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BRANCH OF FISHERY BIOLOGY
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FOR ADMINISTRATIVE USE

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GREAT LAKES FISHERY INVESTIGATIONS

James W. Moffett, Ann Arbor, Michigan

SEA LAMPREYS

Control of the sea lamprey again received major attention. Operation of experimental control structures in 1953 was terminated before the lamprey spawning run ended because threatened curtailment of funds necessitated removal and storage of equipment before fiscal year 1953 closed. The capture of 1,600 lampreys at 10 electrical barriers demonstrated a greater abundance of lampreys in eastern Lake Superior than had been anticipated. In the expanded program of 1954, 44 electrical barriers were placed in operation on known and potential spawning streams along the entire State of Michigan shore of Lake Superior. Records indicate an even greater abundance of lampreys in eastern Lake Superior in 1954 than in 1953; however, results from operation of newly installed devices in central Lake Superior are more encouraging. Failure of 22 of 28 barriers west of Marquette, Michigan, to take any lampreys suggests they may not be firmly established in the central and western areas.

Included in the Lake Superior control system is a mechanical weir on the Chocoley River which is being used to determine whether the life history of the lamprey in Lake Superior differs to an important extent from that worked out for the species in Lake Huron. Seven electrical barriers are being operated on streams tributary to northern Lake Michigan. Records from the early part of the season indicate a large lamprey catch at these structures.

The Wisconsin Conservation Department and the Fish and Wildlife Service are operating structures on 3 index streams on Lake Michigan. A weir is being operated again in the Ocqueoc River, an index stream tributary to northern Lake Huron. Catches indicate continued high abundance of lampreys in both lakes. Barriers of 2 different types are being operated in cooperation with the Michigan Department of Conservation. The inclined screen and trap (for capture of transforming ammocetes on their lakeward migration) on the Carp Lake River (Straits of Mackinac) is entering its sixth year of operation. If this stream, which has been blocked to spawning-run lampreys since the first installation of the dam, ceases to yield lakeward migrants, use of the structure as other than a barrier to upstream movement can be abandoned. Experiments at the barrier dam on Black River, Mackinac County (Lake Michigan), are intended to develop the most effective arrangement of curved lip and lateral guards in stopping lampreys from upstream migration while allowing trout to proceed.

The screening of nearly 4,000 chemical compounds has not yielded a proved specific larvicide but has uncovered several substances of sufficient promise to warrant more detailed investigation and possible field testing.

LIMNOLOGICAL SURVEYS

The first large-scale fishery and limnological survey of Lake Superior was completed in October 1953. Nine cruises were made from May to October, 3 each in the eastern, central, and western areas of the lake. Experimental fishing yielded extensive information on distribution and abundance of fishes, particularly on the little-known smaller species and on the early stages of commercial varieties. Large amounts of limnological data and materials were collected also on currents, temperatures, water chemistry, plankton, bottom types and fauna. Good progress has been made in analyzing these materials.

In May 1954 the vessel Cisco started a fishery and limnological survey of central and southern Lake Michigan. Principal objectives of this year's work are appraisal of status of the chub (cisco) population; development of efficient, economical methods for large-scale production of chubs; and collection of data on limnological conditions affecting productivity.

GREEN BAY FISHES

A manuscript has been completed on the life history of the Green Bay lake herring, and analysis of materials on the yellow perch brought up to date. On the basis of information supplied by staff biologists that lowering of the size limit for yellow perch in southern Green Bay from 8 to 7-1/2 inches has had no adverse effects on the stock, the Wisconsin Conservation Commission has continued the 7-1/2 inch limit. In other shallow-water fisheries in Lake Erie and Saginaw Bay, activities have been largely restricted to routine catch sampling. Progress has been made in studying recent fluctuations in the walleye stock of Saginaw Bay and in analyzing the year-class composition of commercial stocks in Lake Erie.

LAKE TROUT

First drafts of manuscripts were prepared on the following studies of Lake Michigan lake trout: Validity of age determinations as indicated by scale structure of recaptured marked fish of known age; distribution, abundance, early growth. . . . of lake trout as determined from the 1930-32 collections of the research vessel Fulmar. In Lake

Superior, an investigation of lake trout fecundity has been completed and considerable progress made on study of distribution, abundance, food, and growth through the first 5-6 years of life. As part of a continuing study of movements of larger lake trout, 500 additional specimens were tagged in June 1954, from commercial pound nets near Cornucopia, Wisconsin.

STATISTICS

Tabulation and analysis of commercial fishery statistics have been maintained on schedule. Original data are available through cooperation of the several Great Lakes states.

WESTERN INLAND FISHERY INVESTIGATIONS

I. CALIFORNIA-NEVADA INLAND FISHERY INVESTIGATIONS

Reed S. Nielsen, Reno, Nevada

TROUT SURVIVAL

To explain overwinter trout losses in most streams in the United States, native and hatchery trout have been stocked in 4 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 of the fish for fall and spring counting, recording of stream flow, air and water temperatures, velocity, snowfall, and ice formation, and observing of the extent of winter activity of fish.

The fourth year of study began May 7, 1953 and concluded May 3, 1954 with a mid-year check on growth and survival October 27-30, 1953. In the first period (May-October) survival of hatchery rainbow trout was identical between 2 size groups stocked alone at 75 pounds per acre. Rainbow trout superimposed on brown trout (150 pounds per acre) showed a survival rate slightly over half that shown for rainbow trout stocked alone; brown trout in this mixture were recovered at the same rate as rainbow trout stocked alone; low rainbow trout recoveries from the mixed group are, therefore, due to competition with brown trout rather than to stocking intensity. Superiority of brown trout survival in competition is in accord with results of most previous trials. Hatchery-reared rainbow trout held beyond their first year in the stream (group initially stocked August 1, 1952) showed a survival of 39.8 percent in the May-October period, with drastic decline in condition. Stocking in the second period (November 1953-May 1954) was limited to 2 stream sections because of inability of 1 man to care for all 4 sections in

winter condition. A group of larger rainbow trout in experiments initiated in May 1953 was followed through the winter with a survival of 40.0 percent and a decline to a low average condition. Only 31.6 percent of second year rainbow trout (restocked in October 1953) was recovered in May 1954, with a reduction of average length and weight and a slight increase in condition, reflecting large losses among smaller and more emaciated trout. Although handling mortalities limit survival values to 6-month periods, survival of the above group of rainbow trout through 2 years in Convict Creek may be estimated at between 5 and 8 percent.

WINTER STREAM STUDIES

Weather conditions were normal and similar to those of the previous year. Snow and ice bridged stream sections during the period January to April. Anchor and surface ice occurred and many stream bottom areas were inaccessible to fish because of snow and ice. Controlled feeding experiments at low water temperatures (32-33° F.), in which natural stream food organisms were used, were continued when conditions permitted. Small brown trout fed readily at these temperatures when undisturbed. Digestion was slow and varied in speed with size of meal and type of food but progressed steadily at 32° F. In 24 hours, small meals (1/2 gram) of soft-bodied aquatic insects were 70-90 percent digested, and hard-bodied forms 20-30 percent digested. At 32° F. roughly 30 to 72 hours were required for complete digestion.

Two groups of brown trout were held 120 days without food to distinguish malnutrition mortality from winter mortality because of other agents. The 2 groups were exposed to the same low water temperatures (daily averages 32-35° F.) with 1 group held indoors in a hatchery trough and the other exposed to normal winter stream conditions. At the conclusion of the test period, mortality in the stream group was 17.7 percent and mortality in the sheltered group 9.3 percent. Actual starvation appears a minor factor in overwinter losses as many of the 120-day survivors were active and in fair condition. While differences in mortality between exposed and sheltered trout groups were not striking, they indicate icing and other physical factors may be more critical than food lack.

PRODUCTIVITY OF HIGH SIERRA LAKES

Convict Lake--brown trout.--Trap on Convict Lake inlet operated through brown trout spawning season (September 25-December 28). Total catch of 1,434 comprised 444 males and 990 females; the sex ratio was 1:2.23. As with previous 2 years, inlet spawning run consisted mostly of age groups III and IV with few larger trout entering the stream.

New fish made up 80.3 percent of total catch, 1952 marks 16.0 percent, 1951 marks 2.2 percent, and double marks (trapped 1951, returned 1952 and 1953) 1.5 percent. California Department of Fish and Game obtained 190,000 eggs spawned from 239 females. Potential egg production of inlet spawning estimated at 800,000 annually is based on sample ovarian egg counts of green females from all participating age groups. California Department of Fish and Game, basing its action on results of Fish and Wildlife Service studies and observations on this brown trout population, attempted gill net control of large predatory trout during November 1953. Total catch not released was 114 brown trout ranging from 9 oz. to 20 lb. 3 oz. and 10 rainbow trout. Of the brown trout, 24 exceeded 5 lbs. and 14 exceeded 9 lbs. Removal of large brown trout from the lake is to be continued at the close of the 1954 angling season, and effects of these removals on the more desirable rainbow trout fishery will be studied.

Periphyton sampling studies.--Major effort in the 1953 summer field season on the Convict Creek Basin high lakes was directed toward a systematic evaluation of comparative periphyton productivity by means of sampling techniques developed during the preceding year. Results of this sampling have been analyzed. Comparison of periphyton values with the resultant of several physical and chemical values for each lake required that the lakes be rated on a common scale for each measurement involved and a grand mean of all physical and chemical ratings be derived for each lake. Periphyton production was heaviest in the photosynthetic zones of lakes, more especially in shallow water, and unit production values for lakes have, therefore, been derived from periphyton and water mass distributions of various strata. Periphyton abundance in these lakes was in close agreement with the sum of physical and chemical influences which are the basis of aquatic productivity. Of the major ions present in the waters, bicarbonate and sulfate appear the most influential, and periphyton growth seems advanced according to bicarbonate concentration and increasingly inhibited by greater sulfate concentrations. Lake Bighorn has the highest sulfate concentration in relation to bicarbonate concentration of any in the group; this lake is the only one whose periphyton production departs radically from the trend of physical-chemical influences.

Twenty-five day exposures of glass periphyton substrates were made at all levels in Convict Lake through 1 year ending July 8, 1954 to determine incremental changes with water temperature and season. Except for mid-winter difficulties and loss of 1 set in the ice breakup, Convict Lake sampling was successful; analysis will be made on completion of facilities.

II. ROCKY MOUNTAIN FISHERY INVESTIGATIONS

Oliver W. Cope, Logan Utah

Yellowstone Lake studies.--The Yellowstone Lake fishery in the 1953 season was regulated with a reduced limit and a shortened season. Total effort and catch were reduced below 1952 levels and the catch success was sustained at the same level. The 1954 season began slowly with relatively poor fishing success; however, fishing was rapidly improving at the end of the year.

Yellowstone spawning runs were improved in 1953 chiefly because of the shortened angling season. Most of the counted spawners were allowed to ascend streams to spawn naturally as part of an agreement to curtail shipment of eggs outside Yellowstone Park. The 1953 effort was the beginning of an experiment to compare natural reproduction with hatchery production at Yellowstone. The 1954 program followed a pattern similar to that of 1953. Spawning runs of 1954 were below those of 1953 at the end of the year but improved in the later stages.

Average sizes of fish in the 1954 runs and the fishery were greater than those of 1953, probably because of a weakness in the 1950 year class.

Extensive studies on tagging returns and scale reading were conducted during the winter.

Grebe Lake studies.--Studies of Grebe Lake grayling and trout populations are being continued. The 1953 and 1954 spawning runs of grayling were large while trout runs were relatively small. Population studies in Grebe Lake showed a great preponderance of grayling over trout in 1953. Present regulations on Grebe Lake seem suitable for present populations.

Madison River studies.--Creel studies on the Madison, Firehole, and Gibbon Rivers were begun in 1953 and continued on a larger scale in 1954. Estimates of catch and effort were made for these streams for 1953 and data on catch characteristics collected. Marked rainbow and brown trout were planted in the Madison and Firehole Rivers in the spring of 1954. Creel checks strongly indicate planted half-pound rainbow are being caught rapidly in the Madison River.

FRESH WATER BIOLOGICAL LABORATORIES

I. TROUT NUTRITION LABORATORY

Arthur M. Phillips, Jr., Cortland, New York

Trout vitamin requirement.--Vitamin omission studies showed choline, niacin, folic acid, pyridoxine, riboflavin and inositol are necessary growth factors for brook trout. No abnormal conditions, including anemia appearance, could be found, with exception of loss of caudal fin among inositol deficient trout. Experiments are under way to determine if brown trout have a similar need for the vitamins.

Dietary supplements.--Attempts to produce a synthetic cod liver oil indicated phospholipids may be the growth factor in cod liver oil. Experiments are in progress to confirm or reject this possibility.

Aureomycin and penicillin added to rainbow trout diet produced no beneficial effects.

Metabolic studies.--Both cold water and starvation effectively reduced brook trout metabolic rate. Sodium amytal, when correlated with starvation, was effective in prolonging carrying capacity after a period of between 4 and 6 hours had elapsed.

An attempt is being made to correlate effects of starvation, water temperature, chemicals and fish size.

Practical diets.--Experiments with a pelleted fish food showed a level of 60 percent of the usual amount fed, coupled with meat fed twice a week, produced results equal or superior to the usual hatchery diets. Significant savings in labor and food preparation resulted. Present studies include use of a heavily fortified pellet to eliminate meat feedings.

A foreign brand of cottonseed meal, which equals domestic types of the meal, produced no adverse effects when added to the rainbow trout diet.

Radioactive isotopes.--Small non-feeding trout absorbed P^{32} at a more rapid rate the first 48 hours of a 144-hour period. More activity was absorbed at a higher level of radioactive phosphorus than at a lower one. Gills and the gastro-intestinal tract contained the highest radioactivity level. In all cases the amount of P^{32} absorbed was less than values found in previous work with Ca^{45}.

All material has been gathered for determining absorption of Co^{60} from water by brook trout and analytical work is under way.

The experimental design has been completed and work initiated on a complex study upon trout utilization of calcium from water.

Natural food analyses.--Seven natural food species were analyzed for protein, fat, water, magnesium, phosphorus and calcium content. Other forms of natural food were analyzed for biotin, riboflavin and pantothenic acid content. Comparison with a common hatchery diet indicated that, according to present standards, hatchery food is superior to the natural product. However, a correlation of analyses with conversion factors of the 2 food types shows the natural product, with its apparent inferior chemical content of studied factors, is equal or superior to hatchery diets.

Starvation effect on trout.--Weight loss of starved brook and rainbow trout could be correlated with water temperature. Liver analyses showed low levels of pantothenic acid, biotin, riboflavin, and fat, and a high niacin level.

II. SALMON NUTRITION LABORATORY

John E. Halver, Cook, Washington

GENERAL

Major emphasis has been placed on testing facilities in the new laboratory and orienting staff members with problems in using fish as experimental animals. A full-time hatchery feeding program was initiated; the river water system and a constant temperature water system were used to test growth responses and possibilities of existing and altered water supplies. Difficulties encountered in using a galvanized water line were overcome and a new all-steel line has been installed from the spring to the experimental hatchery. Major emphasis in biochemical investigations has been to obtain background information for developing an efficient nutrition feeding program in the coming year.

RESEARCH

Chinook salmon vitamin requirements.--Utilizing the river water portion of the experimental hatchery, the laboratory staff repeated qualitative water-soluble vitamin requirement studies previously conducted and published to measure effectiveness of this low temperature water supply in developing specific vitamin deficiency syndromes in chinook salmon. Unfortunately, 38-42° F. temperatures prevented sufficient growth for development of vitamin deficiency syndromes within a 20 week feeding period. Some growth inhibition and lack of development of deficiency syndromes may be attributed to the Octomitus

infection prevalent in most groups of the water-soluble vitamin deficient lots of fish.

Qualitative fat-soluble vitamin requirement studies were repeated through use of the constant temperature water system adjusted to 50°F. with the river water supply. Low pressure of the water system interfered with action of the constant temperature valves and this, coupled with the contaminated river water system, led to inconclusive results on specific fat-soluble vitamins required. It is anticipated that repeating these studies with the spring water supply, which should be free from fish pathogens, would confirm previous work on requirements for vitamins A and K.

Salmon amino-acid requirements.--Introductory work has been completed on developing a satisfactory vitamin test diet and a cooperative research project has been initiated with members of the protein section of Purdue University for chinook salmon qualitative amino acid requirements. Dr. Edwin T. Mertz visited the laboratory in June and a long-term research program, which would utilize facilities and experience of Purdue University and facilities of the Salmon Nutrition Laboratory, was outlined. Purdue University has tentatively agreed to furnish Dr. Mertz and one graduate student for determining salmon qualitative and quantitative amino acid requirements. Purdue's partially supplemented diet will be used for quantitative requirements and the laboratory's test diet for qualitative requirements.

Chinook salmon fatty acid requirements.--An attempt to determine qualitative fatty acid requirements of chinook fry has been made. The sole source of fat in the diet contained a mixture of stearic, palmitic and oleic acids at a level of 9 percent with linoleic and linolenic acids at a level of 0.2 percent. At this level, and under experimental conditions used, fish developed a severe edema in a large number of cases. Fish receiving no fat in the diet in many cases survived better and liver necrosis was not seen in these lots until after an additional three weeks' feeding. Massive liver necrosis histologically identical with acute yellow atrophy of mammals was observed in moribund fish.

Establishment of inorganic test conditions for chinook salmon.--Through use of the deionized water system, additions of known amounts of pure inorganic salts resulted in at least 2 satisfactory inorganic test conditions for chinook salmon fry. As a prerequisite for studying chinook salmon inorganic requirements, the greatest emphasis was placed on developing a system of known ionic strength and inorganic ion concentration which would allow fish to survive and grow with positive experimental control of inorganic ions present. Low levels of a Sorenson buffer were satisfactory and some concentrations of chlorides and phosphates indicated they could be used for some studies. A copper leakage from the deionizer control valve proved lethal to fish in such a pure water supply.

Chinook salmon inorganic requirements.--Use of the river water supply with its load of fish pathogens prevented development of specific inorganic deficiency syndromes. It is probable that repeating these studies for macro inorganic elements absent in the spring water, which should be free of fish pathogens, would develop specific inorganic deficiency syndromes without using the deionizing equipment. A study of zinc and calcium as enzyme activators was begun.

Chinook salmon carbohydrate requirements.--Feeding salmon lots with increased increments of carbohydrates failed to indicate maximum tolerance levels because of the large load of fish pathogens in the river water supply. The epizootic of octomitus and bacterial gill disease, and the extremely low temperature of the water system prevented adequate growth and development and masked any results which might have been obtained.

Normal histology of salmonids.--An extensive collection program of wild and hatchery fish was completed on June 7, 1954. All species of salmonids on the Pacific Coast, except the California Golden Trout, were included from both hatchery and stream environments. The approximately 100 hatchery and 50 stream collections yielded 3,000 fish. The Oregon Game Commission, the Washington Department of Fisheries, the Fish and Wildlife Service's Regional Office at Portland, the Washington Department of Game, and the Oregon Fish Commission cooperated with the laboratory in this undertaking.

Histology of salmonids under defined nutritional conditions.--Specimens were preserved from nutritional experiments with water and fat-soluble vitamin deficiencies, fatty acid deficiencies, carbohydrate deficiencies, and mineral deficiencies to insure adequate preservation of cellular detail essential to such experimentation.

Material was sectioned from the Service's Cortland, New York, laboratory to describe histology of choline deficiency. In this material no lesions were observed that could be correlated with a vitamin deficiency.

Histological comparison of wild and hatchery-reared salmonids.--Three thousand wild and hatchery-reared salmonids were collected and preserved. They consist of fall chinooks, spring chinooks, silvers, chums, pinks, bluebacks, steelheads, rainbow, brook, brown and cutthroat trout. This material is being sectioned.

Library of histological material of salmonids.--Several thousand tissue sections were prepared and filed. The itemized list of disease conditions, nutritionally deficient material and normal tissues is extensive and will be released periodically to interested and qualified investigators.

Neoplasms of salmonids.--Three neoplasms have been received and diagnosed. These are a large fibroma from a wild black spotted trout in Wyoming, a hemangioma from a hatchery brown trout in Wyoming, and a hemangioma from a hatchery rainbow trout at Manchester, Iowa.

Histopathology of salmonids.--The following pathological conditions were studied and the histopathology was described: virus disease of blueback salmon, granuloma of eastern brook trout, massive ceroid deposition in livers of Leetown rainbow trout, acute pancreatic necrosis of Leetown trout, and effect of prophylactic feeding of sulfonamides and antibiotics.

Hematology of salmonids.--Blood smears were taken from each fish collected for studying normal hematology. Approximately 2,500 such smears are available for study. Each smear can be identified with the fish from which it was obtained; this permits a correlation of hematology with histology.

Intermediary metabolism and cellular physiology of fish.--Methods developed by Schneider and Hogeboom for fractionation of mammalian liver into subcellular components by differential centrifugation have been adapted to salmonid liver. Cytology of various fractions and effects of various types of homogenization and suspending media on this cytology have been studied with the phase microscope. Like mitochondria from mammalian liver, those from salmonid liver are rod-shaped and this shape is preserved when they are prepared and maintained in ice cold 0.88 Molar sucrose. Warming to room temperature for a few minutes or exposure to more dilute media causes the mitrochondria to swell. Cytological alterations which Harmon noted in mammalian mitochondria on exposure to hypotonic media occur with fish mitochondria when they are exposed to a sucrose solution which is isotomic for mammalian tissues.

An abnormal particulate material with a sedimentation velocity close to that of mitochondria was found in livers of yearling chinooks fed on the standard production diet. These granules were present after several days of fasting. Their nature and possibly identity with ceroid will be investigated.

Livers of 4 adult spring chinook salmon and 3 blueback salmon have been homogenized and separated into nuclear, mitochondrial, micromal, supernatant and "cream" fractions. The process of analyzing these fractions has been initiated.

Metabolism of fatty acids by salmonids.--A study of the effect of bile on fat absorption and fat transformation in the intestine has been started through use of bile cannulated fish. This operation, in which the bile duct is cannulated with a polyethylene tube and bile

collected outside the body, was developed after consultation with Dr. O. H. Robertson of Stanford University. Fish were kept alive and the bile collected for several hours after the operation.

An analysis of lipid components present in various subcellular components of fish livers has been initiated. Both chinook and blueback salmon were used; their livers homogenized to break cell walls and resulting nuclei, mitochondria, and microsome fractions analyzed for phosphorus, nitrogen, choline, glycerophosphate, fatty acids and steroids.

In vitro oxidation of acetate has been accomplished through use of blueback salmon liver slices. A satisfactory pH and temperature have been determined for oxidation. Endogenous oxidation was found to stay at a plateau over a wide pH range. Reactions occurring are being compared in chinook salmon and rainbow trout.

III. WESTERN FISHERY DISEASE LABORATORY

Robert R. Rucker, Seattle, Washington

Virus disease.--Information has been accumulated which indicates virus may be present in fish products used for feeding fingerlings. Experimental groups of sockeye salmon were raised last season at Leavenworth, Winthrop, and Little White Salmon Stations, all in the State of Washington, on 2 separate water supplies and on 2 diets -- 1 diet consisting of all meat and the other fish products. Virus disease developed among production fish at the 3 stations. In the experimental groups, virus disease developed only at Leavenworth; it developed in only 1 trough of the 3 troughs of fish being fed the viscera diet and in none being fed the meat diet.

Last season at the Entiat, Washington Station, where the virus disease had not been recognized previously, only fish receiving salmon viscera contracted the disease; of these only those receiving a specific lot of the viscera became diseased.

This season an extensive experiment is under way at the Leavenworth Station to determine the virus source. When the experiment was started, groups of eggs were divided in half. Fish developing from half of the eggs are being fed a straight meat diet while those developing from the other half of the eggs are being fed various viscera diets. Two troughs of sockeye salmon fingerlings, being fed British Columbia sockeye salmon viscera, have developed the virus.

A similar experiment is being conducted at the Winthrop Station where the same viscera diet used last year is being fed to half of the fish and a straight meat diet to the other half. One of 7 ponds of fish on the viscera diet has developed the disease.

Processed viscera.--The feasibility of using heat-treated viscera in place of frozen viscera as a dietary supplement for sockeye salmon fingerlings is being considered. A third of a lot of frozen salmon viscera was heated sufficiently to kill the virus (pasteurized) and another third processed in the regular canning method by the Service's Branch of Commercial Fisheries' Technology staff. These heat-treated products and the frozen viscera are being fed to sockeye salmon fingerlings to determine nutritional adequacy. The effect at this writing of canned viscera on fish is comparable to the frozen product.

New disinfectant.--Lignasan, basically ethyl mercuric phosphate, is being considered to replace the expensive pyridylmercuric acetate commonly used for treating bacterial gill disease in salmon. The Washington State Department of Fisheries is testing this compound under field conditions.

IV. MICROBIOLOGICAL LABORATORY
Stanislas F. Snieszko, Leetown, West Virginia

Physiology of Aeromonas salmonicida.--Amino acid requirements of A. salmonicida have been completed. It possesses an absolute growth requirement for arginine and methionine. Chromatographic methods have demonstrated its ability to convert phenylalanine to tyrosine.

A medium has been developed which may help to isolate this bacterium from contaminated material.

Brook trout kidney disease.--Berlin, New Hampshire, hatchery and Leetown experiments have found sulfonamides effective and antibiotics ineffective in treating this disease. Sulfamerazine and sulfisoxazole (gantrisin) are the most promising of the sulfonamides.

Sulfonamide effect on trout.--Feeding tests were completed on effect of several sulfonamides on growth rate and histological changes of brown, brook and rainbow trout. Several sulfonamides arrest brown trout growth while all sulfonamides tested retard brook trout growth except sulfisoxazole which apparently stimulates them. They least affect rainbow trout.

Rainbow trout liver disease.--For 2 years fingerling rainbow trout at Leetown and other West Virginia hatcheries have displayed a disease which has 2 main symptoms: a severe anemia and yellow discoloration of the liver. It is not a "lipid degeneration" of liver but apparently a cirrhosis. Inoculation tests made with filtered and unfiltered extracts indicated it is not infectious.

Acute catarrhal enteritis in brook trout fry.--Indications suggest a virus caused an outbreak of this disease at Leetown. Histopathological examination revealed the condition is not an "enteritis" but a disease of the pancreas.

V. SALMON CULTURAL LABORATORY

Roger E. Burrows, Entiat, Washington

FEEDING TRIALS

The 1953 feeding trials with blueback salmon were lost because of a virus outbreak in the experimental fish. However, the fish were used in experiments to determine methods of virus transmission.

Results of the 1953 trials with chinook salmon follow:

1. Arrow-toothed halibut made a significant contribution to growth rate in every diet combination in which it was tested.
2. Growth potential of hake appears inferior to that of arrow-toothed halibut.
3. A combination diet of hog liver, arrow-toothed halibut, salmon viscera, seal meal, and distillers' solubles produced growth comparable to the standard meat-viscera-meal control diet at about half the cost.
4. Equal parts of seal meal and distillers' solubles proved an adequate substitute for salmon viscera meal when fed at the 10 percent level in combination diets. These results indicate superior growth and a significant reduction in cost may be attained by substituting this meal combination for the salmon offal meal used in hatchery diets.

The 1954 feeding trials are in progress. In general, the objective of trials with blueback salmon is to develop diets which will produce growth rate comparable to the standard meat-viscera-meal diet and yet eliminate salmon viscera from it. Therefore, scrap fish in combination with meats, and meats in combination with meals are being tested.

The 1954 chinook feeding experiments are directed toward using a 50 percent level of dry feeds in combination with various meats and fish products. The objective is to reduce diet cost through use of cheaper protein sources. After 6 weeks of feeding 50 percent meal, diets are not comparable to the standard meat-viscera-meal combination in growth production.

To improve feeding consistencies of diets, 2 chemical binders, ethyl hydroxyethyl cellulose and carboxymethylcellulose, were compared with the binding action of salt and meats in various production diets. Preliminary tests indicated synthetic binders were, if anything, inferior to salt-meat combinations when turbidity as measured by a photocolorimeter was used as the solubility measure. Further work is planned in this field.

EFFECT OF GONADOTROPINS ON SALMON MATURATION

For the first time in these investigations it has been possible to demonstrate a marked and significant acceleration in sexual maturation of female blueback salmon injected with salmon pituitary glands. No response was indicated from comparable experiments using carp pituitary injections. In certain of the groups receiving salmon pituitary injections, spawning occurred 1 month ahead of the control groups and 2 weeks after injection. In all salmon pituitary groups, ripe males were produced within 3 days after injection. In the accelerated fish it was possible to demonstrate motility in the sperm but the eggs were not viable.

In preparation for the 1954 experiments more than 3,000 chum salmon pituitaries have been collected. Of these, 1,600 have been forwarded to Dr. A. P. Rinfret, endocrine biochemist at the University of California Medical Center, San Francisco, for fractionization. Both whole pituitaries and fraction will be injected this season.

HOLDING POND EXPERIMENTS

The electrical weir effectively diverted salmon from the Entiat River into adjacent holding ponds. Survival of adult fish to spawning was normal. Egg production and survival did not differ from previous years. The conclusion reached was that electrical diversion was applicable to production operations.

VERTICAL INCUBATOR

A vertical incubator with a capacity of 1,000,000 chinook eggs or 3,000,000 blueback eggs was constructed and operated. Results were satisfactory. Tests conducted at the Spring Creek Station by the Service's Branch of Game-fish and Hatcheries were not as encouraging as those conducted at Entiat. A slight alteration in construction of the pans whereby the water level was held higher and the outflow was not directed properly appeared to have caused the difficulties encountered.

THRESHOLDS OF NORMAL DEVELOPMENT FOR SALMON EGGS

One phase of this investigation is in progress. Chinook salmon eggs from the Skagit, Entiat and Sacramento Rivers are being subjected to 5 constant temperatures ranging from 35° to 45° F. at 2.5° intervals. Eggs taken in September were still in the fry stage the following July in the 35° water. No analysis of data has been made to determine racial differences, but results from all groups indicate that constant temperatures of 40° or lower are not conducive to normal development. This experiment is being conducted in cooperation with the Service's Pacific Salmon Investigations.

REARING POND DESIGN

Hydraulic conditions which develop in 3 standard types of rearing ponds have been determined. Correlation of these conditions with their biological and physical characteristics permit establishment of criteria whereby effectiveness of a pond type may be determined. Pond design improvement is being explored by means of hydraulic evaluations in models.

HATCHERY FISH IDENTIFICATION

One phase of this investigation, alteration of scale patterns by feeding, was explored by this laboratory as a part of the investigation which the Service's Pacific Salmon Investigations is conducting. Results indicate neither a reduction in growth rate nor actual starvation for a 4-week period produces recognizable alterations in scale patterns of hatchery-reared chinook salmon.

SPECIAL INVESTIGATIONS

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

The report covering the field investigation of young lake trout conducted on Lake Michigan in 1930-32 has been completed for publication. It gives in detail results on the relation between the trout catch and various sizes of mesh used in gill nets constructed for taking chubs. All important unpublished data on trout biology collected in experimental nets are presented. The scale method of determining trout age and growth is discussed. Fin-clipped trout

of known age were used to check age determination accuracy. Trout abundance was studied in relation to mesh size, fishing time, collection year, season, locality, water depth and age composition.

II. EASTERN FEDERAL WATERS

Robert E. Lennon, Leetown, West Virginia

Fish toxicity investigations.--Toxicity studies of organic compounds to selected species of fishes were continued. Chemicals screened totaled 1,085. Approximately 200 compounds proved sufficiently toxic to warrant detailed testing; 149 of them killed trout, bluegill, and goldfish within 24 hours.

Shenandoah River.--Pollution checks on fish and bottom fauna at established stations along 150 miles of the river found game fish recovery progressing satisfactorily. West Virginia Conservation Commission permits year-round bass fishing in a portion of the stream.

Shenandoah National Park.--Preliminary investigations were extended to include major Park waters; of these, Piney Run, Big Run and Rapidan River were selected for studies of their fish populations and potential productivity.

Severe drought conditions from August through February necessitated postponement of population studies with cresol until March 1954. Long stretches of streams were dry in October and November. Fish populations were reduced and native brook trout spawning was sharply curtailed. A severe flash flood on March 1 altered low-water conditions; stream beds were scoured and access roads made impassable. Advanced sac-fry trout and immature dace were collected from isolated flood pools a few days after the flood. Population checks made with cresol in 6 streams showed fish and bottom fauna were greatly reduced in numbers; in more than 1,500 yards of test waters only 11 legal-size brook trout were collected.

On the basis of these observations the National Park Service closed the streams to fishing in 1954 to permit native fish stock recovery. Restoration by stocking was not warranted because of lack of natural foods.

Great Smoky Mountains National Park.--Stream surveys and population studies made last summer and fall resulted in National Park Service adoption of several new fishery regulations. The daily creel limit for 1954 was reduced and use of natural bait abolished. Two streams were reserved for testing the Hazzard plan of recreational fishing (fishing with artificial lures only and returning all fish alive to the water).

Population studies were resumed and extended in May 1954. Use of cresol as a fish census technique was improved to yield increasingly accurate data.

Through cooperation of the Branch of Game-fish and Hatcheries of the Fish and Wildlife Service and the National Park Service, 500 legal-size and 9,800 fingerling Appalachian brook trout and 1,000 legal-size and 2,000 fingerling rainbow trout were fin-clipped and planted in experimental waters. Marked trout survival and recovery are being checked in population surveys and by creel census.

Results of the 1953 creel checking project on Little Pigeon River showed local anglers caught 98.75 percent of the trout. Nonresident fishermen comprised 21 percent of the fishing pressure but accounted for but 1.25 percent of total catch.

The second season of creel checking was begun on the same river on May 16, 1954. In the first 2 weeks of the season a 50 percent recovery of 1,000 marked rainbow trout was made and a slightly greater number of wild trout were caught.

SECTION OF MARINE FISHERIES HOWARD H. ECKLES, ACTING CHIEF.

NORTH ATLANTIC FISHERY INVESTIGATIONS

Herbert W. Graham, Woods Hole, Massachusetts

International aspect of research.--Research at this laboratory was closely integrated with the program of the International Commission for the Northwest Atlantic Fisheries. This Commission, which is in its fourth year, is concerned with management of the groundfish fisheries of the Northwest Atlantic. While it does not carry out research, it receives reports of and assesses plans for research conducted by member nations.

Georges Bank haddock fishery.--As a result of many years of United States research on Georges Bank haddock stocks, an international mesh regulation became effective last year which makes it illegal to fish for haddock on Georges Bank or in the Gulf of Maine (Subarea 5 of the International Commission) with a net having meshes less than 4-1/2 inches inside dimension. Study of biological effects of this regulation, which has been in operation a year, will constitute one of the most important aspects of research at the Woods Hole Laboratory during the next few years, as the Commission approved the regulation on an experimental basis and requires a careful assessment of its effect.

The larger mesh has proven so successful that fishermen from other countries fishing in other Subareas of the Commission are voluntarily adopting larger mesh nets. There is great interest in immediately extending the regulation to Nova Scotian Banks (Subarea 4) and in considering application of a similar regulation to the entire Convention Area which extends to the west coast of Greenland.

Effectiveness of the large mesh is twofold. It permits small unmarketable fish to escape but holds the larger ones. As a result, more pounds of fish are caught and landed while baby haddock escape. These effects were immediate and did not result from increased fish abundance on the banks. Benefits resulting from baby haddock conservation will not be realized until next year and may not be mathematically demonstrable until sometime after that.

Since haddock abundance on the Bank varies considerably from year to year, a direct comparison of catches after regulation with catches in pre-regulation years would have no significance.. Use of several commercial vessels licensed to use the old, small mesh gear has made possible assessment of effects of the larger mesh. A measure of the benefit of the large mesh is obtained by comparing the catch of these vessels after regulation relative to their previous

catches, with relative catches of vessels using large mesh gear. Catches of small mesh vessels have been down about 10 percent which indicates a decreased fish abundance this year. However, catches of the large mesh vessels have remained steady.

Continued saving of small fish through use of the larger mesh should result in an increased yield from each year class that enters the fishery. The large mesh is not expected to affect incoming brood strength. Natural factors cause wide fluctuations in successive broods year by year and commercial landings fluctuate accordingly. The problem of the Woods Hole Laboratory is to demonstrate effect of regulation on the yield from each year class whether it be initially a strong or a weak brood.

This program requires an accurate measure of the strength of each incoming year class (2-year-old fish) and a measure of the pounds landed from this age group throughout its life in the fishery (about 5 years). Data and specimens collected at principal ports and at sea on commercial trawlers are being examined and analyzed.

Dynamics of the Georges Bank haddock population are sufficiently well known that catch predictions can be made at the beginning of each year. Annual predictions have been made for several years with a high degree of accuracy. The predicted catch of 73.6 million pounds for 1953 was within 4 percent of landings; prediction for 1954 is 74.4 million pounds. The incoming year class often contributes a high percentage of the total catch so that catch predictions from a study of commercial catches alone cannot be made more than a year in advance.

A series of vessel surveys was initiated in 1953 to determine the fate of haddock eggs spawned on Georges Bank.

Three plankton surveys of the Gulf of Maine and Georges Bank were conducted in the spring of 1953 by the vessel Albatross III. Drift bottles were released throughout the areas studied. Results of these surveys indicate a poor egg and larvae survival in 1953. Drift bottle returns corroborate results of plankton data and indicate a high percentage of eggs and larvae was swept out to sea and lost during that year. A September search found few young bottom fish. A definite confirmation of the indicated weakness of this year class must wait until next year when that age group is due to enter the fishery. Routine market sampling will then determine its relative strength.

Study of haddock food habits has been in progress for a year. Contents of 2,000 stomachs from fish caught at 41 locations have been analyzed and a report on these findings is in preparation.

Georges Bank seems to have 3 food-type areas: (1) Northern Edge - characterized by amphipod crustaceans; (2) Northeast Peak - characterized by brittle stars, toad crabs, and annelid worms; and (3) Southeast Part - characterized by sand dollars, amphipod and cumacean crustaceans.

Georges Bank haddock include small amounts of fish in their diet in contrast to Nova Scotian western banks haddock which subsist as much on small fish as on invertebrates. This study must extend over several years before it can be known whether availability of food organisms on the bottom influences haddock abundance and distribution.

Nova Scotian haddock.--A large percentage of United States haddock catch is taken from Nova Scotian Banks. Although market samples have been collected for many years, it was not possible to start analyzing the accumulated data until this year.

Certain areas on the Nova Scotian Banks (Subarea 4 of the Commission) have been selected for intensive study. Dynamics of these populations will be worked out and results submitted to the Commission in conjunction with recommendations for regulating the fishery in this Subarea. Canadian biologists are pursuing similar studies on other populations in the Subarea. Recommendations for regulation will come from an international group of biologists.

Haddock tagging.--Fish tagging is essential for defining stocks and may be used to establish mortality rates. Experiments during the year with various tag types have shown superiority of a new internal anchor tag. About 1,500 fish have been tagged in these preliminary tests. Tagged haddock have been successfully held in aquaria. From observations on these fish and results obtained in tagging fish at sea a large tagging program was outlined for the coming year.

Mesh selectivity.--In conjunction with the international mesh regulation for the New England area and in anticipation of an extension of the regulation to other areas, experiments on selectivity of various mesh sizes were conducted on the vessel Albatross III. Experiments were designed to provide percent escapement of each size of fish, percent escapement through belly of net, percent escapement through each part of the cod end, and effect of fine mesh covers, vessel speed, and catch size on selectivity.

Climatic change.--Evidence of a climate amelioration in New England continues to accumulate. Important changes in marine fauna are taking place in response to warming of the waters. Studies of this problem are continuing but are hampered by lack of long-term records of subsurface water temperatures. However, important changes in range of certain marine creatures, such as the green crab which has extended northward, are occurring at a rapid rate. Possible effect of climatic change on the important commercial fish species is demanding careful attention.

Redfish.--Work concentrated on determining growth rate. Since a European worker challenged the Woods Hole Laboratory's original estimate of a slow growth rate, precise data were collected and analyzed to determine growth rate of redfish on the American side of the Atlantic.

Specimens were collected from the same stock every 3 or 4 months. From these collections an increasing width of a zone of material deposited on the otoliths was observed. The establishment that only 1 otolith ring is laid down each year confirmed the Woods Hole Laboratory's original estimate of growth. Older fish grow only about 1 centimeter a year. Age of fish in the commercial catch varies from 6 to 20 years and age at first maturity is about 11 years for males and 9 for females.

With redfish age and growth no longer a mystery, mortality rates must be established for stocks supporting the commercial fishery. To do this, the abundance of each age in the population for a number of years must be determined.

For many years careful records have been kept of relative redfish abundance from areas fished by the United States fleet. Total abundance has leveled off in the Gulf of Maine, Nova Scotian Banks, and Gulf of St. Lawrence. Rich grounds on the Grand Banks decline 15 percent in abundance during the past year.

A puzzling aspect of the redfish fishery is maintenance of average size of fish in the face of declining abundance. A possible explanation for this phenomenon is the presence of a large stock of fish in the depths which may continue to supply fish to commercial grounds. Greater exploration in deeper water, midwater trawling, and tagging must be used in attacking this problem.

Delaware Bay survey.--The continued survey of the sport and commercial fisheries of this area is designed to yield information on possible industrial pollution effects.

A biological study of menhaden was initiated with expectations of developing a research program on this species in the area.

GULF FISHERY INVESTIGATIONS

Albert W. Collier, Galveston, Texas

General.--Results of a comprehensive fishery and oceanographic survey of the Gulf of Mexico are being analyzed to establish the chemical composition and circulation pattern and to study other organisms, in addition to fish, for taxonomic, distribution and environmental interpretations. The vessel Alaska was used to collect water and plankton samples and physical data for the Gulf FisheryInvestigations, the Department of Oceanography of Texas Agricultural and Mechanical College and the United States Geological Survey, Trace Elements Section. The collection of samples and data by the Gulf Fishery Investigations includes plankton, water for chemical analysis and bottom and water samples for the Geological Survey.

Biology and chemistry of the Gulf of Mexico.--All tow net plankton data have been reduced to a standard volumetric basis. Their classification according to surface areas above the depth zones shows the waters over the shelf (0-100 fathoms) are the most productive, those over the slope (100-1,000 fathoms) are next, and those over the abyss (over 1,000 fathoms) lowest. Zooplankton caught over the shelf is about three times in volume that caught over the abyss; fish larvae were 4 to 1 in number and fish eggs 50 to 1 in number. In all cases slope values are nearer to those for the abyssal zone than those for the shelf.

The same data organized according to geographic regions show the northwest, northeast and southeast shelf areas were the most productive and those regions receiving the Mississippi River discharge were the highest in productivity. The area bound by Longitude 94° W. on the west, longitude 85° W. on the east, latitude 27° N. on the south and the United States coast on the north is the most promising in the Gulf of Mexico for fisheries development. This interpretation is tentative until full information is obtained from the southwest Gulf.

The vertical distribution of inorganic phosphorus in the Gulf of Mexico is similar to that ordinarily given for the Atlantic Ocean, i.e., low values at the surface, a gradual increase to a maximum of about 2.5 /ug-atoms/liter at about 700 meters and then a gradual decline to approximately 1.5 at 1,500 meters. Nitrates correspond to this curve with a nitrate phosphate ratio of 15:1 where the maxima occur at about 700 meters. In a zone just above the phosphate and nitrate maxima, carbohydrate and tyrosine determinations indicate a maximum of organic material which occupies a stratum lying principally between the 100 and 500 meter levels. This may represent a downward extension of the photosynthetic zone and would suggest an investigation to determine if this is a productivity which a deep sea fishery can use to advantage. At times the organic analyses indicate a greater level of photosynthetic activity than exists in the upper 100 Gulf meters.

Analyses of chemical samples taken on the Alaska cruises were completed and efforts turned to developing and appraising analytical techniques available for sulfides, ammonia, sulfate, carbon dioxide, carbonate, bicarbonate, dissolved oxygen (miro-analytical procedure), copper, and various trace elements.

Through continuous dialysis, vacuum distillation and chromatographic separations various carbohydrates were extracted from mixed algae tank cultures. One component has been tentatively identified as a polysaccharide having some characteristics of gum arabic. Production of carbohydrate-like substances which give N-ethyl-carbazol traces with peak absorptions in the 540 to 570 /un region of the spectrum is associated with photosynthesis.

Preparations were completed for studying proteinaceous substances which occur in the open sea in varying quantities (0.0 to 4.0 mg/liter tyrosine). Significant tyrosine values occurred at all depths sampled.

Red Tide.--When the September 1953 Red Tide outbreak occurred the microorganism Gymnodinium brevis was isolated and a medium evolved in which it could be grown as a unialgal culture (not bacteria free). In a series of experiments, tube cultures were enlarged to 10-liter tank cultures which culminated in development of small-scale blooms which were toxic to fish. The success with Gymnodinium brevis was made possible by success with cultures of a related species, Gymnodinium splendens. Cultures of the latter tested for toxicity on fish (Membras and Mollienesia) were non-toxic at concentrations of 3,000,000 cells per liter. Gymnodinium brevis was toxic at 1,300,000 cells per liter, a concentration which does not cause a pronounced water discoloration in the 5-gallon pyrex container where the culture is maintained. In the deeper waters of the Florida littoral regions, however, this concentration would cause the "milky green" which often characterizes areas where fish are killed.

These mass laboratory cultures are set up so cells can be harvested daily and the volume of total culture removed made up by adding fresh medium. Daily and biweekly sampling has been made for pH, carbon dioxide, nitrate nitrogen, phosphate phosphorus, carbohydrate, tyrosine, ammonia, and sulfide in these cultures. Metabolic studies on mass cultures are used in interpreting field data and will assist in diagnosing field conditions which can lead to a Red Tide.

Field surveys which began with the September 1953 outbreak have shown Florida waters have never been entirely free of Gymnodinium brevis. Although suitable hydrographic conditions have been present to some degree through the whole period, it is unknown whether continued presence of G. brevis is because of these conditions or because of im-

proved techniques for locating the organism when it is not in bloom. Data from laboratory and field studies support the tenative conclusion that optimum salinity for a bloom of this organism lies between 32 and 34 parts per thousand.

Analysis of climatic factors has confirmed the theory that rainfall distribution is a prime factor in initiating fish kills.

Laboratory experiments have further confirmed the theory that decaying fish bodies reinforce the blooms.

ICHTHYOLOGICAL LABORATORY

Isaac Ginsburg, United States National Museum, Washington, D. C.

One of the major problems of the science of taxonomy is what constitutes a species. Because this problem is in a state of flux Mr. Ginsburg has developed a method in attacking it which is adapted to needs of taxonomists in drawing appropriate conclusions from their data. Four papers treating of various phases of this problem have been published; his fifth paper is listed in the Publications Section of this report.

Work was concluded and a manuscript prepared on the important group of fishes belonging to the genus Merluccius, commonly known as whitings in the region of their greatest abundance, the coast of the North Atlantic states. Data prove these whitings, which enter the commercial catch in large quantities on the coast of the North Atlantic states, belong to 2 species instead of 1 species as hitherto thought. This paper includes accounts of all species of whitings occurring on the Atlantic and Pacific coasts of North and South America. It describes 1 unknown species from the Gulf of Mexico that may have economic possibilities, a new species from the coast of Chile and a new subspecies from Peru.

Studies continued on the western Atlantic species of the family Scombridae, including such species as mackerels, tunas and bonitos, and on the family Percophididae.

A number of hitherto undescribed species of marine fishes discovered in collections made under Fish and Wildlife Service auspices in waters of the southern states on the Atlantic and Gulf coasts have been studied and accounts of them prepared for publication. To definitely identify these species, the present state of knowledge of the whole family must be studied and reviewed. At least 1 species may prove exploitable in fishing operation and form an addition to the number of species of commercial food fishes. It is said to have a good flavor, reaches a marketable size and seems to occur in considerable numbers in offshore waters on the coast of the Gulf states.

SOUTH PACIFIC FISHERY INVESTIGATIONS

John C. Marr, Stanford, California

General.--The South Pacific Fishery Investigstions is cooperating with Scripps Institution of Oceanography of the University of California, Bureau of Marine Fisheries of California Department of Fish and Game, Hopkins Marine Station of Stanford University, and California Academy of Sciences in the California Cooperative Oceanic Fisheries Investigations. The Marine Research Committee is coordinating the research. They continued their study of the Pacific sardine, greatest contributor to the fish catch of the Nation until the sharp abundance decline after 1944. By determining variations in amount and range of spawning, in current patterns, and in other characteristics of the marine climate off the West Coast, they are attempting to determine population size in various years and fluctuation causes.

Sardine subpopulations.--Sardine scale studies have proven valuable in several phases of the subpopulation problem. Fish in different areas have different growth patterns (discussed by Phillips, 1948, and Felin, 1954). Fish in the Pacific northwest grow faster, reach a larger size and older age than fish off central California, which in turn grow faster than fish off southern California, etc. The sardine in different parts of its range also differs in the size attained at time of formation of the first annulus. The average size at first ring formation is generally largest from southern California (including Ensenada), decreasing both to the north and south of this. Examination is being made of the relation of first growth increments to predicted size as an approach to the problem of origin of stocks. An interest obtains in origin of year classes, whether predominantly northern or southern, because of influence on fish availability to fishermen and possible influence on size of year classes.

In line with this project, the 1948 year class is being carefully studied, since in recent collections this year class is bimodal in its length distribution. In catches of the past season, the 1948 year class was 5 years of age. Individuals of the smaller group of 5-ring fish have a significantly different growth curve from individuals from the larger mode. The difference in means of the 2 groups lies between the 1 and 5 percent significance level.

Growth experiments.--One of 2 experiments conducted on related species of Xiphophorus to determine the nature of certain growth observations has been terminated. Xiphophorus maculatus appeared to have reached its asymptotic length under present conditions.

The experiment on X. maculatus, which lasted 14 months, was conducted at 2 food levels; two tanks of fish were used for each food level.

At the start of the experiment 16 fish were placed in each of the 4 tanks. Although the 2 tanks of fish fed at the higher food level showed a more rapid initial growth, the rate of deceleration of growth was also more rapid (0.6653 and 0.6612 for the higher food level as compared to 0.6884 and 0.6949 at the lower food level). The asymptotic length reached by fish held at the 2 food levels was almost identical (37.5 mm. for the lower food level and 37.6 mm. for the higher food level).

Conclusions drawn from the experiment are (1) the lower food level must have been nearly optimal for food increase did not influence growth rate or the asymptotic length reached by the fish and (2) the significant differences in growth for fish fed at the 2 levels occurred during the first 2 months of the experiment. Therefore, more frequent measurements of growth, preferably at weekly intervals, should be made at the start of the experiment, if repeated.

Use of paper chromatography in studying subpopulations.--Studies are being conducted to evaluate paper chromatography as a tool in identifying species or smaller subgroups of fish. Whether the environment of fish influences chromatograms is of prime interest.

The problem is being investigated on the sardine and on 2 closely related species of Xiphophorus. Each species has been separated into 2 batches, one of which is fed a maximal vegetable diet, the other a maximal animal diet. The sardine experiment is being conducted at the aquarium of the California Academy of Sciences on sardines caught off central Baja California.

Sardine population size.--Two methods are being used to estimate population size, 1 based on total annual egg production in conjunction with fecundity data, the other on catch, age and effort data.

Estimates of the total number of eggs spawned are available for the years 1950-53. The largest estimate is for 1951 (611×10^{12}), the smallest for 1952 (146×10^{12}). The 1953 estimate for the main spawning period (January-June) amounts to approximately 100×10^{12} eggs. Off-season spawning during 1953 was heavier than that for previous years. Although data for this period are not completely worked up, the estimate of eggs spawned during the period July through December may be as large as the estimate for the first half of 1953. The off-season spawning may (1) result from a separate subpopulation (in which case it is increasing in numbers) or (2) be produced by young sardines spawning for the first time, probably at 1-1/2 years of age (in which case it is further evidence that the 1952 year class is better than the three preceding year classes) or (3) result from spawning of the main sardine population of all ages -- unlikely, but still a possibility.

Adequate fecundity data are needed to translate egg numbers into estimates of number of spawning females. Main problems in fecundity studies may be simply stated: (1) how many eggs are spawned per batch by females of different sizes and ages, and (2) how many batches are spawned per season by females of different sizes and ages?

An investigation of the number of ova in the largest developing mode has shown the number decreases as ova increase in size; atresia probably causes this.

The number of eggs spawned by fishes has been correlated with body length (to the first, second or third power), weight and/or age. The number of ova will often show a straight line correlation with any of the above. In theory, the best relationship between fish length and fecundity should be with the cube of the length. In the sardine, however, those individuals having a high condition factor (a measurement of weight-length relationship) may produce more eggs than fish of comparable lengths having a low condition factor. Furthermore, sardines near the midpoint of the length range of spawning fish tend to have a higher condition factor than those at the ends of the range.

Estimates based on commercial catch data.--Since the 1951-52 season, California landings have been small, and the California Department of Fish and Game has not attempted to give effort or catch-per-unit-of-effort data. Currently, with less than 1 percent of the sardine population estimated to be in waters off the United States, as shown by egg and fish scouting surveys, population dynamics data can be obtained only from research ships. More effective methods of locating and sampling fish schools during scouting surveys are needed.

Availability.--To understand availability phenomena, pilchard behavior must be understood. A behavior understanding requires an acquaintance with the anatomy of the sensory systems and the way they function (under controlled conditions). As a preliminary step, anatomical details of the sensory systems are being investigated.

A study describing the gas bladder and its relationship with the inner ear in the sardine and anchovy has been completed. Form and orientation of the gas bladder are compared in the 2 species. In the sardine, the pneumatic duct arises from the end of the blind sac of the stomach, the gas bladder is single-chambered and has a post-anal opening to the exterior. In the anchovy, the pneumatic duct arises from the dorsal wall of the cardiac stomach, the bladder is 2-chambered and has only a short blind caecum at its posterior end.

An investigation of the lateral line system and the cutaneous sensory system is in progress.

Causes of year-class strength variation.--Sardine spawning during 1953 was, in most respects, similar to that of 1952 and earlier seasons. Spawning decline off southern California and adjacent Baja California continued. During the past 4 seasons, the percentage taken in the principal spawning areas was as follows:

Year	Spawning north of Point Conception	Southern California and adjacent Baja California spawning center	Central Baja California spawning center
1950	0.8	17.2	82.0
1951	0	5.6	94.4
1952	0	3.1	96.9
1953	0	0.9	99.1

Sardine larvae collected during 1953 have been measured and their numbers standardized. Determinations of abundance and survival of different size larvae groups are being made.

Procedures followed in determining abundance and survival rate of sardine larvae are discussed in a paper to appear as Fishery Bulletin 93 (now in page proof). Estimates of sardine larvae abundance are not as readily made as egg abundance estimates because of difficulties in (1) sampling larvae (net selection, i.e., small larvae loss through mesh openings in standard nets and day escapement, i.e., undersampling during daytime which increases with size) and (2) getting precise data on growth rate.

Rearing marine fishes.--Rearing trials have been conducted on 17 identified species. Five species have been raised from the egg stage to metamorphosis; these are Aulorhynchus flavidus, Leuresthes tenuis, Atherinopsis californiensis, Clinocottus recalvus, and Oligocottus snyderi. Several species have been collected as partially grown larvae and reared to metamorphosis; included in this group are Citharichthys stigmaeus, Engraulis mordex and Sebastodes spp. Larvae of several species hatched from eggs raised in the laboratory have been carried for a few weeks to 2 months after yolk sac absorption, but died before completing metamorphosis. Included in this group are Sebastodes goodei, Sebastolobus sp., Genyonemus lineatus, Spirinchus starksi, Clupea pallasi, Clinocottus analis, and Hexagrammos sp.

Eggs and larvae have been reared in cylindrical stoneware crocks which hold 27 to 28 liters of water during trials.

Principal mortality causes during rearing trials are (1) bacterial infections, (2) mortality associated with gas bladder development, (3) renal calculi, and (4) mortality because of temperature fluctuations. Bacterial infections usually occur after larvae have suffered abrasions from contact with sides of rearing containers, a condition that would seldom occur in nature. Mortality at the time of gas bladder development was not associated with excessive amounts of gas in the water (a condition experienced by some investigations), but rather with complete failure of gas to appear in the bladders. In a number of trials, mortality of individuals coincided with appearance of hard, gritty calculi in the renal tract. Temperature control inadequacies are held responsible for the greatest larvae mortality. In a number of trials, larvae were doing well as long as the temperature was controlled within narrow limits, but died when unavoidable temperature fluctuations occurred.

Particular attention has been given to food and feeding mechanisms of young larvae. Because of inability to digest many organisms taken in as food, young larvae probably must depend, at least in part, on dissolved and colloidal organic material in the water. This idea is not new. Pütter tried for years to substantiate a similar idea. His theory was discarded because there did not seem to be an adequate mechanism by which fish larvae (or other organism) could obtain organic nutrients. What is new is that a possible mechanism in young larvae has been found. Young larvae of Spirinchus starksi and Engraulis nordax have been found to have a large mucous area in the mouth that may function in removing colloidal (and possibly dissolved) organic material from water taken in during respiration. Experiments are planned to test the idea, probably through use of radioactive carbon as a tool.

Hatching eggs at sea.--During 2 cruises of 1954, eggs collected at sea were sorted from plankton hauls and raised to hatching. Purposes of these rearing trials are to (1) follow development of living material of known types, (2) build up a series of stages of unknown fish eggs and (3) obtain information on egg development rate (in relation to temperature). Among the species successfully hatched at sea were sardine, northern anchovy, jack mackerel, Pacific mackerel and Bathylagus wesethi.

Other fishes.--In addition to the sardine, larvae of the northern anchovy, jack mackerel and Pacific mackerel are enumerated and measured, and hake and rockfish (Sebastodes spp.) larvae enumerated. The 1953 collections differ from those of previous years in relative abundance of the above species. Year by year coverage has tended to become more intensive in the 2 major sardine spawning centers and less extensive as a total area; this trend continued in 1953. As a result, species with widespread, offshore distributions, such as hake and jack mackerel, were sampled less intensively than previously, while species such as sardine and anchovy, were sampled much more intensively than previously.

Relative abundance of the above species in the 1953 collections follows:

	Number taken	Percent of total
Sardine larvae	20,274	6.1
Anchovy	103,245	31.1
Jack mackerel	7,522	2.3
Pacific mackerel	1,320	0.4
Hake	40,350	12.1
Rockfish	35,244	10.6
All others	124,506	37.4
	332,461	100.0

Anchovy larvae dominated the collection; they were 2-1/2 times as abundant as hake larvae (which in previous seasons outnumbered anchovy larvae) and over 5 times as abundant as sardine larvae.

Jack mackerel.--A manuscript has been submitted for publication on jack mackerel, and a study is being made of survival rates during early stages.

Hake.--In a manuscript submitted for publication, hake eggs and larvae are described, and hake larvae distribution and abundance during 1951 and 1952 are discussed.

Zooplankton.--Zooplankton volumes continue to be routinely determined. Two additional papers dealing with zooplankton volumes have been prepared, 1 reporting on the 1949 and 1950 collections, the other on 1953 material. These reports record volumes of plankton collected during regular survey cruises and haul data (locality, time of collection, depth of haul, volume of water strained, etc.) for all plankton tows made on these cruises.

Anchovy fishery.--Cooperative studies with the California Department of Fish and Game on sampling the catch and determining age have been continued.

California gray whales.--Two independent censuses were made of the California gray whale. At Point Loma, near San Diego, the National Park Service and the Fish and Wildlife Service daily counted gray whales migrating south to their calving grounds. An air census over the calving grounds was made principally by Scripps Institution of Oceanography.

The Point Loma count of 792 whales during the period December 26, 1953 to March 15, 1954 is lower than the count during the preceding season. The sharp tapering off of the count after January probably indicated the whales had passed by earlier this year than last. Air census estimates of whales on the calving grounds are not available for comparison with the Point Loma counts, although they are higher.

PACIFIC OCEANIC FISHERY INVESTIGATIONS

O. E. Sette, Honolulu, Hawaii

GENERAL

Research on the 4 major projects continued with changes in emphasis. The initial phase of locating and describing yellowfin stocks near the Equator ended and commercial fishing on a limited scale has begun. Results of equatorial and commercial fishing studies are being published.

Increased effort was expended on sea work and laboratory study of the Hawaiian skipjack. Concurrent research on tuna reaction to artificial stimuli in ponds and at sea continued. The phase of the study dealing with tuna reaction to chemical stimuli was completed and the study of visual stimuli was begun, with observations being made primarily at sea.

A hydrographical and biological reconnaissance of the region north of Hawaii was carried out in cooperation with the State of California; two POFI vessels explored the region north of Hawaii while California vessels covered the area intervening between POFI and the mainland coast. This survey, designed to locate and describe albacore fishing grounds in the subtropical Pacific, is planned as a cooperative research project by various Pacific Coast fisheries agencies and POFI.

Sea work included 5 cruises in equatorial waters, 1 of which passed through the Marquesas, Tuamotu and Society Islands; 6 cruises were made in Hawaiian waters to study features of ocean circulation affecting tuna school distribution and to delineate distribution from inshore island waters to about 1,000 miles offshore; 2 survey cruises were made in potential albacore waters north of Hawaii; and 1 local cruise tested new designs in fishing gear and oceanographic equipment.

RESEARCH

Yellowfin abundance.--Tuna abundance in central Pacific equatorial waters has been estimated, limits of the yellowfin tuna resource located near the Equator south of Hawaii have been defined and relationships between tuna and ocean currents more accurately described. Cruises have substantiated earlier findings that the region between 0° and 5° N. latitude and about 140° and 165° W. longitude consistently yields the highest catch rate of tuna on POFI experimental gear. POFI's all-time average catch rate within this zone of best fishing is 6.8 yellowfin per 100 hooks, with a range of averages from 3.4 to 11.7 yellowfin per 100 hooks for the best 4° of latitude on each of 11 fishing sections crossing the Equator. One cruise of the Charles H. Gilbert along 110°

W. longitude increased knowledge of the easterly extent of the band of yellowfin at the Equator. Although the catch rate on 110° at the 5 best stations was only 2.6 yellowfin per 100 hooks, this cruise, with previously collected data on 120° W. longitude, proved yellowfin extend continuously along the Equator from 180° east to the American continent. Japanese commercial fishing west of 180° shows they also extend continuously to Asia.

Catch rates.--Because POFI cruises to the Equator are intermittent, seasonal differences have been difficult to assess. During 1953, 4 cruises at different times of the year showed catch rates as follows:

	January-February	May	July-August	December
Number of fishing stations	4	4	5	5
Average yellowfin catch per 100 hooks	2.4	5.5	7.3	1.6

These data indicate more clearly than previous years' records that best catches occur during late summer.

Effects of islands upon yellowfin distribution near the Equator were studied. Cruises designed to test this feature gave catching rates 1.8 times better around the islands than in the ocean. Catch rate of medium-sized and larger fish was about the same on both types of locations. The increase was attributable to presence of small, surface-schooling yellowfin around the islands in addition to the ever-present adults found at mid-depths regardless of nearness to islands.

Distribution of chemical and physical properties--equatorial zone.--Data from all equatorial oceanographic cruises are being assembled to determine geographical and seasonal distribution of physical and chemical properties in the mid-Pacific equatorial region. Data from oceanographic cruises by other activities (such as the Shellback, Carnegie, Albatross, and Galathea) are being included to supplement POFI data and extend the geographical coverage.

Preliminary examination suggests that along the Equator from 110° W. (the eastern limit of available data) to about 155°-160° W. there is a gradual deepening of the thermocline from near the surface to 400-500 feet, but from 155°-160° W. to 165° E. thermocline depth changes little. All properties studied demonstrate the region between 155° W. to 160° W. is a transition zone between eastern and western areas of the sector under study. Several biological indices support

the idea that ecological conditions in the eastern half may differ from those in the western half of the section.

Christmas Island field station.--With cooperation of the United States Weather Bureau, POFI set up a field station with meteorological instruments and 2 sea temperature thermographs on Christmas Island. Recording thermometers have been difficult to keep in operation but have functioned over long enough periods to give records of surface water temperature variation. Accompanying weather data are expected to show variation causes.

Tuna biology.--Studies of tuna biology continued. The bigeye tuna, P. sibi, spawns in the equatorial Pacific Ocean at a minimum size of about 20 pounds. Maturing females were found during most months of the year in equatorial waters, but none of the fish taken in Hawaiian waters were as advanced as the equatorial bigeye tuna in spawning condition. From 2.9 to 6.3 million eggs are estimated to be released during 1 spawning; there is evidence these tuna spawn more than once per season.

Tuna larvae.--A detailed description of various tuna larvae found in central Pacific waters has been completed and a report thereon is in preparation. Tuna larvae distribution in equatorial waters closely parallels that of zooplankton, with both skipjack and yellowfin larvae, the predominant tuna species in the plankton, being found in greatest abundance in the central Pacific from 5° S. to about 8° N. latitude and from 120° W. longitude to 180°. Larvae seem to be equally abundant from about 140° W. longitude to 180°, a distance of about 2,500 miles. While POFI experimental fishing in equatorial waters produces preponderantly adult yellowfin tuna, over 3 times as many skipjack larvae as yellowfin larvae are taken in the quantitative plankton tows. Obviously, POFI's sampling methods are not accurately measuring skipjack populations, either in its scouting or longline fishing. Large skipjack stocks must spawn near the Equator; at this time it is only conjectural whether these spawning stocks contribute to existing commercial skipjack fisheries elsewhere.

Tuna age and growth.--Analyses of both yellowfin and bigeye tuna length and weight frequency data for evidences of age and growth are being completed. Bigeye tuna weight data from the commercial "ahi" fishery of the Hawaiian Islands indicate they apparently do not spawn every year. An annual alternation of size groups occurs, the same modal size appearing in the Hawaiian fishery every other year. Growth, measured from progression of frequency modes, appears to average about 40 pounds each year, with good evidence that 7-year-old fish are about the oldest distinct age group to occur in the Hawaiian Islands.

Yellowfin length frequencies from equatorial waters show 2 distinct modes which occur in about the same position in POFI samples throughout the year. This consistency in modal sizes has prevailed more or less regularly through the 3 years since experimental longline fishing in central Pacific equatorial waters began in earnest. No progression of modes can be found during succeeding seasons of the year. One explanation for this lack of progression might be that ingress and egress of the 2 size groups of yellowfin in mid-depths sampled by longlines are relatively constant. Where the fish come from and where they go after leaving this environment is highly speculative; it is not difficult to imagine the equatorial belt of favorable environment is only a stopover in some, as yet unknown, migratory pattern.

Commercial fishing trials.--Two commercial fishing trials to equatorial waters were completed and a third trial begun. Two West Coast fishing vessels, the Alrita and North American, under contract with POFI, completed 2 longline fishing trips to the Line Islands region south of Hawaii between late February and mid-May, fishing a total of 121 boat fishing days and catching 210 tons of yellowfin tuna, averaging 4.75 yellowfin per 100 hooks. The line used for the hook droppers by these boats proved too light for continuous use and many fish were lost as a consequence.

Mechanical difficulties and inadequate refrigeration caused an equatorial fishing trip in April by a local fishing boat (sampan), the Taihei Maru, to be unsuccessful. Forty baskets of longline gear were fished for 5 days in the vicinity of Palmyra and caught only 2-1/2 tons of yellowfin. Because of mechanical failures the gear was retrieved by hand without use of a power winch.

Commercial development of equatorial fishing grounds.--A most significant move in the commercial development of equatorial fishing grounds south of Hawaii has occurred. The Pacific Northwest fishing company of Kayler-Dahl is undertaking development of Palmyra Island as a fishing outport for tuna longline boats. Three vessels from the West Coast are fishing near Christmas Island with steel longlines. Early reports indicate discouragingly low catch rates, which may result from use of the new and as yet unproven steel fishing gear.

Another Honolulu-based fishing boat, the Sea Hawk, is getting ready for a longlining trip to the Line Islands region. The conventional cotton gear will be used and experienced Hawaiian longline fishermen will be aboard.

Steel fishing gear.--Realizing the importance of improving the longline gear for efficient use aboard American vessels, POFI is experimenting with steel cable for mainline, with the gear wound on metal spools and set and retrieved with a modified Rowe halibut winch. Several devices for mechanically attaching hook-droppers have been tried and 1 device, a "straphanger" attachment, shows much promise. The function of the strap-hanger is to attach baited hook-droppers automatically as the steel mainline is being set, eliminating the delay caused by stopping the winch to attach the droppers by hand. A speedy and efficient way of setting and hauling this gear which would reduce the time required below that of the presently used cotton longlines has not been devised.

Plankton.--Analyses of plankton abundance in the equatorial region continued. Although there are only slight weather changes from one time of the year to another, there is considerable seasonal variation in plankton abundance. The period from January through March ranked low in standing crop of plankton for most longitudes sampled, while July, August, and September, almost without exception, marked the period of greatest production. Considering the east-west variation, POFI data show a gradient of increasing plankton abundance from west to east, with a tendency toward a leveling-off east of 140° W. As in past analyses, zooplankton was found most abundant between the Equator and 4° N. Samples taken at 3 depths -- the surface, the level of the 70° isotherm (within the thermocline), and 200 meters--indicated a significant plankton increase in the surface layers during the night. Greatest plankton concentrations occurred day and night in surface layers. There was no evidence of a concentrated plankton layer at the thermocline level at the Equator. Copepods were the most abundant group in the samples, followed by foraminifers, invertebrate eggs, tunicates, gastropods, chaetognaths, radiolarians, crustacean larvae, ostracods, euphausiids, siphonophores, and amphipods respectively.

Live-bait.--The vessel Charles H. Gilbert made a live bait survey of the Marquesas and Tuamotu Islands. Live bait was plentiful in the small bays and along rocky shores of the Marquesas. About 3,000 buckets of bait, primarily a sardine-like fish, were located and 365 buckets taken in 2 scouting days. In the atolls of the Tuamotus, however, there was little evidence of worthwhile tuna bait concentrations at the 4 atolls surveyed.

Skipjack distribution.--Studies of Hawaiian skipjack distribution and environmental factors affecting their movements continued. Six scouting cruises were carried out in 1953 in conjunction with 6 scouting flights in United States Navy PBY amphibian planes. Airplane scouting found far fewer fish schools per unit of distance covered than did vessel scouting. Principal reasons for this difference are the prevailing choppiness of Hawaiian waters and difficulty of seeing dark-colored

birds--which make up the bulk of the school-accompanying bird flocks--against the deep blue water. The Hawaiian skipjack fleet obtains three-fourths of its catch within 20 miles of land, but tuna schools were seen on POFI scouting cruises in equal numbers per unit area several hundred miles from the islands.

Hydrographic studies in Hawaiian waters revealed a semi-permanent eddy system in the lee waters of the archipelago. These eddies, well developed during periods of strong, continuously blowing trade winds, exhibit seasonal fluctuations. Circulation features in the windward offshore waters are complicated and little understood. Scouting revealed noteworthy concentrations of skipjack schools around the periphery of the eddies, about 100 miles offshore and outside the local fishery range.

Skipjack tagging.--Skipjack tagging was begun by means of the plastic tube tag developed in California; 22 have been released, primarily outside the local fishery range. Fish migrations around the islands will be traced by this means.

Artificial tuna live bait.--Search for an artificial tuna live bait continued with pond studies and sea tests with research vessels. Further tests of chemical attractants in the ponds continued to show a pronounced feeding tuna reaction to the colorless tuna extracts. However, sea tests failed to produce a noticeable reaction in skipjack schools from these attractants. Subsequent visual tests have proved an artificial bait must be attractive in appearance and exhibit motion before tuna schools will show a marked and continuous positive reaction. Studies are being made to develop a self-propelled lure which will be attractive in appearance and contain a chemical attractant as well.

Albacore.--A reconnaissance by 2 research vessels last winter gave encouraging evidence of a rich biota and a possible concentration of albacore north of the Hawaiian Islands. Preliminary plots of vertical temperature sections and of horizontal distribution of temperature and inorganic phosphate reveals the northern edge of the North Equatorial Current was near 35° N. latitude. Between 30° and 35° N. there was a region of considerable mixing, while north of 35° N. lay colder waters of the easterly flowing North Pacific Drift. Within the region of mixing, near its northern edge, the vessel John R. Manning took 42 large albacore in 1 day's longline set. Small numbers of albacore were taken at 2 other locations during the cruise, but a severe storm prevented completion of the planned fishing survey.

SOUTH ATLANTIC FISHERY INVESTIGATIONS

W. W. Anderson, Brunswick, Georgia

General.--The South Atlantic Fishery Investigations, the Navy Hydrographic Office, the Office of Naval Research, the Georgia Game and Fish Commission and the Florida State Board of Conservation (through the Marine Laboratory of the University of Miami) are making a biological, chemical and physical oceanographic survey along the South Atlantic coast from Cape Hatteras, North Carolina, to the Florida Straits. Waters from off the beaches to beyond the Gulf Stream are studied. The Navy Hydrographic Office and the Office of Naval Research cooperate on physical oceanography and related special studies, the Georgia Game and Fish Commission on the biological and chemical programs, and the Florida Board of Conservation in the biological studies.

CRUISES

Five cruises of approximately 4 weeks' duration each were conducted between July 1953 and June 1954 with the vessel Theodore N.Gill. Objectives were to plot currents and distribution and abundance of fish eggs, larvae, and juveniles; to discover spawning areas of various fishes; and to make a biochemical determination that might have a bearing on the biological potential of the area.

CHEMICAL PROGRAM

Tentative analysis of processed data yields interesting general trends in concentrations and distributions of several chemical sea water constituents being measured. Results of the spring cruise of 1953 are used as a discussion basis. The work area from the Florida Straits to Cape Hatteras has been divided into 2 sections for comparative purpose--waters lying over the Continental Shelf and those to seaward. Average concentrations for various standard depths are:

Salinity.--Over the Continental Shelf the average salinity ranged from a low of 35.3 parts per thousand ($o/_{oo}$) at the surface to a high of 36.3 at 50 meters. (From 50 meters there was a salinity decrease to 200 meters' depth).

Average salinities seaward of the Continental Shelf at surface, 10 and 20 meters were constant at about 36.2 $o/_{oo}$. A slight rise occurred at 50 meters and again at 100 meters where a peak of 36.4 $o/_{oo}$ was reached and held constant to 200 meters. Below 200 meters average salinity decreased until 35.2 $o/_{oo}$ was reached at 900 and 1,000-meter depths. Salinities were lower from 300 to 1,000 meters than from surface to 200 meters.

Phosphate (Measured in microgram atoms per liter).--Inorganic phosphate concentrations over the Continental Shelf averaged 0.1 at the surface and only a little more at the 10 and 20-meter depths. Concentrations rose steadily and rapidly from 0.3 at 50 meters to 1.4 at 200 meters.

Seaward of the Continental Shelf the average inorganic phosphate concentrations from surface to the 50-meter depth were comparable to those over the Shelf at surface to 20 meters, or a little over 0.1.

Total phosphate concentrations over the Continental Shelf averaged about 0.8 at the surface and decreased to 0.3 at 30 meters. At 50 meters the concentration rose to 0.9 and thereafter increased sharply to 2.3 at 200 meters. The range of concentrations varied from zero to 4.0.

Nitrate-Nitrite (Measured in microgram atoms per liter).--Over the Continental Shelf the average nitrate-nitrite concentration at the surface was 0.9, which gradually rose to 1.8 at the 30-meter depth.

Seaward of the Continental Shelf average nitrate-nitrite concentrations were lowest at the surface and 10-meter levels with a value of 1.3, and rose to only 1.6 at 50 meters.

Protein (tyrosine) (Measured in milligrams per liter).--Less variation in concentration was found for protein than for any of the other constituents measured. The average concentration over the Continental Shelf ranged from 0.4 to 0.7 at all depths from surface to 150 meters.

Seaward of the Continental Shelf average concentrations from surface to 1,000 meters ranged from 0.4 to 0.6.

BIOLOGICAL PROGRAM

Plankton.--In the area as a whole, quantities of plankton collected on the spring cruise of 1953 were lowest off Florida and highest off Georgia and South Carolina. Quantities of plankton collected off North Carolina were similar to those from Florida waters. Over the Continental Shelf section the volume was lowest in the north, followed closely in the south, and with the central states highest by a considerable margin. Seaward of the Continental Shelf the smallest volume was off Florida with the central and north areas about equal. Plankton volumes were greater over the Continental Shelf than to seaward.

Fish eggs were found in the greatest numbers in the central portion, least abundant in the north, and much more abundant over the Continental Shelf than to seaward. Average number per tow in the central part of the cruise area was 2,545 over the Continental Shelf and 12 seaward; in the south, 1,990 over the Continental Shelf and 7 seaward; in the north, 826 over the Shelf and 53 seaward.

Fish larvae were most numerous off the central portion and least numerous in the north.

Eighteen families, 2 suborders and leptocephali are represented in tentatively identified larvae from plankton samples collected in February and March 1953. The 2 suborders, 7 familes and the leptocephali comprise approximately 80 percent of occurrences. Clupeoidei and Pleuronectoidei represent approximately 14 percent each of occurrences; Gadidae, 10 percent; Serranidae, 8 percent; Amphioxidae, 7 percent; Syngnathidae and Synodidae, 6 percent each; Brotulidae, 5 percent; Scorpaenidae and unidentified leptocephali, 4 percent each.

Dip net samples.--Thirty families are represented in the tentatively identified specimens collected by use of dip nets. Ten families comprise approximately 72 percent of occurrences. Exocoetidae represent approximately 12 percent; Carangidae, 11 percent; Mugilidae and Mullidae, 9 percent each; Myctophidae, 8 percent; Coryphaenidae, 6 percent; Monacanthidae, 5 percent; Antennariidae, 5 percent; Xhphiidae, 4 percent; and Hemirhamphidae, 3 percent.

Trolling results.--Bone and nylon jigs were trolled during all cruises when the Theodore N. Gill was under way. Two hundred and forty-seven fish, representing 12 species, were taken on the first 7 cruises. The 10 most frequently caught species are little tuna (Euthynnus alletteratus), dolphin (Coryphaena hippurus), blackfin tuna (Thunnus allanticus), great barracuda (Sphyraena barracuda), oceanic bonito (Katsuwonus pelamis), great amberjack (Seriola dumerili), king mackerel (Scomberomorus cavalla), Spanish mackerel (Scomberomorus maculatus), yellowfin tuna (Thunnus argentivittatus), and wahoo (Acanthocybium solandri).

SECTION OF ANADROMOUS FISHERIES RALPH P. SILLIMAN, CHIEF

ATLANTIC SALMON INVESTIGATIONS

Alden P. Stickney, Boothbay Harbor, Maine

Investigations were reoriented in April 1954 and headquarters transferred from Orono, Maine, to Boothbay Harbor, Maine. The research program on the ecology of marine estuaries as related to salmon was begun on June 9.

The Clam Investigations of the Fish and Wildlife Service and 5 Investigations of the Maine Department of Sea and Shore Fisheries--Herring, Marine Worm, Alewife, Smelt and Salmon--have begun a general hydrographic and ecological survey of the Sheepscot estuary. Through combined effort these Investigations can determine the ecology of this estuary and compare results with estuaries of other salmon-producing streams.

Similar studies are planned for the Narraguagus River estuary.

A program to measure, tag and release salmon taken in the marine environment has been undertaken. Commercially operated fish traps have been visited, and live salmon purchased and tagged. Trap operators also furnish viscera and scale samples of marketed salmon taken in their traps and information on time of capture and size of fish. Viscera are being examined for stomach contents, gonad condition and parasites.

MIDDLE ATLANTIC FISHERY INVESTIGATIONS

Gerald B. Talbot, Beaufort, North Carolina

SHAD INVESTIGATIONS

Connecticut River.--Vital statistics for the 1953 run show (1) a 50 percent fishing rate, (2) a run of 230,000 shad, (3) the advance 1-year prediction of this run was 95 percent accurate, and (4) the runs increasing since 1950 were directly related to increased spawners. Data analyses indicate runs can be increased to 300,000 to 350,000 fish with an annual catch of 150,000 to 200,000 shad. Fishing rate should be held to less than 57 percent for run recovery.

Holyoke Fishway passed 262 shad during the 1953 run; only a small number appeared in the collection system. However, successful spawning occurred above the dam.

Hudson River.--Catch and effort records for the 1952 and 1953 seasons indicate a slight run recovery since 1950. The 1953 run consisted of 1,700,000 pounds, the catch of 851,000. The fishing rate was 49 percent and should be continued below 50 percent to enable run recovery.

Chesapeake Bay --Upper Bay.--Fishing effort has more than doubled since initiation of the Maryland Management Plan which was instigated to stabilize effort at the 1944 level. Since 1944, shad catches have doubled and the run size has fluctuated from 1,800,000 to 3,200,000 pounds. Factors influencing run size cannot be determined because Virginia fishermen have removed Maryland shad.

Chesapeake Bay--Lower Bay.--A small percentage of shad tagged near the Bay mouth were destined to North Carolina streams, Hudson River, Connecticut River and Canadian streams. Those destined for upper Chesapeake Bay tend to enter the Bay earlier than those destined for the lower Bay. The majority entering the Bay apparently follow the southern shore. James River fishing intensity was 70 percent. Catch and effort data were obtained for James, York, and Potomac Rivers and most of the Bay.

Neuse River, North Carolina.--The 1953 catch in the commercial fishing area yielded approximately 100,000 shad. On the early run the fishing rate was estimated at 67 percent. Commercial fishing terminated on May 1 because of the heavy menhaden influx. While the sport fishermen's catch in the upper river areas was about the same as the commercial catch, it consisted of late running shad which entered the river after commercial fishing closed.

Goldsboro fishway passed an estimated 563 shad. High water temperature in the dam area resulting from condensing water from the steam-electric plant appeared to deter shad from using the fishway during some periods.

Ogeechee River, Georgia.--Field work on this project began January 7 and ended April 28, 1954. Preliminary analysis shows the commercial catch was approximately 73,000 pounds and the sports catch about 12,000. Total run and spawning escapement data have been collected and prepared for analysis. Of 236 tags applied at the river mouth, 62 percent were recovered. Back commercial catch records have been obtained for a portion of the fishery for the years 1945 through 1952. Further analysis is in progress.

St. Johns River, Florida.--Catch and effort data show a slightly higher catch for 1954 than for 1953.

STRIPED BASS PROGRAM

The States of Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Maryland, Virginia, South Carolina and Florida are actively participating in the Atlantic States Cooperative Striped Bass Program which came into existence in early 1954. The Middle Atlantic Fishery Investigations carries on the work of the Fish and Wildlife Service which is the coordinator of this research program. Fish and Wildlife Service fish tags have been furnished to Massachusetts, Maryland, South Carolina and Rutgers University.

The Middle Atlantic Fishery Investigations and Office of River Basin Studies of the Fish and Wildlife Service, the United States Public Health Service, the North Carolina Sanitation Commission and the North Carolina Wildlife Resources Commission participated in a study of the Roanoke River in relation to water releases at Kerr Dam as they affect striped bass.

PACIFIC SALMON INVESTIGATIONS

Clinton E. Atkinson, Seattle, Washington

General.--Pacific salmon research extends from the Sacramento River in California to the Aleutians and the Bering Sea, Alaska. Since a single Service unit handles all Pacific salmon research, similarities and differences in form, in migratory and spawning habits, in reaction to environment, and in mortality factors between many individual stocks are more easily detected and understood than they would be with several small units.

Pink salmon in Southeastern Alaska.--Research centered on problems affecting salmon productivity and survival. Mild fall and early winter temperatures resulted in high fresh-water survivals in most areas. The 6.7 percent survival rate at Little Port Walter, the second highest in a 14-year series of weir counts, was exceeded only by the 9.3 percent survival of the 1951 brood. Survival rates also are well above average at 3 of the 4 counting stations where comprehensive records are available for 5 or 6 years.

Lake fertilization, red salmon.--Results from fertilization studies at Bare Lake on Kodiak Island have been successful. By July 31, 1954, over 11,000 migrants were counted, the largest migration recorded at this 2-way weir. Average size of migrants in both age groups was larger than that of migrants sampled in past years. The lake was fertilized twice in 1954 and the response in terms of photosynthesis and phytoplankton was high. Dolly Varden and sticklebacks were again marked for subsequent checks on their abundance.

Red salmon in Alaska.--At Karluk Lake egg cartridges which had been buried at 8 locations on Karluk spawning grounds last September were removed in mid-May. Low survival of developing eggs over winter was indicated. At Moraine Creek approximately 30 percent of the known number of eggs in the cartridges had hatched; the hatch of eggs in cartridges buried in other areas was also low. Presence of large numbers of oligochaetes and leeches in many cartridges, as well as improper burial and handling methods, possibly accounts for the high loss. Further work must be done to perfect this method of measuring survival.

For the first time an index of the extent of fingerling migration out of Karluk Lake was begun. Four downstream fingerling traps were built into the Karluk weir which captured approximately 100,000 migrants between May 24 and August 1. By installing these traps in identical fashion each year some idea of fresh-water survival will be obtained.

Bristol Bay area studies indicate charrs are the main red salmon predators in the Nushagak area. From June 25 to July 4, 1953, the period of seaward migration, 1,234 red salmon fingerlings were found in 206 charr stomachs. However, little predation was found at other times of the year.

Origin of fish being exploited by the newly developed extensive gill net fishery in the Cook Inlet area is being determined from 1,500 tagged red salmon released from July 5 to 17; tags have been recovered from commercial fisheries and spawning areas. Three years of sampling age and lengths of fish in the commercial catch and spawning escapement indicate Cook Inlet reds are predominantly 5-year fish, with most of the group spending 2 or 3 years in fresh water. In the Kenai races approximately 90 percent were 5-year olds with 2 years in fresh water.

Chinook salmon, Sacramento River.--Chinook salmon studies at Mill Creek indicate freshets are the most serious factor in egg survival. Eggs placed in a control channel had much higher survival than those placed in Mill Creek proper.

Marine salmon mortality.--Because of disastrous marine mortalities resulting in the small pink salmon pack in Southeastern Alaska in 1953, adaptability of seaward migrating young salmon to salt water in Southeastern Alaska is being studied. Pink and chum salmon fry can move directly from fresh into salt water with no loss; coho fry cannot tolerate such a rapid change.

Columbia River fish protection research.--At Rock Island Dam salmon are being tagged to evaluate relative efficiency of 3 fishways. This year about 200 chinooks and 1,500 blueback salmon have been tagged and recoveries indicate a random mixing of salmon below the dam. Fish released on either side of the river may enter any 1 of the 3 ladders.

Last year studies were initiated to develop methods of guiding salmon around dams, turbines, and other dangerous areas into channels of safe passage. Electricity has proven successful in laboratory tests. For the first time this has been taken into the field. Results from Jenkins Creek show this method successfully guided fish in 8 of 9 trials. More work is planned to solve various technical problems and to increase efficiency of such apparatus.

Preliminary studies at Minter Creek show light can divert silver and chum salmon, cutthroat and steelhead trout. New experiments are planned to determine more conclusively the use of light in directing fish.

The most difficult problems involve enumeration of salmon runs and studies of salmon migratory behavior. Much attention has been given to developing apparatus for use in such studies. A recently built Lethlean-type fish counter has given accurate counts of fish passing back and forth through the electronic field. Use of a "fish tracker" being developed and tested will greatly increase salmon migration knowledge.

An effective way of marking salmon easily and free from experimental bias is needed. A method being explored will change distinctively the pattern or composition of fish scales. Groups of fish are successfully fed diets containing manganese, cobolt, and bismuth. Scales will be examined for presence of these metals.

Age determination.--An examination of scales of chinook salmon kept first in fresh water and later in salt water tanks at the University of Washington provides valuable information on time and frequency of annuli check formation. For example, fish that are little more than 2 years old show 3 checks--1 formed last summer, 1 formed at the time of their shift to salt water, and 1 formed last winter. Another check appears to be forming on the scale edge. Fish from the same group which have remained in fresh water show only 2 checks, with another check forming on the scale edge.

Studies show scales completely regenerate on small silver salmon within 2 weeks.

High seas research.--At the invitation of the Japanese Government a biologist was again placed aboard a Japanese mothership. Complete cooperation has been extended to the Fish and Wildlife Service in obtaining catch information and various data from the catch for the preliminary study on racial differences between North American and Asiatic salmon stocks. Detailed analyses of these differences are being made at the Seattle Laboratory through use of fish collected aboard the Japanese mothership in 1953, from the Cobb Expedition in 1954 and from samples being collected.

As part of the North Pacific treaty studies, biologists aboard the trawler Deep Sea are collecting records of catch composition of king crabs, fishing area and oceanographic conditions. Live king and Tanner crabs are being held at the University of Washington Oceanographic Laboratories (Friday Harbor) and the State of Washington's Laboratory at Bowman Bay.

Alaska herring.--Limited herring investigations have been continued. Through cooperation of the Exploratory Fishing and Gear Development Section of the Service's Branch of Commercial Fisheries, the vessel John N. Cobb engaged in exploratory herring fishing in Prince William Sound last November and December to test herring availability in that area. Results were negative except for schools of moderate size off Goose Island and Bligh Island. Scale readings showed these schools were composed mainly of 3-year herring of the 1951 year class.

Fishery management biologists of the Service's Region VI made aerial surveys of Southeastern Alaska herring spawning grounds. In the important Sitka spawning area only 7.5 miles of beach had been spawned on as compared to 11.3 miles in the 1953 aerial surveys.

The high percentage of 3-year fish in the Southeastern Alaska 1953 herring catch indicated recruitment from the 1951 year class may have been above average, especially since the catch per unit of effort was higher than that in the preceding year. In samples of the current season's catch, 4-year fish of the 1951 year class comprise approximately 40 percent of the fish, a fact which supports the earlier evaluation of the 1951 year class as being above average strength.

SECTION OF SHELLFISHERIES

SHELLFISH LABORATORIES

I. WOODS HOLE SHELLFISH LABORATORY

Paul S. Galtsoff, Woods Hole, Massachusetts

Oyster ecology.--An oyster ecology study in several inshore bodies of water of Cape Cod was continued, with particular attention to spawning and setting time. Shell planting on the Woweantic River banks, conducted on a large commercial scale, was of special interest because of the wide fluctuation in the salinity of water which, in other places along the Massachusetts coast, remains fairly constant. Woweantic River waters carry a heavy load of organic sediment.

To counteract shell fouling, a local oyster grower has developed a method of washing shells at low tide through use of a portable gasoline pump. The effectiveness of this method is being studied.

Oyster ground survey of New Hampshire.--Great Harbor is the only place within the State of New Hampshire where living oysters can be found in quantities sufficient to meet needs of residents living along the Harbor banks. Oysters of marketable size are scarce, and no commercial fishery exists in the Harbor. The oyster population consists of a relatively large number of old, thick-shelled specimens and 1 and 2-year old seed oysters. Setting irregularity or poor seed survival probably causes this abnormal composition of oyster population.

II. MILFORD LABORATORY

Victor L. Loosanoff, Milford, Connecticut

Long Island Sound oyster spawning and setting.--Observations were made to determine what environmental factors may be responsible for setting time and intensity. Spawning beginning and setting dates were predicted in advance to enable the industry to plant shells on time. Bulletins issued at approximately weekly intervals informed the industry and interested biologists during the summer on spawning and setting progress.

A medium good set occurred in the Bridgeport area; other areas, especially New Haven, suffered another failure. The industry, as a whole, has not had a good set since the summer of 1945.

Extensive studies were conducted on larvae behavior under natural conditions in the lower parts of some rivers entering the Sound and in the Sound proper.

At the request of the industry and with its cooperation spawning beds were established in the Housatonic River, Milford Harbor, Oyster River and Saugatuck River.

An investigation was made of adult oyster mortality in the Greenport area which in some instances killed 75 percent of the stock. The Milford Laboratory is cooperating with an oyster company which checked on this mortality in the summer of 1954. The Laboratory cooperated also in oyster and clam culture in several salt water ponds on Gardiners Island.

Experiments were made on feeding behavior of disturbed oysters. Results are different from those reported by G. E. MacGinitie for 4 pelecypods of the Pacific Coast.

Experiments on oysters from different geographical areas showed they have distinctly different physiological requirements. For example, Long Island Sound oysters can develop gonads and spawn after a much shorter conditioning period than that required by oysters from New Jersey, Virginia, and more southern groups. At temperatures of 21.0, 24.0 and 27.0° C. approximately 4 to 5 times as long was required for New Jersey oysters to reach spawning condition as for the Long Island Sound group. Conversations and correspondence with other aquatic biologists show they agree with the Milford Laboratory that different physiological races of oysters exist. The northern oyster industry is convinced also that importing southern oysters into their waters is unwise and wasteful.

A statistical analysis of data on oyster spawning and setting in Long Island Sound shows a correlation lack between setting intensity and ecological factors.

Oyster larvae requirements.--This work was largely confined to a search for food and other substances which induce good larvae growth. Experiments were made to learn the importance of the "water factor" which seems to control oyster larvae ability to utilize food. Since numerous workers have reported vitamins in natural waters, 8 different vitamins or vitamin-like substances were tested to ascertain if their addition would favorably reflect on oyster growth rate. Riboflavin and Calcium pantothenate gave encouraging results while Thiamin HCl and Pyridoxine HCl appeared promising. Other vitamins, including Vitamin A and Vitamin B_{12}, gave negative results. Results from adding a mixture of several vitamins to water containing oyster larvae indicated they may contribute to increasing growth rate of Crassostrea virginica and Ostrea lurida larvae.

Results from adding water of culture jars of unidentified substances which were adsorbed to charcoal during filtering of sea water and then redissolved appeared also to increase larval growth rate.

Preliminary work on use of radioactive substances in oyster larvae nutrition studies gave encouraging results.

Enemies and diseases.--The light starfish setting in Long Island Sound in the summer of 1953 contrasted with the heavy setting of the previous summer which increased the Sound starfish population about 600 percent. Starfish setting again demonstrated, as is the case of many other invertebrates and fish, that an increase in the number of progeny does not necessarily follow an increase in the number of parents.

Two graduate students of Rutgers University studied starfish morphology and physiology. While they devoted their studies primarily to starfish nutrition and digestion, they worked also on interbreeding of Asterias forbesi and A. vulgaris and starfish gonad development at different depths of Long Island Sound. They found sex reversal from male to female in A. forbesi common; this may indicate protandry. They discovered also a method to quickly distinguish A. forbesi and A. vulgaris.

During the spring and summer of 1953 observations were made on drill activities in the Sound, especially egg deposition intensity and, later, release of embryos. Quantitative data were obtained also on the presence of the crab, Pinnotheres, in oysters of different sections of the Sound.

Attempts were continued to find a method for controlling fungus, Sirolpidium, which kill lamellibranch larvae in laboratory cultures. This fungus also affects larvae of Venus mortoni (= Venus campechiensis) and larvae produced by crosses of this species with Venus mercenaria. Several lamellibranch larvae in Long Island Sound plankton samples may also have been fungus-infested.

Sulfa drugs and antibiotics, such as penicillin and chloromycetin, successfully controlled what appeared to be bacteria-caused diseases of lamellibranch larvae.

Lamellibranch larvae cultivation.--As in the case of oyster larvae, various vitamins were added to clam larvae cultures. No significant differences have been found between cultures receiving additional vitamins and those that did not receive them.

Studies of low salinity effect upon larvae and experiments on growth variation of larvae of known parents were begun.

Other experiments were devised to evaluate quality of sperm and eggs used in experiments, especially as to viability of gametes in relation to the time after the clams discharged them. These seem to have some effect upon larval survival to straight hinge stage.

Crossing of Venus mercenaria of Long Island Sound with Venus mortoni (campechiensis) of the Gulf of Mexico was successful. Both species, after being conditioned, were induced to spawn on November 31. Two crosses--Venus mercenaria ♀ x Venus mortoni ♂ and Venus mercenaria ♂ x Venus mortoni ♀ appeared to grow better than non-hybrid larvae of both stocks grew. All, however, began to set at approximately the same size. After setting, the hybrids grew vigorously and thousands of them, as well as young Venus mercenaria and Venus mortoni, were distributed to other investigators for a joint experiment on growth and survival of these 4 groups of clams under different ecological conditions.

Observations on juvenile clams placed in special boxes in Milford Harbor in April 1953 show Venus mortoni x Venus mortoni and Venus mortoni ♀ x Venus mercenaria ♂ cannot endure the low temperature prevailing at that time of the year.

III. BEAUFORT LABORATORY (SPECIAL SHELLFISH INVESTIGATIONS)

Walter A. Chipman, Beaufort, North Carolina

Marine plankton studies.--Sea productivity depends primarily on marine phytoplankton which serve either directly or indirectly as food for many animals. Factors affecting growth and multiplication of phytoplankton have been an important phase of the laboratory work.

To study plankton physiology under more controlled environmental conditions, artificial sea water in which cells would grow well was devised. Not all species grew equally well in 1 artificial sea water, but more than 8 plankton species, including diatoms, green algae, a red alga, and a dinoflagellate, grew well in water prepared by the basic formula. Formula changes allowed for maximal growth of different species under culture conditions. Additional amounts of silica benefited diatom growth. Changes in total salt or salinity enabled a grouping of different algae maintained in the laboratory with brackish water forms and marine forms. A few species showed equally good growth in a middle range of salinity as in a high salinity.

Calcium, strontium, and yttrium metabolisms in marine phytoplankton.--Plankton food organisms may be an important source of calcium and strontium in marine animals, particularly the filter-feeding lamellibranch molluscs. The relative importance of calcium in sea water and in food in supplying shellfish needs has been questioned considerably. Investigations were made to study calcium and strontium uptake and accumulation in marine algae.

In making studies of the concentrating ability of phytoplankton cells, comparisons were made of amounts accumulated in cells over the amount present in the water through use of an isotopic dilution method. Consequently, it was necessary to know the wet weight of plankton cells used. Conversion of the dry weight value to wet weight required water content measurement of various species. Drying cells at 60° under vacuum to constant weight showed a water content varying from 88 to 92 percent.

Phytoplankton cells concentrate calcium, strontium, and yttrium. The amount accumulated varies with the element and plankton species. Experiments with radioactive Ca^{45} on 7 species show algae accumulate as much as 332 times the amount of calcium of the surrounding sea water.

From experiments with Ca^{45} and Sr^{89} comparisons of the effect of varying calcium and strontium concentrations on uptake of other elements were made. In tested species, some calcium (about 25 percent of that present in normal sea water) was necessary for cell growth and division. This requirement could not be met by substitution of strontium. The presence or absence of strontium in the medium up to sea water concentrations did not affect the uptake of Ca^{45} and the concentration of calcium in the medium did not affect the uptake of Sr^{89}. Apparently phytoplankton has a definite need for calcium in its metabolism for which strontium cannot be substituted. Cell growth and division took place in the absence of strontium in the medium except for possible small amounts added as a contaminant. Algae do not seem to require much, if any, strontium for their growth.

Phytoplankton cells grown in culture medium containing both radioactive strontium and radioactive yttrium vary in their accumulation of these isotopes. Almost all species studied selectively uptake yttrium from such a mixture so nearly all their radioactivity is due to accumulation of $yttrium^{90}$, the short-lived daughter-product of $strontium^{90}$. The radioactive decay of the activity contained within the cells separated from the medium followed that of the original medium in which grown in the case of a species of Carteria only. In other species, the initial decay rate more clearly followed that of $yttrium^{90}$. By plotting decay curves of the radioactivity of the separated cells sufficiently long and extrapolating back to estimate the amount of radioactivity originally present due to each isotope, percentages of accumulation of the 2 isotopes in the various species were estimated. Results of these measurements follow:

Algal species	Percentage radioactivity from strontium	Percentage radioactivity yttrium
Carteria sp.	100	0
Thoracomanos sp.	50	50
Amphora sp.	10	90
Navicula sp.	8	92
(A yellow green)	8	92
Chlamydomonas	7	93
Nitzschia closterium	6	94
Nannochloris sp.	6	94
Chlorella sp.	5	95
Porphyridium sp.	4	96

Carteria cells appeared to concentrate strontium only. The original culture medium contained strontium^{89} with less than 10 percent of the radioactivity due to strontium^{90}-yttrium^{90}. The mixture had a decay rate giving a 55-day half life. Percentages of the original activity remaining after periods of time in the culture medium and the separated Carteria cells follow:

Time in days	Percentage activity remaining in medium	Percentage activity remaining in cells
1	98.75	98.64
3	96.29	96.71
10	88.16	88.20
13	84.89	83.73
25	72.98	70.52

Phytoplankton cells concentrate strontium. The contained radioactivity of the cells resulting from strontium indicates considerable concentration of this element over sea-water concentrations. Of all activity contained in the cells about 90 percent is due to radioactivity of the short-lived isotope, yttrium^{90}. Cells selectively absorb yttrium when present in water.

Cultures of Carteria cells grown in the light remove more strontium^{89} from sea water than similar cultures kept in the dark. The following comparison shows the population size is much larger and the amount of strontium^{89} taken up is much greater after 4 days' growth by cultures grown in the light:

	Cells per liter	Relative activity in counts per minute
Cells in light	68×10^7	47,542
Cells in dark	3×10^7	24,284

Accumulation of strontium by marine phytoplankton is directly proportional to the total amount present in sea water. Cells grown in 5 and 10 times the normal sea-water concentration of strontium contained proportionately more strontium than those grown in sea water which contained no added strontium. This uptake was measured from the uptake of the strontium^{89} added to the cultures. The specific activity of Sr^{89} was the same for all concentrations of strontium tested.

Metabolism of cesium in marine phytoplankton.--Through use of an isotope-dilution method the accumulation of cesium^{137} by several species of marine algae was followed. Cells were grown in sea water containing cesium-barium^{137} until cell division ceased and equilibrium between cells and medium was reached. Decreased radioactivity of the medium from addition of cells was compared to that which would have been expected from adding an equal weight of water. A greater loss of radioactivity from the medium indicated a concentration of cesium in the cells. The number of times that cesium is concentrated in cells of various species of marine plankton over the concentration in sea water follows:

Bacillariocease:	
Nitzschia closterium	1.2
Amphora sp.	1.5
Nitzschia sp.	1.7
Chlorophyceae	
Chlamydomonas sp.	1.3
Carteria sp.	1.3
Chlorella sp.	2.4
Pyramimonas grassi	2.6
Nannochloris sp.	3.1
Rhodophyceae	
Porphyridium cruentum	1.3

Results show there is no great cesium accumulation in phytoplankton. Ratio of cesium^{137} in the cells to that in the water at equilibrium was somewhat greater than 1. However, these small cells have a tremendous surface area. It is possible some cesium was accumulated on the surface of the phytoplankton cells. That this surface accumulation may account for a concentration factor greater than 1 is indicated in observations that the smallest cells, Chlorella, Pyramimonas, and Nannochloris, provide the largest surface area per unit of weight and have the largest concentration factors.

Since cesium normally occurs in the oceans in small amounts and is not concentrated to any great extent by photoplankton, visualizing any great uptake of cesium^{137} by filter-feeding marine animals from food

eaten is difficult. Believing the uptake from the sea water is of much more importance seems more logical. One gram of cells on a wet weight basis would contain about the same amount of cesium as 1 gram of water. Filter feeding animals, however, would need to filter 10,000 or more grams of water to obtain a gram of cells.

Shellfish foods and feeding.--Water propulsion rate of a number of bay scallops was measured through use of the indirect method of observing the decrease in the number of suspended planktons in the water with time. Of particular note is the fact that the use of plankton labeled with radioactive material provides an accurate means of determining suspended cells at any time in dilute concentrations.

Scallops efficiently filtered the water passed through their gills with apparently complete retention of Chlamydomonas and Nitzschia cells after adjustment to immersion in the suspensions. Rapid rate of decrease of suspended plankton was not continued, however, for there was evidence of gill efficiency decrease and increasing return to suspension of phytoplankton cells previously removed.

The bay scallop has a relatively high water propulsion rate which is probably correlated with its rapid growth rate and active mode of life. Average rate for small scallops, 38-44 mm. in length, was 3.26 liters per hour. The largest scallops, about 12 to 14 months of age and measuring 64.65 mm. in length, averaged 14.72 liters per hour. The maximum rate was 25.4 liters per hour. Smaller scallops had a rate of about 1 liter per hour per gram of tissue while older scallops pumped an average of about 0.7 liter per hour per gram.

Oysters were fed plankton cells of various species made radioactive through uptake of phosphorus^{32} and strontium^{89}. Like the scallop, oysters rapidly removed plankton cells from the water. As feeding continued, plankton removal rate lessened. Changes in the rate seemed related to changes in efficiency of the gills as filtering organs rather than to changes in the amount of water passed through the gills. Gill efficiency varied with species of plankton fed. Small cells were not retained as well as large ones. Measurements of oyster filtering activities are being continued through use of the method of decrease in suspended material with time in a plankton suspension and use of an "apron" to collect the water filtered by an oyster in a flowing sea water system to which radioactive plankton cells are added.

Role of metal ions in shellfish metabolism.--Additional measurements were made of the zinc content of estuarine waters and of mollusc bodies and tissues. Although all pelecypod molluscs contain considerable amounts of zinc the oyster contains more zinc than clams and scallops.

The use of autoradiographs in locating zinc in oyster tissues was successful, and this method promises to yield valuable information on zinc metabolism. There is a great accumulation of zinc in oyster gills. Lesser amounts accumulate also in the mantle, palps, liver and other organs; the least amount occurs in the gonad tissues and muscles. The high zinc concentration in the cells lining the intestine may indicate fecal excretion is important to the oyster.

Scallops took up radioactive Zn^{65} by direct absorption from sea water. Gill tissues, liver, digestive glands and rectum contained large quantities; a small amount was in the adductor muscle, gonads, mantle, heart and foot. Since large amounts of Zn^{65} soon appeared in the kidney, this organ may serve in excreting zinc in the scallop.

Metabolism of selected fission-product elements in shellfish. Strontium uptake, distribution, and retention.--Studies on radio-strontium uptake and distribution in organs and tissues of oysters, clams, and crabs confirmed earlier work. Uptake was rapid and accumulation was greatest in those parts containing the greatest amount of strontium and calcium. Retention time of the small amount remaining in tissues after initial rapid loss following return of the animals to normal sea water gave half life values shorter than those observed in winter months which apparently was related to an increased metabolic activity during the summer. The biological half life of radioactive strontium in edible portions of these shellfish is approximately 5 days. As in the oyster, clam and crab, edible portions of the scallop and shrimp, primarily the muscles, contained the lowest radioactive strontium concentrations after exposure of these animals to sea water containing this isotope. The biological half life of radiostrontium in scallop and shrimp tissues was likewise short and similar to that of other shellfish.

Cesium uptake, distribution and retention.--Oysters, clams and crabs were studied in regard to their metabolism of cesium^{137}. These shellfish accumulate this isotope when it is present in the sea water in which they are held. Aside from the more rapid initial penetration and uptake, there was a long-continued gradual uptake with time. This uptake was continuing at a rather high rate after 6 days of exposure.

Unlike strontium, cesium is accumulated in soft tissues of the shellfish body. It was high in the mantle and gills of oysters and clams during early times of exposure which was possibly related to its entry into the body through these tissues. Muscle tissue, however, was continuing to increase in its content of cesium^{137} at a greater rate than other tissues as observations continued.

Loss of radioactive cesium by shellfish that have accumulated this isotope when they are returned to normal sea water does not proceed at a constant rate with time. Aside from a rapid rate of loss initially, there is a long-continued slow loss diminishing with time. In observa-

tions on oysters exposed to sea water containing 0.05 uc Cs^{137} per ml. for 91 hours and then returned to sea water, radioactivity decreased almost semilogarithmically with time for the first 8 to 10 days. Following this there was an increased retention with little decrease in radioactivity for the next 10 days. This long-continued retention of activity may be of considerable importance in instances of pollution of sea water with radioactive cesium since this isotope accumulates chiefly in the edible portions of these marine animals.

IV. PENSACOLA LABORATORY
(GULF OYSTER INVESTIGATIONS)

Philip A. Butler, Pensacola, Florida

General.--Hydrographic records for the past year show more clearly than ever the importance of long-continued surveys in evaluating status of an animal or group of animals in a given environment. This past winter had 50 percent above normal rainfall with lowest salinity levels of the laboratory's 5-year records. A drought followed this condition which resulted in salinity levels 20 percent above normal. During the spring, temperature levels were 33 percent above the 5-year norm.

Faunal changes correlated with these conditions include scallop population elimination and almost complete absence of the usual migratory fish and crabs. Oysters failed to grow normally in the winter. High temperatures and salinities of early spring resulted in a twofold increase in average plankton volumes, heaviest sets of barnacles, bryozoa, and noncommercial oysters experienced at the laboratory. Commercial oysters produced unusually heavy gonads, but the subsequent set has failed in relation to normal conditions.

These faunal changes indicate no definite trend and there is no reason to think they represent permanent changes in the area. The decline of the scallop population, for example, has been checked, and a few scattered individuals are again present.

Oyster investigations.--The program of selecting oyster stocks for breeding experiments was reactivated. Growth experiments demonstrated repeatedly the importance of oyster heredity in regulating growth rate. Efforts are being made to select for later work brood stock which shows resistance to fluctuating hydrographic conditions and disease.

Observations on growth rates at stations on either side of the island continue to demonstrate importance of the local environment in producing characteristic growth rates. Factors which may be responsible for differential growth rates at these 2 stations will be investigated.

Fouling organisms.--The fifth season of observations on fouling and setting rates at Pensacola has been completed. Different types of experiments to fill in gaps in observations on oyster larvae behavior at the setting stage have been completed. They emphasize and clarify the importance of barnacles as a spatfall deterrent.

Sets of non-commercial oysters are increasing gradually in intensity. Recent observations indicate the possibility of identifying the new spat on the basis of pigmentation. Individual spat, which show 3 distinct color patterns, have been marked and will be held until they reach adult size for confirmation of identifications. Previously spat have been separated on basis of size and shape and the laboratory has found considerable variation in species frequencies in the new set compared to older oysters. These variations can be explained only on the basis of differential mortality rates.

Oyster drill, Thais.--Work continued on developing a more satisfactory device for trapping drills. The final model tested consists of a 20-inch cube of hardware cloth containing within it, suspended at the center, a 6-inch wire box holding the bait. Each side of the trap is funnel shape with a 1 x 3-inch opening centered over the bait box. While the trap catches snails satisfactorily, it is a success only under experimental conditions when the amount of food available to snails outside the trap is limited. Trap efficiency can be increased by making bait more attractive to snails. Initial test using Crepidula, barnacles and mussels did not increase the catch rate. The chief advantage of this device is that less than 25 percent of the snails caught escape over a 30-day period; the snails do not reach the bait which remains alive as long as the trap is in use.

Equipment for observing snail drilling behavior under the microscope has been devised. Work is in progress to determine mechanics of drilling and to learn whether chemical action is involved. Additional experiments are under way to test effects of secretion from snails' purple gland on oysters and to learn function of this secretion in snail biology.

Attempts to complete knowledge of the life cycle of the snail by culturing the larvae were unsuccessful. Unusual spring hydrographic conditions caused snails to reproduce approximately 1 month earlier than normal. When the laboratory was prepared to start its culture work, larvae were unavailable. Their usual 2-1/2-month spawning season apparently lasted only 1 month because of the early onset of high water temperatures.

Clams.--In cooperation with federal and state laboratories, the Pensacola Laboratory has undertaken a growth rate study of the hard clam, Venus, along the Atlantic and Gulf coasts. This study will be valuable because techniques of handling animals will be similar at different locations and results will be more satisfactory for comparison than in many previous studies.

CHESAPEAKE BAY SHELLFISH INVESTIGATIONS

James B. Engle, Annapolis, Maryland

Oyster seasonal spawning and setting.--Oyster setting in 1953 was a failure commercially in upper Chesapeake Bay and tributaries, especially as it relates to seed production. The following setting record comparison in Eastern Bay for 1952 and 1953 shows failure extent:

Station Eastern Bay	Spat catch per bushel of test shells 1952	1953
Millhill Bar	377,350	675
Bodkin Rock	74,775	1,350
Long Point	22,800	1,525

When Millhill fails, the seed oyster transplanting program is reduced 25 percent or more. When other seed areas fail, as they did this season, the oyster seed transplanting program for rehabilitation and expansion is set back a year and efficiency for setting of shells that have been on the bottom for a year or more is greatly reduced. Of the 4 principal seed areas in the Maryland portion of Chesapeake Bay, 3 failed and the fourth, St. Marys River, received only a minimum set of 600 spat per bushel of shells for the seed crop.

Oyster setting in upper Chesapeake Bay proper is seldom of much magnitude. A comparison of setting on test shells in the Bay similar to that made in Eastern Bay showed the following results:

Station Chesapeake Bay	Spat catch per bushel of test shells 1952	1953
Swan Point, South	325	3,225
Swan Point, East	400	1,425
Swan Point, North	150	1,025
Tea Table		2,800
Tollys	75	400
Hacketts	100	750

In the upper Bay proper, represented by these stations, setting increased in 1953 over that of 1952. Test shell results, however, represent the optimum setting rate and not the actual addition to current populations. On natural cultch the effect of fouling and predator action usually reduces this figure to 1 percent or less of test shell results. Therefore, seed rates may be predicted as about 1 spat surviving on natural cultch to 100 recorded on test shells. This would make setting on Bay bars too meager for satisfactory recruitment to the present crop to replace market oysters currently harvested.

Gonad development, following a course similar to that of other years, reached its peak in June. Spawning, which followed, produced no set. A second peak of gonad development, not as pronounced, occurred during mid-July and produced the peak setting of oysters for the 1953 season during the last week of July and the first days of August. A minor peak again formed late in August and the spawning that followed produced a light setting during the first week of September. Resorption of sex products was practically completed by the end of October and oysters began to fatten.

Fluctuations in abundance of oyster larvae in the plankton indicated the spawning period. Heavy or light spawning did not indicate, however, the setting magnitude. The number of late stage larvae in the samples, which fluctuate from year to year and also during the season, shows this. For example, in Eastern Bay in 1952, survival of oyster larvae to metamorphosis and magnitude of setting were directly related. This was also true for 1953. The following table illustrates this relation:

	1952			1953		
Station Eastern Bay	Total Larvae	Survival Late Stages	Oyster Set Per Shell	Total Larvae	Survival Late Stages	Oyster Set Per Shell
Millhill Bar	28,630	470 (1.64%)	754.70	13,880	40 (0.29%)	1.35
Bodkin Rock	8,660	140 (1.62%)	150.15	9,640	60 (0.63%)	2.70
Long Point	10,410	190 (1.83%)	46.30	10,250	130 (1.17%)	3.05

	1952			1953		
Station Ches. Bay	Total Larvae	Survival Late Stages	Oyster Set Per Shell	Total Larvae	Survival Late Stages	Oyster Set Per Shell
Swan Pt. S.	3,320	0 (0%)	0.65	3,100	40 (1.29%)	6.45
Swan Pt. E.	4,080	0 (0%)	0.80	4,760	120 (2.52%)	2.85
Swan Pt. N.	2,750	0 (0%)	0.30	4,600	60 (1.30%)	2.05
Tollys	1,680	0 (0%)	0.15	1,550	10 (0.64%)	0.80
Hacketts	1,580	0 (0%)	0.20	4,090	60 (1.47%)	1.50

The 1952 oyster set in Eastern Bay produced a commercial set of seed of 1,000 to 1,300 young oysters to the bushel of planted shells. The set of 1953, about 40 young oysters to the bushel of bottom material, did not meet requirements for commercial seed use. No great addition to the population by natural recruitment occurred in either year in the Bay proper.

However, when actual numbers of spat and larvae were compared, the same relation existed in the Bay as in Eastern Bay. Again, this is evidence that setting is a function of larvae survival.

Before seed is produced the oyster passes through 2 phases of heavy mortality, first during the free swimming period and then during the stage of oyster set and spat. The measure of availability of commercial seed is made in the fall when these 2 major mortality periods are passed. The loss from set to seed size may be illustrated by comparing the catch per bushel of shells on test spat collectors and that on commercially planted shells from the same place. At Millhill Bar, Eastern Bay, spatbag shells had 675 young oysters per bushel while planted shells had 40 young oysters per bushel for the 1953 season. The loss, therefore, is about 94 percent of the initial set. The loss in larval oysters is greater or 99.71 percent for the same year, even before the first setting occurred. Cumulative losses to the larvae and early set resulted in no commercial seed from Millhill Bar for 1953. In 1952, when survival was sufficient to produce a commercial seed crop 1.64 percent of larvae survived to produce a set of 377,350 spat per bushel of test shells which, in turn, produced on planted shells at Millhill 1,300 seed oysters per bushel of bottom material, a loss of 99.55 percent of the initial or potential set. In 1953 loss of larval oysters was mostly responsible for low seed production. In 1952 the reverse occurred, with sufficient larvae surviving to produce a tremendous potential set which, despite heavy loss in this age spat, produced a commercial seed crop.

Oyster condition.--Oyster meat condition varies through the year from season to season. Indices of condition are percent glycogen, percent solids and "condition factor." Glycogen developed slowly this fall after the normal summer low following spawning. The peak of glycogen storage was reached in December in Eastern Bay and in January in Chesapeake Bay. In both areas, percent glycogen dropped slowly in the spring from the January level of 25 percent to 20 percent in March. In May, prior to spawning, glycogen again increased to about the January level, but dropped precipitously during gonad development and the first spawning. Oysters in Eastern Bay remained slightly higher in glycogen than those in Chesapeake Bay during most of the year. The percent solids and the "condition factor" followed the same trend through the year as shown by the glycogen.

Oysters at paired stations in Chesapeake Bay and in Eastern Bay continued to show a consistent difference in condition by these tests. Tollys' oysters were better than Hacketts' in Chesapeake Bay and Bodkin oysters were better than Millhill oysters in Eastern Bay. The environmental factor of phytoplankton abundance measured at each station shows a greater quantity available at Tollys than at Hacketts, and more at Bodkin than at Millhill. The cause of this difference is unknown.

Salinity, temperature and inorganic phosphates are measured at these stations in a partial effort to seek some differences which may be significant.

Chlorophyll cycle as a measure of grazing potential and its relation to oyster condition.--Chlorophyll "a" measurements in water samples from the above stations indicate phytoplankton abundance. The purpose of this measurement is the quantitative estimation of amount of plant material available as food to plankton feeding organisms. No attempt was made to treat separately individuals of different sizes in the phytoplankton crop; the figures mentioned here represent the total chlorophyll from all phytoplankton in 1 liter of sea water in micrograms per liter. Four seasons of observations in Eastern Bay found the following relation:

Year	Chlorophyll "a" /ug/liter	Spat per Bushel
1950	1.30	42
1951	1.69	151
1952	2.40	1,172
1953	1.85	60

Although this relation may be coincidental, it does suggest the possible influence of food availability to larvae and spat survival. A refinement of these observations to measure quantities of different size organisms constituting the phytoplankton population is planned for the coming 1954 season.

Phosphate cycle and its relation to productivity.--When phytoplankton is abundant in Chesapeake Bay and in Eastern Bay, the inorganic phosphate quantity is low and vice versa.

Methods of determining oyster population changes.--The season just passed is the third consecutive one for making observations of oyster population changes on Swan Point Bar in upper Chesapeake Bay. The bar is being used as a study area because its revival from near depopulation in 1946 is being attempted through yearly stage plantings on the central third of its 3,300 acres.

Analysis of the observations this year demonstrates that (1) a practical oyster population census can be made through use of a small dredge, (2) appreciable recruitment to the population and a resumption of commercial removals has been accomplished only through seed plantings since 1947, and (3) the population available to legal removal can be estimated.

A short series of abundance indices correlates well with commercial removal from the bar. A rising index has presaged an increased take. Last season, however, the estimated increase in commercial yield was not fully realized by the tong fishery. The reason for this discrepancy is yet to be found since the post-season oyster census is not completed. Oystermen claimed a scarcity, but a decreased fishing effort could have caused the discrepancy.

Inventory of oyster population of Chesapeake Bay.--The Chesapeake Bay Shellfish Investigations, Maryland Department of Tidewater Fisheries and Maryland Department of Research and Education conduct a cooperative survey annually to assay the Chesapeake Bay oyster population. The 1953 survey included examination of 132 oyster bars in the Maryland portion of Chesapeake Bay and tributaries. Objectives were to determine approximately the number of marketable oysters available for harvest during the present season; the number of smaller oysters available for future crops and the current natural recruitment as indicated by survival of the 1953 spatfall.

Areas	No of Stations	Oysters per bushel bottom material Market	Small	Yearling	Spat
Chesapeake Bay proper	50	62.4	31.8	22.2	16.0
Choptank River	16	51.4	52.4	30.7	6.1
E. Shore Tributaries	48	35.0	50.4	32.0	60.8
Potomac River	14	69.4	53.0	19.9	2.6
Average 128 stations [1/]		50.4	42.6	26.0	30.0

1/ Four bars in St. Marys River are not included.

These figures show roughly production to be expected for the next few years. Market size oysters are fewer this year than they were 1st year; small oysters are fewer than market size this year which may mean a smaller harvest for 1954-55; and current spatfall in all places, except some Eastern Shore tributaries, was sparse and will be responsible for a continued low oyster yield from Maryland.

Clam study.--Young clams of the genus Venus and species mercenaria and mortoni with their hybrids were planted in Virginia as part of an east coast growth and survival study. The clams, natural crosses and hybrids, were hatched in Milford, Connecticut, and distributed to different areas from Maine to Florida for local planting. Semi-annual measurements and survival data will be recorded.

CLAM INVESTIGATIONS

John B. Glude, Boothbay Harbor, Maine

Clam farms.--Continued observations on 1951 and 1952 plantings in Sagadahoc Bay Farms show at least 2 years are required to produce legal-sized (2") clams. Even here, where best survival was found in past experiments, green crabs must be excluded in order to farm clams successfully.

The herring kill at Loves Cove Farm was estimated at 5,000 bushels on July 18 and 500 bushels on July 30. Seed clams from Western Beach were planted on August 3 in screened and unscreened plots. Survival in both plots was good because of partial disappearance of green crabs which followed the herring mortality. A similar planting on October 10 resulted in a good survival in the screened plot and a poor one in the unprotected plot. Clam growth of planted and native clams was excellent during August and September probably because of the fertilizing effect of decaying herring.

In April 1954, a 25' square plot fenced with 1" mesh galvanized wire 18" high, topped with a horizontal 1" x 6" board, was established in Loves Cove. Western Beach seed Mya, about 20 mm. long, were planted inside and outside this fenced area to determine green crab predation effect. The population inside the fence remains high while few clams remained in the unprotected area.

A fenced plot identical to that installed in Loves Cove was established in Jonesport, Maine, in April and planted with small Mya. An unfenced planting beside the fenced plot was also stocked. Few clams remain in the unprotected area while those within the fence are surviving well.

Clam census.--Sagadahoc Bay Mya census was completed in June 1954 and is being analyzed. The clam population remains low and the green crab population high.

Initial tests indicate staining shells with Schiff reagent and subsequent erosion of shells with dilute hydrochloric acid may aid in showing first 2 years' growth on Mya and Venus shells. Alizarin is better than Schiff for staining oyster shells.

Mya larvae and set.--Sampling continued through December 10, 1953; larvae were present to November. Sampling started again on April 29, 1954 in Loves Cove on a weekly basis and continued until June 14, when larvae showed in considerable numbers; thereafter daily sampling began in an effort to follow the spawning-setting cycle.

Total spawning throughout the season was greatest in 1951, next in 1953, and least in 1952.

Sagadahoc samples were continued. Early spring survey before the green crab predation and before 1954 set showed 1953 set up to 30 per square foot. Loves Cove sampling continued. Counts before green crab predation and 1954 set showed 1953 set up to 50 per square foot. No 1954 set has been found.

Green crab predation.--Size distribution samples in Bedroom, Sagadahoc Bay, indicate a wide gap between the 1953 set and clams close to 2" legal size. The missing group of clams is that most readily available to green crabs. Similar samples in Loves Cove indicate good survival of the 1952 set through 1953 and the spring of 1954. This survival may result because of the 1953 herring kill which drove most green crabs from the flats during the latter portion of the 1953 growing season.

Three crab fences were installed in Sagadahoc Bay. Each fence enclosed 100 sq. ft., one with wire 12" above the flats, two with wire 18" above the flats. No clams were planted in these plots. Samples were taken when the fences were installed to determine concentration of the set inside and outside the fences. Periodic samples will show efficiency of the fences in protecting the set from crabs.

Tidal spat trap.--An automatic filtering device to collect bivalve larvae by utilizing tidal rise and fall was designed, built and tested in the summer of 1953. Two additional simplified traps are being tested at Wickford, R. I., and Orr's Cove, Me., for Venus. The original model is being retested at Loves Cove for Mya. Results will not be available until the setting season ends.

Biology of the green crab, Carcinides maenas.--At Newburyport, Mass., crabs were sampled by trapping; 3 traps were fished 2 24-hour periods each month at upper, middle and lower Plum Island Sound during the period July through December 1953; fishing these traps resumed on April 21, 1954. Catches during 1953 were high all season--883 were taken from 1 trap on December 9. Subsamples were taken from traps for size composition, sex ratio, and gonad condition.

Thatch banks were sampled soon after the severest cold snap since 1949 but no evidence of mortality because of cold weather was found. The poor April and June trap catches probably resulted from seasonal behavior of crabs rather than reduction in numbers.

Small crabs were kept in pans at the Newburyport Laboratory to study feeding habits and size and color changes at molting. Crabs of 5 size groups 10 to 35 mm. consumed clams from 3 mm. to a length equal to width of crab. Colors may change at molting but background effect is undetermined.

Green crab traps fished throughout the year at Loves Cove confirmed the seasonal migration pattern of larger crabs offshore in winter and onshore in spring. Crabs tagged in 1953 and recovered in the spring of 1954 at the same location indicate a trend to return to the same cove after wintering in deep water.

A marked crab population decrease followed the herring mortality in the summer of 1953. Death of crabs in traps at this time may have resulted from oxygen deficiency; other crabs probably moved offshore. Population was high again in the spring of 1954; however, the temporary crab scarcity allowed the 1953 year class Mya to survive.

Green crab abundance and temperature trends.--The Maine Department of Sea and Shore Fisheries and the Service conducted a green crab trapping program from June through October 1953 to provide an estimate of relative abundance. Three traps were fished 2 days each month in 5 locations from Jonesport, Me., to Ipswich, Mass. The program is being repeated to determine if the 1953-54 winter was severe enough to reduce the crab population. Present indications are that few crabs were killed even though the 1953-54 winter was colder than the preceding 4 winters. Crab tolerance to low temperature and salinity was investigated in the laboratory and is described below.

In the summer of 1954 emphasis was placed on determining if decreased soft-shell clam abundance can be blamed on green crabs. Flats in Washington County, Me., surveyed in 1949 and 1950 by the Maine Department of Sea and Shore Fisheries are being re-surveyed to determine changes during this period when crabs become abundant.

Temperature tolerance experiments.--Adult green crabs were held at Boothbay Harbor, Me., Laboratory at temperatures of 0.65° to 1.9° C. in varying salinities to determine their survival under extreme conditions. Some crabs lived from 6 to 9 days in fresh water at these temperatures. At 5 parts per thousand salinity and temperature of 1.6° C. 18 days were required to kill all crabs. At salinity of 3.57 and temperature of 0.81 12 days were required to kill all crabs. These experiments show green crabs resist low salinities and low temperatures. Further experiments at temperatures below 0° C. are planned.

Green crab eggs were held at salinities of 5, 10, 15, 20, 25, 30 and 35 ppt for 5, 10, 15, 20, 25 days at 1.7° C. and then transferred to room temperature and salinity of 30 in dark and exposed to daylight until hatched. Eggs hatched best in the dark. Eggs held in all salinities for 5, 10 and 15 days hatched with varying degrees of success; eggs held 20 and 25 days at salinities of 10 and above hatched but their larvae appeared abnormal. Experiments showed a combination of cold water and low salinity can kill eggs, but that they should resist most winter conditions observed in Maine in recent years.

Greenwich Bay, R. I., studies.--Geographical distribution and density data from 4 annual surveys--1950-53--show a rather consistent pattern. Hard clams are found in relatively high concentration in 3 areas in Greenwich Bay in all years. An explanation of these dense areas was sought in accumulated ecological data. No correlation seems evident between clam density and temperature, salinity, or depth. The type of bottom seems related to density; high density occurs where shell is a major part of the bottom.

The 1953 survey showed a noticeable drop in the number of hard clams in the 16-48 mm. group. From 1950-52 this group averaged 1.76 quahaugs per bucket; in 1953 the group average was 0.67 quahaugs per bucket. This condition indicates poor fishing for 1954 and 1955.

Catch averages about 2.5 bushels per man per day. The number of fishermen working the area rises to a peak of about 60 in August and drops to about 10 in January. About 5.0 hours comprise the average work day.

"Aqua-lung" examinations of the action of the clamshell bucket showed that, even in the hardest bottom encountered in the area, the area sampled is equal to the maximum bucket opening to a depth of 4-1/2 to 5-1/2 inches. In several experimental samples taken 2 quahaugs were found in the holes; 1 of these, however, could have fallen in from the sides.

Larval studies.--Mya arenaria larvae first appeared on April 21 and Venus mercenaria on June 2, 1954. Water temperatures were slightly lower than average during the spring; this was especially true during the month of May which was unusually wet. Mya seasonal larval abundance has been poor; since the major spawning season has not passed spawning for 1954 will doubtless be below average. Venus spawning has been about average and is continuing.

Predator studies.--Studies have been confined almost entirely to Neopanope texana (mud crab) predation on small quahaugs. Results of numerous laboratory and 1 field experiment follow:

1) Predation is confined almost exclusively to quahaugs below 15 mm. in length.

2) Crabs of 8-10 mm. (carapace width) cannot successfully prey on quahaugs 5 mm. in length or larger. Crabs 13-16 mm. cannot successfully prey on quahaugs larger than 7 mm. Crabs 17-19 mm. and larger can successfully prey on quahaugs up to 15 mm. in length.

3) Predation is carried on successfully at temperatures down to 11° C.

Parasites and diseases of soft and hard clams.--Studies on clam parasites at Milford, Conn., were restricted to determination of cultural characteristics of suspect Gram-negative motile bacillus isolated from Mya and to further studies on the physiology and host specificity of larval trematodes of the genus Himasthla which occur in both Mya and Venus.

Initial studies on pathogenicity of clam bacillus indicate a high degree of pathogenicity with foci of infection in lumen of absorbtive portion of intestine. Under experimental conditions death ensues in susceptible hosts without marked histolysis and generally within 5 days at temperature range 18-21° C. Among various media used best growth occurs on solid media, particularly blood agar base rehydrated with diluted sea water. Salinity, temperature and pH influences were studied.

Studies on metazoan and protozoan parasites were essentially completed; it is tentatively concluded that none of the observed members of these groups are responsible for extensive mortality of clam stocks in nature. Assessment of the significance of the parasitic thigmotrich, Ancistrocoma myae, in relation to juvenile clams must be studied further. A new peritrich species from Mya was studied and described.

Clam farming at Newburyport, Mass.--A fence was built in June 1953 to protect clams from green crabs and horseshoe crabs. The 1" mesh chicken wire fence was 300 feet in circumference, 18" high, with a flange on top of 1" x 6" boards. Survival of transplanted and native clams, crab trap catches and observations with the Aqua-lung showed the fence kept out practically all horseshoe crabs and most of the larger green crabs.

In the spring of 1954 officials of several towns became interested in constructing fences similar to this one. With Service assistance, Hampton, N. H., and Ipswich, Mass., built fences, each fence enclosing about a half acre. The Hampton fence appears effective while the Ipswich fence has been partially washed out because of debris and strong currents. Repairs will be attempted.

The Service has continued to work closely with the owner of a clam grant in Rye Harbor, N. H., who has built 2 pools in the marsh, each pool 250 x 33 feet. Preliminary experiments indicated clams would grow well in small pools but the owner reports some trouble from hydrogen sulfide in the large pools.

The year 1953 apparently was unusually favorable for clam growth in Plum Island Sound. The 1952 year class grew rapidly; by the winter of 1953-54 it produced good commercial digging in upper Plum Island Sound for the first time in at least 6 years. From May to October 1953 the 1952 year class grew from an average of 9 mm. to 49 mm. and in March the

average length was 54 mm. This is about 15 mm. more growth than either the 1950 or the 1952 year class made in similar periods.

Horseshoe crab population and migration studies.--Since 1952,1,720 horseshoe crabs have been tagged. Because of a tag shortage only 262 crabs were tagged in the summer of 1953; however, 1,000 were marked by V-notches. In the summer of 1954, 408 have been tagged, 74 in Essex Bay, 4 in Black Water Creek, N. H., and 330 in Plum Island Sound.

Since 1952, 58 tag recoveries have been made. In the summer of 1953, 21 were recovered in the Sound and Crane's Beach, 2 in Gloucester and 2 in Essex Bay. In the summer of 1954, 15 were found in the Sound and Crane's Beach, 1 in Gloucester and 1 on Plum Island Beach. Eleven of the 17 were tagged in 1952. Of the 1,000 V-notched crabs of July 1952, 4 have been recovered.

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* Chief, Pacific Coast and Alaska Technological Research Branch of Commercial Fisheries.

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RESEARCH PERSONNEL

Name	Title	Investigation	Location
Abegglen, Carl F.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Ahlstrom, Elbert H.	Fish. Biol.	South Pacific	Stanford, Cal.
Aldrich, David V.	Fish. Biol.	Gulf	Ft. Myers, Fla.
Allen, Donald M.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Allison, Beverly J.	Fish. Aid.	South Pacific	LaJolla, Calif.
Anas, Raymond E.	Fish. Biol.	Pacific Salmon	Bonneville Dam, Ore.
Anderson, Gaylord A.	Fish. Biol.	Great Lakes	Marquette, Mich.
Anderson, Wm. W.	Fish. Biol.	South Atlantic	Brunswick, Ga.
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.
Austin, Thomas S.	Oceanographer	POFI	Honolulu, T. H.
Ball, Orville P., Jr.	Fish. Biol.	Rocky Mountain	Logan, Utah
Baptist, John P.	Fish. Biol.	Clams	Newburyport, Mass.
Bartley, Louise G.	Fishery Aid	South Pacific	La Jolla, Calif.
Belding, David L.	Collaborator	Clams	Woods Hole, Mass.
Beil, Joseph	Fish. Biol.	Great Lakes	Marquette, Mich.
Bell, Joe O.	Fish. Biol.	Gulf	Ft. Myers, Fla.
Berkley, Earlie Mae	Fishery Aid	South Pacific	La Jolla, Calif.
Bliss, Chester I.	Collaborator	North Atlantic	Milford, Conn.
Bocken, Claude F.	Fishery Aid	North Atlantic	Gloucester, Mass.
Bolin, Rolf L.	Fish. Biol.	Marine Section	Pacific Grove, Cal.
Bottenfield, Vernon C.	Phy.Sci.Aid	POFI	Honolulu, T. H.
Braem, Robert A.	Fishery Aid	Great Lakes	Rogers City, Mich.
Brewington, Willard O.	Fishery Aid	Pacific Salmon	Seattle, Wash.
Brey, Wm. E.	Fishery Aid	Clams	Kingston, R. I.
Broad, Robert D.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Brock, Vernon E.	Collaborator	POFI	Honolulu, T. H.
Brown, Wm. J.	Fishery Aid	Clams	Boothbay Harbor, Me.
Bryant, Clyde C.	Fishery Aid	South Atlantic	Brunswick, Ga.
Brynildson, Clifford L.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Buettner, Howard J.	Stat. Asst.	Great Lakes	Ann Arbor, Mich.
Burner, Clifford J.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Butler, Philip A.	Fish. Biol.	Gulf Oysters	Pensacola, Fla.
Cable, Louella E.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Carbine, William F.	Fish. Biol.	Inland Section	Washington, D. C.
Carrington, Mildred H.	Fishery Aid	Ichthy. Lab.	Washington, D. C.
Casey, Harold D.	Fishery Aid	South Pacific	La Jolla, Calif.
Cating, James P.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Chanley, Paul E.	Fish. Biol.	Milford Lab.	Milford, Conn.
Chenoweth, Harry H.	Hydraul. Engr.	Salmon Cult. Lab.	Seattle, Wash.
Chipman, Walter A.	Fish. Biol.	Beaufort Lab.	Beaufort, N. C.
Clark, John R.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Burrows, Roger E.	Fish. Biol.	Salmon Cult. Lab.	Entiat, Wash.

Name	Title	Investigation	Location
Clarke, George L.	Fish. Biol.	Marine Section	Cambridge, Mass.
Clarke, George M.	Fishery Aid	North Atlantic	Gloucester, Mass.
Coffin, Gareth W.	Fishery Aid	Clams	Boothbay Harbor, Me.
Cogswell, Sterling L.	Stat. Clerk	North Atlantic	Woods Hole, Mass.
Cohen, Edward	Chemist	South Atlantic	Brunswick, Ga.
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.	Sal. Cult. Lab.	Entiat, Wash.
Cope, Oliver B.	Fish. Biol.	Rocky Mountain	Logan, Utah
Counts, Robert C.	Fish. Biol.	South Pacific	La Jolla, Calif.
Craddock, Donovan R.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Cromwell, Townsend	Oceanographer	POFI	Honolulu, T. H.
Davis, Harry C.	Fish. Biol.	Milford Lab.	Milford, Conn.
Dreyer, Frank A.	Stat. Clerk	North Atlantic	Woods Hole, Mass.
Dunbar, Clarence E.	Fishery Aid	Micro. Lab.	Leetown, W. Va.
Eckles, Howard H.	Fish. Biol.	Marine Section	Washington, D. C.
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.	Fish. Biol.	Great Lakes	Marquette, 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.
Felin, Frances E.	Fish. Biol.	South Pacific	Stanford, Calif.
Feltham, Catherine B.	Fishery Aid	South Pacific	La Jolla, Calif.
Finucane, John H.	Fish. Biol.	Salmon Cult.Lab.	Entiat, Wash.
Fredin, Reynold A.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
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.
Garrett, Holbrook L.	Elec. Engr.	Pacific Salmon	Seattle, Wash.
Gauley, Joseph R.	Fish. Biol.	Pacific Salmon	Bonneville Dam,Ore.
Gaylord, William E.	Fish. Biol.	Great Lakes	Marquette, Mich.
Gehringer, Jack W.	Fish. Biol.	South Atlantic	Brunswick, Ga.
Gilmore, Raymond M.	Wildlife Biol.	Whales	La Jolla, Calif.
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.
Golding, Arnold G.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Gonzales, Robert S.	Fishery Aid	Gulf	Galveston, Texas
Goodwin, Charles P.	Phy.Sci.Aid	South Atlantic	Brunswick, Ga.
Gosline, William A.	Collaborator	POFI	Honolulu, T. H.
Graham, Herbert W.	Fish. Biol.	North Atlantic	Woods Hole, Mass.

Name	Title	Investigation	Location
Griffin, Philip J.	Bacteriologist	Micro. Lab.	Leetown, W. Va.
Grom, Robert A.	Fishery Aid	South Pacific	La Jolla, Calif.
Hall, Albert E., Jr.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Halver, John E.	Chemist	Sal. Nutr. Lab.	Seattle, Wash.
Hanavan, Mitchell G.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Hapgood, Wm. F.	Fishery Aid	South Pacific	Stanford, Calif.
Hartt, Allan C.	Collaborator	Pacific Salmon	Seattle, Wash.
Henry, William G., Jr.	Biol. Aid	Gulf	Galveston, Texas
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, Calif.
Hile, Ralph O.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Howell, John H.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Hunter, Charles J.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Hunter, Lois E.	Fishery Aid	South Pacific	La Jolla, Calif.
Ikehara, Isaac I.	Fish. Biol.	POFI	Honolulu, T. H.
Iverson, Edwin H.	Fish. Biol.	POFI	Honolulu, T. H.
Jayko, Michael E.	Chemist	Salmon Nutr. Lab.	Willard, Wash.
Jenson, Albert C.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Joeris, Leonard S.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Jones, Hughey	Lab. Mechanic	Gulf Oysters	Pensacola, Fla.
June, Frederick C.,Jr.	Fish. Biol.	North Atlantic	Newark, Del.
Karlos, Lester S.	Fishery Aid	Great Lakes	Marquette, Mich.
Kelly, George F.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
King, Joseph E.	Fish. Biol.	POFI	Honolulu, T. H.
Kolloen, Lawrence N.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Kramer, David	Fish. Biol.	South Pacific	La Jolla, Calif.
Laakso, Martin	Fish. Biol.	Rocky Mountain	Logan, Utah
Lander, Robert H.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Landers,Warren S.	Fish. Biol.	Clams	Kingston, R. I.
Lansford, Lawrence M.	Fishery Aid	Gulf	Galveston, Texas
LaPointe, Donald F.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Lee, Fanny	Fishery Aid	South Atlantic	Brunswick, Ga.
Lennon, Robert E.	Fish. Biol.	East.Fed.Waters	Leetown, W. Va.
Liscom, Kenneth L.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Livingstone, Robert,Jr.	Fish. Biol.	South Pacific	Stanford, Calif.
Loeb, Howard A.	Fish. Biol.	Great Lakes	Rogers City, Mich.
Loosanoff, Victor L.	Fish. Biol.	Milford Lab.	Milford, Conn.
Lovelace, Floyd E.	Biochemist	Trout Nutrition	Cortland, N. Y.
Lucash, Joseph F.	Lab.Mechanic	Milford Lab.	Milford, Conn.
McGary, James W.	Oceanographer	POFI	Honolulu, T. H.
McKernan, Donald L.	Fish. Biol.	POFI	Honolulu, T. H.
McLain, Alberton L.	Fish. Biol.	Great Lakes	Marquette, Mich.
McNamee, Zene M.	Stat. Clerk	Pacific Salmon	Seattle, Wash.
MacGregor, John S.	Fish. Biol.	South Pacific	Stanford, Calif.
Macy, Paul T.	Fish. Biol.	Pacific Salmon	Seattle, Wash.

Name	Title	Investigation	Location
Malone, John C.	Fishery Aid	North Atlantic	Boston, Mass.
Mann, Herbert J.	Fish M&E Spec.	POFI	Honolulu, T.H.
Marak, Robert R.	Fishery Aid	North Atlantic	Woods Hole, Mass.
Marquette, William M.	Fishery Aid	Great Lakes	Marquette, Mich.
Marr, John C.	Fish. Biol.	South Pacific	Stanford, Calif.
Marvin, Kenneth T.	Chemist	Gulf	Galveston, Texas
Mason, James E.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Matsumoto, Walter M.	Fish. Biol.	POFI	Honolulu, T. H.
Mattson, George M.	Illustrstor	South Pacific	La Jolla, Calif.
Maule, Sumner W.	Fishery Aid	Great Lakes	Marquette, Mich.
Maxfield, Galen H.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Mead, Giles W. Jr.	Zoologist	North Atlantic	Woods Hole, Mass.
Miller, Richard G.	Fish. Biol.	Great Lakes	Marquette, Mich.
Miyahara, Takashi	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Moffett, James W.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Moore, Harvey L.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Morris, Robert W.	Fish. Biol.	South Pacific	Pacific Grove,Cal.
Mosher, Kenneth H.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Murai, Sueto	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Murphy, Garth I.	Fish. Biol.	POFI	Honolulu, T. H.
Murray, Harriett E.	Stat. Clerk	North Atlantic	Woods Hole, Mass.
Myers, George S.	Zoologist	Marine Section	Stanford, Calif.
Nelsen, William V.	Fish.Eq.Spec.	POFI	Honolulu, T. H.
Nelson, Philip R.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Newman, H. William	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Nielson, Reed S.	Fish. Biol.	Calif-Nevada	Reno, Nevada
Nomejko, Charles A.	Biol. Aid	Milford Lab.	Milford, Conn.
O'Connell, Charles P.	Fish. Biol.	South Pacific	Stanford, Calif.
Olson, Jerrold M.	Fishery Aid	Pacific Salmon	Little Port Walter, Alaska
Ordal, Erling J.	Collaborator	West.Fish.Diseases	Seattle, Wash.
Otsu, Tamio	Fish. Biol.	POFI	Honolulu, T. H.
Page, Robert M.	Collaborator	South Pacific	Stanford, Calif.
Palmer, David D.	Fish. Biol.	Salmon Cult. Lab.	Entiat, Wash.
Parker, Phillip S.	Fish. Biol.	East. Fed. Waters	Leetown, W. Va.
Peterson, Stanley R.	Fish. M&E Spec.	POFI	Honolulu, T. H.
Phillips, Arthur M.,Jr.	Fish. Biol.	Trout Nutrition	Cortland, N. Y.
Podoliak, Henry A.	Phy.Sci.Aid	Trout Nutrition	Cortland, N. Y.
Premetz, Ernest D.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Price, Thomas J.	Fish. Biol.	Beaufort Lab.	Beaufort, N. C.
Pyle, Zoula Pauline	Chemist	Gulf	Galveston, Texas
Reimers, Norman	Fish. Biol.	Calif.-Nevada	Convict Creek, Cal.
Reintjes, John W.	Fish. Biol.	North Atlantic	Newark, Del.
Rice, Theodore R.	Fish. Biol.	Beaufort Lab.	Beaufort, N. C.
Ridgway, George J.	Chemist	Salmon Nutrition	Willard, Wash.
Robertson, Oswald H.	Collaborator	Sal. Cult. Lab.	Stanford, Calif.
Ropes, John W.	Fishery Aid	Clams	Newburyport, Mass.
Roppel, Alton Y.	Fishery Aid	Pacific Salmon	Seattle, Wash.

Name	Title	Investigation	Location
Rounsefell, George A.	Fish. Biol.	Marine Section	Woods Hole, Mass.
Royce, Rodney D.	Fishery Aid	West. Fish. Disease	Seattle, Wash.
Royce, William F.	Fish. Biol.	POFI	Honolulu, T. H.
Rucker, Robert R.	Fish. Biol.	West.Fish.Diseases	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.
Seckel, Gunter R.	Oceanographer	POFI	Honolulu, T. H.
Sette, Oscar E.	Fish. Biol.	POFI	Honolulu, T. H.
Shea, John F.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Shomura, Richard S.	Fish. Biol.	POFI	Honolulu, T. H.
Silliman, Ralph P.	Fish. Biol.	Anadromous Sec.	Washington, D. C.
Skud, Bernard E.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Smith, Bernard R.	Fish. Biol.	Great Lakes	Marquette, Mich.
Smith, Osgood R.	Fish. Biol.	Clams	Newburyport, Mass.
Smith, Stanford H.	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Snieszko, Stanislas F.	Bacteriologist	Micro Lab.	Leetown, W. Va.
Soderstrom, Clifford E.	Fishery Aid	Pacific Salmon	Seattle, Wash.
Spear, Harlan S.	Fish. Biol.	Clams	Boothbay Harbor, Me.
Squires, Delpha M.	Fishery Aid	South Pacific	La Jolla, Calif.
Stewart, Dorothy D.	Fishery Aid	POFI	Honolulu, T. H.
Stringer, Louis D.	Fish. Biol.	Clams	Kingston, R. I.
Stroup, Edward D.	Fishery Aid	POFI	Honolulu, T. H.
Stunkard, Horace W.	Collaborator	Clams	New York, N. Y.
Sykes, James E.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Taft, Bruce A.	Fishery Aid	South Pacific	La Jolla, Calif.
Talbot, Gerald B.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Taylor, Clyde C.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Tetzloff, Clifford L.	Fish. Biol.	Great Lakes	Marquette, Mich.
Thompson, Paul E.	Fish. Biol.	-	Washington, D. C.
Thompson, William F.	Collaborator	Pacific Salmon	Seattle, Wash.
Thorne, Donald L.	Elec. Tech.	Pacific Salmon	Seattle, Wash.
Thrailkill, James R.	Fish. Biol.	South Pacific	La Jolla, Calif.
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 Landingham, John W.	Phy. Sci. Aid	POFI	Honolulu, T. H.
Van Oosten, John	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Vaughan, Elizabeth	Statistician	Pacific Salmon	Seattle, Wash.
Vieira, Manuel	Stat. Assist.	North Atlantic	Woods Hole, Mass.
Vlymen, Lillian L.	Fishery Aid	South Pacific	La Jolla, Calif.
Volz, Charles D.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Vrooman, Andrew M.	Fish. Biol.	South Pacific	Stanford, Calif.
Walburg, Charles H.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Walford, Lionel A.	Fish. Biol.	--	Washington, D. C.

Name	Title	Investigation	Location
Wangersky, Peter J.	Chemist	Gulf	Galveston, Texas
Watson, Frank H.	Fishery Aid	South Pacific	La Jolla, Calif.
Watson, Stanley W.	Fish. Biol.	West.Fish Diseases	Seattle, Wash.
Weaver, Charles R.	Fish. Biol.	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.
Wells, LaRue	Fish. Biol.	Great Lakes	Marquette, Mich.
Wheeler, Ray S.	Fishery Aid	Gulf	Galveston, Texas
Widrig, Theodore M.	Statistician	South Pacific	Stanford, Calif.
Wigley, Roland L.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Wilson, William B.	Fish. Biol.	Gulf	Galveston, Texas
Wise, John P.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Wolf, Robert S.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Wong, Stanley H.S.	Mech. Engr.	POFI	Honolulu, T. H.
Wood, Edward M.	Fish. Biol.	Salmon Nutr. Lab.	Willard, Wash.
Woodall, Arthur N.	Chemist	Salmon Nutr. Lab.	Willard, Wash.
Yamashita, Daniel T.	Fish. Biol.	POFI	Honolulu, T. H.
Yasutake, William T.	Histo. Tech.	Salmon Nutr. Lab.	Willard, Wash.
Young, Robert S.	Phy.Sci.Aid	POFI	Honolulu, T. H.
Yuen, Heeny S. H.	Fish. Biol.	POFI	Honolulu, T. H.