R.	Fish. Biol.	Clams	Boothbay Harbor, Me.
Widrig, Theodore M.	Statistician	South Pacific	Stanford, Cal.
Wolf, Robert S.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Wood, Edward M.	Fish. Biol.	East. Fish Cult.	Leetown, W.Va.
Yamashita, Daniel T.	Fishery Aid	POFI	Honolulu, T.H.
Yuen, Heeny S. H.	Fish. Biol.	POFI	Honolulu, T.H.

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64. Juvenile Oceanic Skipjack from the Phoenix Islands. By Bell M. Shimada. Issued 1951.

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Note: Where more than one author is shown in a listing, not all of whom are Service biologists, those whose names are underscored are personnel of the Branch of Fishery Biology.

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Ginsburg, Issac

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Hile, Ralph

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Loosanoff, Victor L.
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Loosanoff, V. L. and H. C. Davis
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Loosanoff, V. L., and C. A. Nomejko
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