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John L. Farley, Director

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(July 1, 1952 through June 30,1953)

BRANCH OF FISHERY BIOLOGY
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FOR ADMINISTRATIVE USE

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James W. Moffett, Ann Arbor, Michigan

SEA LAMPREYS

Major emphasis in the Great Lakes program was shifted from developing methods for controlling the parasitic sea lamprey to actual initiation of a large-scale pilot control program on Lake Superior. Other lamprey work was limited largely to preparing reports based on completed studies and to surveying lamprey spawning streams with a view toward later expanding control activities.

Delays in obtaining land leases and easements prevented attainment of the goal of 23 control structures which would have blocked lamprey runs in all major known or potential spawning streams along the Michigan shore of Lake Superior. By June 30, however, 12 structures had been completed, 8 were being constructed, and a contract had been let for a large mechanical weir for use in studying lamprey biology in Lake Superior. In one stream, modification of an existing dam provided a block to lamprey movement and in another stream potential lamprey productivity was judged to be too low to warrant installing a barrier this year.

Operation of 10 electrical barriers on Superior streams during much of the spawning run completely blocked the lampreys and diverted useful fish into traps from which they were removed and passed safely upstream. More than 1600 lampreys were taken at these barriers. The presence of such large runs suggests runs may have been substantial in immediately preceding years and hence the streams may be stocked with large numbers of larvae that will provide parasitic-phase lampreys for the next 4 or 5 years. This situation points up the urgency for extension of control to all Unites States streams of Lake Superior (Canada is initiating a similar program this year) and for intensive research on possible methods of destroying ammocoetes in larval beds. Regardless of measures taken, a severe decline of Lake Superior lake trout fishery seems probable.

In preparing for a scheduled expansion of control activities, detailed surveys were made of streams tributary to Wisconsin and Minnesota waters of Lake Superior to determine potential productive capacity for lampreys, type of control structure best adapted to each stream, and the most suitable site for installation. A short reconnaissance survey was made also of streams tributary to southern Lake Michigan, the next area scheduled for control operations after coverage of Lake Superior streams has been completed.

LAKE TROUT

After a series of exploratory cruises in Green Bay and Lakes Michigan, Huron and Superior in the last half of the 1952 season, the research vessel Cisco was assigned full time in 1953 to a fishery and limnological survey of Lake Superior, with special emphasis on the early life history of lake trout and factors affecting their distribution, abundance and movements. By June 30, a large amount of material and data was collected on hitherto little known or unknown stages of their life history. Redords of depths and grounds inhabited by young of the year and yearlings provide information essential to efficient conduct of any program for rehabilitating stocks by artificial propagation. Operation of water-level recorders and thermographs at several points on Lake Superior and Green Bay and intermittent short cruises of the Siscowet out of Marquette in Lake Superior and of the Duckhawk out of Sturgeon Bay on Green Bay have supplemented limnological and fishery observations from the Cisco.

Tagging of a group of lake trout captured in commercial pound nets in the Apostle Islands region of Lake Superior extended information on their movements. Rate of return of tagged fish was about 20 percent the first year. The larger fish moved farther than the smaller ones, many of which were retaken locally. Trout moved over both interstate and international boundaries.

Other lake trout research included: continued collection of records of small trout abundance in chub gill nets in Lake Michigan; further study of food habits in Lake Superior; experimental fall and spring planting of two lots (about 70,000 each) of fin-clipped hatchery-reared fingerlings to determine possible survival and growth benefits from retention overwinter in rearing ponds; recording of percentage of scarred lake trout in Lake Superior commercial catch (for the fourth year the trend has continued upward).

GREEN BAY FISHES

Except for routine annual sampling of certain stocks in Lake Erie and Saginaw Bay, research on shallow-water fisheries has been confined largely to Green Bay, a highly productive area that has accounted for 60-70 percent of Lake Michigan production in recent years. A major benefit to southern Green Bay industry has resulted from our investigations on age, growth and movements of yellow perch in that area. These studies led the State of Wisconsin to reduce the legal minimum length from 8 to 7-1/2 inches to permit more efficient use of this abundant but slow-growing fish. Because of this regulation change a considerable degree of prosperity has returned to fishermen who had been in financial straits. Periodic catch sampling indicates no decline in average size of fish on the grounds as a result of the liberalized fishing.

WESTERN INLAND FISHERY INVESTIGATIONS
I. CALIFORNIA-NEVADA INLAND FISHERY INVESTIGATIONS

Reed S. Nielson, 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 the fish for fall and spring counting, recording stream flow, air and water temperatures, velocity, snowfall, and ice formation, and observing the fish to determine their winter activity extent.

The third year of the study began August 1 and ended April 28-29, with a growth and survival check on November 8. In the previous 2 years, experiments began about May 1, but high water and peak flows prevented stocking the stream sections until August 1; even then only 2 of the 4 sections could be used. One section was stocked at the rate of 100 lbs. per acre--50 lbs. per acre of catchable-size, hatchery-reared rainbow trout were superimposed on 50 lbs. per acre of stream resident brown trout. The second section was stocked with rainbow trout only at the rate of 50 lbs. per acre. Survival to November 8 (100 days) was 85.1 percent for rainbows and 36.8 percent for browns. Since previous trials had demonstrated brown trout superiority, this reversal is so far unexplained. Both species exhibited similar growth patterns, but rainbows lost weight in relation to length and declined in condition. Browns exhibited a normal weight gain with a slight increase in general condition. The same stream sections were restocked November 10 with survivors of the summer period for winter survival studies. Stocking by weight per acre was identical with that for the summer period and required adding rainbows and browns to compensate for oversummer losses. Overwinter survival, which was superior to previous overwinter trials, was 77.2 percent for rainbows and 85.2 percent for browns. Rainbows showed best survival in competition with browns, and at a density 100 percent greater than in the section where they were alone. While growth was good for both species, it was superior for browns. Both rainbows and browns declined in condition in competition, but rainbows alone showed a slight gain.

The fourth year of the study, which began May 7, will compare survival of 2 size classes of hatchery-reared rainbows stocked at the same density by weight, and will compare small rainbow survival in competition with browns. In addition, rainbow survivors from successful third-year trials are being retained to check on their continued survival, time of maturity, fecundity, and spawning habits.

WINTER STREAM STUDIES

While conditions were near normal for the general area, they were more severe than in 1950-51, but milder than the record 1951-52 winter. Temperature pattern and stream ice formations were similar to those in 1950-51. Although the snow cover was less than in 1951-52, it was sufficient to bridge all four stream sections for short periods. The trout, as in 1950-51, were wary and active at all times. Controlled feeding studies in which natural stream foods were used, indicate 50-100 percent digestion of hard and soft-bodied insect forms in 16 hours at 34° F. Bottom and drift net samples collected in series of 3 during February and March indicate that in critical weather organisms most abundant in the stream are available only at times of anchor ice breakup followed by increased flow. Greatest feeding activity occurs at these times.

PRODUCTIVITY OF HIGH SIERRA LAKES

Because of the heavy snow pack resulting from the record 1951-52 winter field work could be performed only from August 11 to September 1. Observing and collecting data from the experimental lake continued but attempts by various means to make a population estimate failed. Methods for collecting periphyton were perfected and tried in 4 lakes. As results indicate they have promise in measuring lake productivity, plans were completed for studying periphyton in all 11 lakes in Convict Creek Basin. Since the upper Basin lakes cannot be reached in winter, year-long periphyton collections cannot be made from them. However, monthly collections will be made from Convict Lake to determine seasonal variations in this material in relation to plankton abundance and thermal patterns.

The 2-year study of Convict Lake thermal characteristics concluded May 10. Plankton hauls and bottom samples supplemented temperature gradients which were taken weekly. Tables, graphs, and temperature data summaries have been completed. An attempt is being made to develop new formulae and concepts for expressing lake thermal capacity to permit direct comparison of lakes of various sizes, forms and geographical location. Two distinctly different winters produced no startling differences in lake thermal patterns; excessive runoff following the severe winter lowered the lake heat content in the following summer despite warmer air temperatures.

The study of Convict Lake brown trout spawning continued during the October 8-January 31 run. The new type fish trap designed and installed prior to beginning of the run operated positively and efficiently. The fish trapped numbered 754 femals and 411 males. The California Department of Fish and Game spawned 472 femals to obtain 292,000 eggs which have an estimated value of $1460. Potential egg yield of run was estimated at 800,000 based on ovarian counts of 14 females representative of size groups comprizing the run. Results of this year's operations were similar to

those obtained in 1951, with age groups II, III, and IV making up 90 percent of the run. Returns of only 20 percent of fish marked in 1951 indicated a high turnover rate among spawning age groups. Information from trapped fish supplemented age and growth rate data (morphometric data and scale examination from 235 individuals) of the lake population. Because no knowledge exists as to the spawning congribution of large brown trout (5 lbs. or over), a system of gill netting and lake trapping is being devised to determine to what extent they participate in production.

II. ROCKY MOUNTAIN FISHERY INVESTIGATIONS

Oliver W. Cope, Logan, Utah

All efforts have been directed toward collecting and analyzing data relative to determining the best regulation of the black-spotted trout fishery on Yellowstone Lake. To achieve this objective, field crews and the office staff have continued, intensified and improved the program inaugurated in 1950.

Yellowstone Lake spawning runs.--The 1953 spawning migrations into tributaries of Yellowstone Lake began earlier than usual and promise to be larger than those of 1952. Pelican, Clear, and Chipmunk Creeks had good early surges of spawners. Closure of the fishery season until June 15 probably helped considerably in getting spawners into the streams. Anglers caught 20,000 fish in the first 2 weeks of the 1952 season. About 24,000 fish had ascended the 5 principal trapped tributaries by June 29, 1953.

A feature of the 1953 operations pertained to liberating fish for natural reproduction until certain quotas had been reached. Egg taking was to be secondary and no plants were to be made in Yellowstone Lake in 1953. The following table shows progress through June 29:

Stream	Established 1953 Quotas		Liberation through June 29		Females Spawned
	Females	Males	Females	Males	
Pelican Creek	6000	4000	6581	3543	1084
Cub Creek	2000	1500	111	47	0
Clear Creek	3000	2000	437	494	428
Chipmunk Creek	3000	2000	2005	2356	1788
Grouse Creek	2000	1500	991	472	90
Totals	16,000	11,000	10,125	6,912	3,390

Quotas will probably be reached in Pelican, Grouse and possibly Chipmunk and Clear Creeks, but not in Cub Creek. By the end of 1952, possibly 10 million of the 16 million egg quota had been sent upstream for natural reproduction.

Tagging program.--To determine upstream mortality, both upstream

and downstream migrating fish were tagged in 1953 in Pelican, Clear, Chipmunk, Grouse and Arnica Creeks, on the Cascades of Yellowstone River, and in Yellowstone Lake behind Fishing Bridge Museum. Recovered tags total 175. An unusually high number of returns to Pelican Creek trap suggests closure of the fishery until June 15 added to the numbers of fish entering Pelican Creek.

Arnica Creek.--Arnica Creek Test Stream, in which operations began on May 3, 1953, has yielded the most reliable count and tagging figures. Chief activities have been tagging, nest studying and testing streamer tags versus Peterson disks. Arnica Creek runs in 1953, which have been close to predictions based on former tagging studies, have contained many trout with clipped fins. These fish were clipped as fingerlings in 1950, and represent our first fish of known age.

Grebe Lake.--Basic biological data were gathered at Grebe Lake. The 1952 work consisted of collecting scales, morphometric data on grayling and rainbow trout, and stomach samples, preparing a map of the lake bottom and estimating population. The 1953 work has consisted of sampling grayling and trout spawning populations in the main stream above Grebe Lake, in smaller tributaries to the lake, and on Gibbon River between Wolf and Grebe Lakes. Trapping and shocking have secured spawners. Traps operate on 3 large and 2 small streams, and an upstream-downstream trap is operating at Grebe Lake outlet. For some weeks high water caused difficulties, but at the end of 1952 all structures were operating smoothly. About 500 spawning fish were tagged and fin-clipped to study their distribution. The 1953 grayling run has numbered over 5,000 fish in the hatchery trap. However, the count of over 6,000 in 1952 was the largest on record. Spawners reached a length from 10.5 to 13 inches. The 1952 population estimates and 1953 spawning observations show grayling outnumber rainbow trout in Grebe Lake.

Suckers.-- The sucker run into Pelican Creek was under way at the end of 1952. The 1952 migration was the smallest on record and the 1953 run thus far seems about the same size. Suckers are caught in good numbers in a trap net in Yellowstone Lake; individual catches at the end of 1952 were greater than those of trout. Two tagged suckers of the 1951 marking were recovered in the spring of 1953.

Madison and other rivers.--Conducting creel censuses on Madison, Firehole and Gibbon Rivers and securing length and scale data will yield information on the effectiveness of stocking and present regulations. Good catches have been made in Madison and Firehole Rivers, but Gibbon River has produced little in 1953.

III. COLORADO COOPERATIVE FISHERY RESEARCH UNIT

William C. Beckman, Fort Collins, Colorado

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

Age and growth studies.--Yellow perch from Lonetree and Jackson Lake Reservoirs are being analyzed. Age group V in Lonetree, which is dominant, was group III when this investigation started. Next season's investigation will be valuable and interesting since only 34 fish older than age group V have been taken. Jackson Lake yellow perch grow rapidly but only 2 fish older than age group II have been caught.

Spawning periods.--Collecting data in Lonetree and Jackson Lake Reservoirs on spawning periods of carp, suckers, and yellow perch continues. There is some correlation between spawning time and water levels.

Stream improvement.-- Work continues on the South Branch of Poudre River. The dam, which was constructed last year and was washed out in part during the high spring runoff, will be replaced with a stronger one.

After a survey of Spring Creek, Larimer County, recommendations for stream improvement work were made to the Colorado Game and Fish Department.

Bottom fauna investigations.--The study continues of movements of bottom organisms as the water level drops in reservoirs.

Food habits.--A study on food habits of yellow perch found direct competition between carp, suckers and yellow perch. Recommendations were made for rough fish control. Work continues on largemouth bass, black and white crappies and golden shiners.

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Because of appropriation cuts the Fish and Wildlife Service has withdrawn from the Colorado Cooperative Fishery Research Unit. Work will continue under bilateral agreement between the Colorado Game and Fish Department and Colorado Agricultural and Mechanical College. Dr. Howard Tanner, Assistant Leader of the Unit for the past year, will assume leadership of the program.

FRESH WATER BIOLOGICAL LABORATORIES

I. TROUT NUTRITION LABORATORY

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

Trout vitamin requirement.--Trout fed a synthetic diet (Wolf's, 1951) grew at a slow rate in comparison to their growth when fed control diets. Mortality was low. Results following omission of biotin, folic acid, riboflavin B12, pantothenic acid and pyridoxine from the diets showed they were essential.

Studies started last April have confirmed results found for pyridoxine and riboflavin and indicate several additional vitamins may prove essential.

Trout absorption of glucose.--Brook trout absorbed large amounts of glucose which had been dissolved in tap water. Fish held in a closed system showed increased blood sugar which was correlated with accumulated metabolic products. Starvation reduced the blood sugar to a constant level and decreased accumulation of metabolic products. Low levels of blood sugar are considered maintenance levels at 51° F.

Experiments are underway to determine actual effects of metabolic products upon trout blood sugar and factors which influence formation of metabolism products.

Dry pellets as fish food.--Although preliminary experiments have shown dry pellets have considerable promise as fish food, pellets have not been proved the most efficient feeding method. Experiments with brook trout in raceways have been designed to determine level of pellets to feed and necessity and frequency of supplemental meat feeding.

Oil in the trout diet.--Oil up to 15 percent in the diet produced no visible harmful effects on trout. A difference occurred in fish flesh produced between controls and those fed oils. Neither fatty acids nor cod liver oil soap contained growth fraction of cod liver oil. Experiments are in progress to determine if phospholipids are responsible as they seem to be, for accelerated growth of trout fed cod liver oil.

Antibiotics and brown trout diet.-- No beneficial effects were noted from feeding several antibiotics to brown trout. Growth was not accelerated, conversion was not decreased and mortality was similar to that of fish on control diets. Fish were fed normal levels of food. Experiments are in progress to determine if antibiotics would be beneficial when brook trout are overfed.

Radioactive calcium and brook trout.-- Feeding brook trout, exposed to radioactive calcium, absorbed activity which remained in the body for the 32-day test period. Feeding food containing radioactive calcium also produced radioactive trout, but at a lower activity level. Analysis showed gills, head and skin had the highest activity and intestinal tract the least. The remainder of the body and the viscera were intermediate in activity.

Experiments show brook trout absorb radioactive phosphorus from water at a lower level than they absorb calcium.

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

II. SALMON NUTRITION LABORATORY
John E. Halver, Cook, Washington

GENERAL

Final equipment tests at the new laboratory, near Willard, Washington, which is in operation, have been completed. With receipt of biological material in the early fall, it will operate full time. It has facilities for research in the fields of protein, lipid, carbohydrate, inorganic, organic, vitamin and hormone chemistry, with additional facilities independent from the main laboratory for histopathology investigations. Completion next summer of the radioisotope tracer laboratory addition will be the final major step toward making this laboratory a research center capable of handling almost any problem relating to fish nutrition, biochemistry and histopatholgy..

RESEARCH

Research problems on chinook salmon include establishment of an amino acid test diet, qualitative water soluble vitamin requirement and fat soluble vitamin requirement, and isolation, purification, identification and characterization of some tryptic enzymes present in them.

Research problems begun on chinook since last June 1 include establishment of a fatty acid test diet, qualitative fatty acid requirement, lipoid fraction distribution under specific nutrition conditions and establishment of an inorganic test diet. Studies on salmonids cover their normal histology, their histology under defined nutritional conditions, and their histopathology and histophysiology.

A histology library of salmonids has been begun. Additions to it will continue from samples in current work from this laboratory and other stations and from wild and hatchery stock samples.

The University of Washington Departments of Microbiology and Biochemistry, the State of Washington Department of Fisheries and the Service, who are working cooperatively on research problems, will complete a series of papers covering analytical techniques for isolating and identifying lipoid fractions and steroid hormones. The University and the Service have begun a comparative biochemistry of liver particulate matter.

Through use of a vitamin test diet consisting of a vitamin-free base supplemented with crystalline vitamins, feeding tests substantiated chinook salmon requirements for thiamin, riboflavin, pyridoxine, niacin, pantothenic acid, inositol, biotin, folic acid, vitamin B12, choline and vitamins A and K. No requirements for vitamin C and paraaminobenzoic acid in the water soluble group and for vitamins D and E in the fat soluble group were demonstrated under the experimental conditions used.

Caeca from mature, actively feeding, ocean-caught chinook salmon was collected and a preliminary extraction and separation of tryptic-like enzymes made.

Chinook salmon growth rates in the existing, untreated river water supply were measured for both production and complete test diets to determine possibility of obtaining sufficient growth for nutritional studies without heating water. A parallel study in which a spring water supply was used was discontinued because of a toxic material in the water. The pipeline contains the toxic material; preliminary tests disclose a substantial quantity of acidic and weakly acidic compounds within the pipeline tar coating. Tests are in progress to determine the compound(s) responsible for the toxicity.

Preliminary work on developing a fatty acid test diet was carried out and groups of fish were raised through use of pure oleic and palmitic acids as the sole dietary fat source. This work will be expanded.

III. WESTERN FISHERY DISEASE LABORATORY

Robert R. Rucker, Seattle, Washington

Virus disease.--A virus disease causing severe mortalities in blueback salmon fingerlings is under investigation. The following table of high mortality period shows the disease severity:

Station	Fish on hand at beginning of period	Size	Period date 1952	Mortality for the period
Leavenworth	2,047,730	No. 1-1/2	June 1 to Aug. 1	93%
Winthrop	106,803	No. 4	July 16 to Sept. 8	37%
Little White Salmon	235,886	No. 3-4	Sept. 1 to Dec. 1	95%

All blueback fingerlings at Leavenworth and Winthrop stations were marked for survival information and resistant stock development. A method for preserving virus for stock use was developed. Fish at 50° to 60° F. seem more susceptible to virus disease than those held at 40° F. Three- to six-month old bluebacks are more susceptible than yearlings.

Experimental blueback salmon groups are being held this season on two water supplies and on two diets (one all meat and the other containing fish products) at the Leavenworth, Winthrop, and Little White Salmon stations. No disease has appeared in these groups.

New fish diseases.-- A Vibrio was isolated as the etiologic agent in a rainbow trout group. Vibrio, controlled by sulfonamide therapy, may have been introduced through feeding salmon viscera or ocean scrap fish.

An organism similar to the Ichthyosporidium of the Maine herring was identified as the etiologic agent causing a severe epizootic at a rainbow trout farm.

IV. MICROBIOLOGICAL LABORATORY

Stanislas F. Snieszko, Leetown, West Virginia

Physiology and nutrition studies of fish pathogenic micro-organisms.--Basic work has been completed on developing a selective medium for isolating Aeromonas (Bacterium) salmonicida from water, mud, decaying fishes, etc. Practical value of the method will be tested.

The chemically defined medium was developed and minimum nutritional requirements of A. salmonicida have been established. Results are ready for preparing a research publication.

Preliminary work was conducted on serodiagnosis of furunculosis and ulcer disease.

Results are negative in experiments made by the Service and the West Virginia Conservation Commission to detect carriers of Hemophilus piscium, cause of trout ulcer disease.

Fish toxicity studies.--On December 29, 1951, the United States Marine Corps requested the Fish and Wildlife Service to conduct a research project to develop an improved method for taking fish. Emphasis was to center on an extensive screening program to locate high toxicity chemicals which would kill or stun fish; the latter condition would facilitate their removal from water. Approximately 3400 chemicals were examined for toxicity; about 20 compounds have been identified as being more toxic than the best commercial fish poison available (5% emulsifiable rotenone). Most of these compounds have not been previously identified as fish poisons. A program extension has been proposed to evaluate the most toxic group of chemicals under field conditions and to determine satisfactory application methods. An additional thousand or more chemicals will also be screened.

Study of bacteria belonging to the genus Aeromonas.--As the result of experimental work on characteristics and taxonomy of numerous cultures from America and Europe, a chapter will be entirely revised in the next edition of Bergey's Manual of Determinative Bacteriology.

Trout kidney disease.--The Microbiological Laboratory and the Berlin, N. H. fish-cultural station are working together on diagnosis, histopathology, epidemiology and therapy of trout kidney disease. Their goal is to develop an effective control of this disease before its next expected outbreak in brook trout at the Berlin hatchery in the spring of 1954.

V. SALMON CULTURAL LABORATORY

Roger E. Burrows, Entiat, Washington

FEEDING TRIALS

The 1953 feeding trials had been in progress 8 weeks at the end of the year. The entire set of blueback salmon experiments appears to be in jeopardy because of a disease outbreak which is suspected of being of a virus origin. Destruction of the first suspect trough of fish did not limit spreading of the disease. Mortalities are increasing in 3 troughs; numerous other lots show infection indications. Isolation does not give favorable results. As these fish were derived from a single egg take and homogeneous samples were procured for each diet, it is doubtful if isolation would be effective, provided infection was carried in the fish at the time they were received from Leavenworth, Washington. Chinook salmon show no evidence of this infection.

The report of the 1953 feeding trials, which is in the final draft stage, indicates distillers' solubles and seal meal were adequate substitutes for salmon viscera meal when incorporated at the 10 percent level in blueback salmon diets. Beef liver was demonstrated not to be a necessary adjunct to either blueback or chinook salmon diet provided salmon viscera in combination with either hog liver or beef lung or both was fed.

EFFECT OF GONADOTROPINS ON BLUEBACK SALMON MATURATION

The report of the 1952 experiments, which is in the final draft stage, indicates injections with chum salmon pituitary glands had a measurable effect on maturation of sex organs of blueback salmon. This effect was most pronounced in male fish. Excessively high mortalities in eggs derived from injected fish indicated an abnormality in development which impaired egg viability. A possible antagonistic action from crossing either male or female hormones was shown not to have caused this abnormality.

Chum salmon pituitaries have been collected for 1953 experiments and arrangements made for collecting carp pituitaries. In these experiments larger doses of pituitary will be used and fish will be anesthetized during injection.

HOLDING POND EXPERIMENTS

Adult salmon were successfully held in experimental holding ponds in 1952. Losses on the lot of 805 fish amounted to less than 5 percent prior to spawning and 15 percent for the holding and spawning period.

An electrical weir, installed in the Entiat River in early May, is successfully diverting both steelheads and chinooks into holding ponds. Thirty-two steelheads and 9 chinooks have been trapped. A test conducted with 9 to 12-inch whitefish show fish placed in the field are knocked out but recover quickly. Fish placed below the barrier will not enter the field but remain 5 to 10 feet below the ground line. Fish placed 1 to 5 feet above electrodes are stimulated to move upstream. If carried by the current into the main field, they turn belly up and are carried by the current below the barrier where they quickly right themselves. There have been no indications of salmon or trout moving into the electrical field from the downstream side to the point where they are subjected to sufficient shock to lose control of their movements. Although the main salmon run has not entered the Entiat River, indications show the barrier will effectively divert the run.

Results of evaluating 3 types of rearing ponds indicate no single type of rearing pond now used can be universally recommended to meet varied conditions in hatchery operations.

DEVELOPMENT OF INCUBATION FACILITIES

Of two types of incubators tested on a production basis, one was selected and plans are being prepared for constructing it. It will carry eggs and fry to the feeding stage in a tenth of the floor space and use a fifth of the water inflow required for conventional deep troughs.

THRESHOLDS OF NORMAL DEVELOPMENT FOR CHINOOK SALMON EGGS

An experiment, conducted to determine upper thresholds of normal development for chinook salmon eggs, indicated upper thresholds varied with development stage. During the green stage, eggs would tolerate a temperature of 57.5° F. In the eyed stage, eggs developed normally at 55° F. and below. The same was true for the fry stage. During the early fingerling, stage, however, an abnormal mortality developed at 55° F. temperatures while normal mortalities occurred at 50° F. temperatures.

ALGAECIDES

Three potential algaecides are being tested for algae control in rearing ponds. While toxic levels for salmon have been determined, efficacy of the chemicals for controlling algae at levels fish will tolerate has not been determined.

SPECIAL INVESTIGATIONS

I. BIOLOGY OF GREAT LAKES FISHES

John Van Oosten, Ann Arbor, Michigan

Data on Lake Michigan lake trout collected in 1930-1932 have been compiled into tables and most of it analyzed. This work, on which a final report is in progress, deals with time of formation of annuli on scales, relation of standard-total lengths, effect of mesh size on small trout escape, distribution and abundance, length frequencies, average lengths and weights, age, and growth, length-weight relationship (condition factor), and sex ratio.

II. EASTERN FEDERAL WATERS

Robert E. Lennon, Leetown, West Virginia

Shenandoah National Park in Virginia.--An intensive survey was begun on Pass Run, Jeremys Run, Piney Run, Big Run, Rapidan River, Hughes River, North Fork of Moormans River, and North Fork of Thornton River, all trout streams. Brook trout autumn spawning activities were studied, fish and bottom fauna collected and stream physical and chemical characters analyzed. Those waters which most drastically reflected conditions of the prolonged 1952 drought were carefully considered.

Great Smoky Mountains National Park in Tennessee and North Carolina.--Surveys were begun on Little Pigeon River, Middle Prong Little Pigeon River, West Prong Little Pigeon River, Oconaluftee River, Porters Creek, Bradley Fork, Abrams Creek and Mill Creek. Fishes and bottom fauna were collected, preliminary estimates of fish populations made and stream physical and chemical characteristics studied. Prior to the 1953 fishing season National Park Service placed in effect recommended changes in regulations governing Park water fishing.

A creel checking station was established in May 1953 on Little Pigeon River to measure watershed fish and angling pressure intensity on mainstream and various tributary waters.

Shenandoah River in Virginia and West Virginia.--Periodic bottom fauna sampling at certain river stations was continued to determine river recovery degree from once adverse industrial pollution effects. Fish and bottom-living organisms were collected at river points between Elktion, Va., and Harpers Ferry, W. Va., and analyzed. Pollution now does not seem to be a limiting factor in fish production, and sport fishing has increased to pre-pollution levels.

An investigation of fish mortalities in the South Branch of the Shenandoah River during June 1953 revealed dead and dying fish infected by the pathogenic myxobacterium C. chondrococcus columnaris which probably caused the kill.

III. DORENA DAM EXPERIMENTAL LABORATORY

Harlan E. Johnson, Dorena, Oregon

The laboratory was established in the summer of 1950, in cooperation with the States of Oregon and Washington and the Corps of Engineers (U. S. Army), to determine if salmon and trout eggs could be incubated and hatched and the fish reared in water from Dorena Reservoir, a Corps flood-control project.

Water from 3 levels (765', 785' and 805' elevation) in the reservoir is available in the hatchery during summer and early fall. For the remainder of the year water from only the lower intake is assured. During summer and fall, fish of all species handled are reared in water from the lower and upper intakes and also in a mixed supply.

Laboratory equipment, which has been dismantled because the experiments were concluded in the fall of 1952, included 22 deep troughs and 24 circular tanks, 6' in diameter, for rearing fish, a cold storage plant, feed preparation equipment, laboratory bench, office and storeroom, all in a building which the Corps provided.

A report, which will be published, was prepared on results of the project. The researchers found:

1. Neither water analyses nor hatchery experiments showed Dorena Reservoir water contained any toxic substance in high enough concentration to harm salmon or trout.

2. During part of the summer and fall, water from lower levels of Dorena Reservoir became deficient in dissolved oxygen, and aeration was required to make this water suitable for hatchery use.

3. When adequately aerated during periods of low dissolved oxygen content, water from the lower intake was satisfactory for rearing fingerling chinook and silver salmon and rainbow and cutthroat trout. In some years water from this level may become warmer than normal and increase danger of bacterial diseases, especially columnaris.

4. Water from the lower intake was suitable for incubating and hatching eggs of silver salmon and rainbow and cutthroat trout. Any abornmal losses during hatchery experiments probably result from conditions other than Dorena Reservoir water quality.

5. In the fall of 1950, 1951, and 1952, water available through any of the 3 hatchery intakes was too warm for satisfactory incubation of spring or fall chinook salmon eggs. Cooling this water to below 55° F. conditioned it for such use.

6. Fingerling salmon and trout reared in water which had temperatures of over 65° F. for extended periods contracted columnaris and suffered high mortalities. Sulfamerazine treatments partially controlled the disease.

NORTH ATLANTIC FISHERY INVESTIGATIONS

Herbert W. Graham, Woods Hole, Massachusetts

International aspect of research.--Through functioning of the International Commission for the Northwest Atlantic Fisheries, United States research in the North Atlantic is closely integrated with that of other countries fishing in the area. A special committee, appointed by the Commission, developed a long-term research program for the Convention area which the Commission approved at its New Haven, Connecticut, meeting in May 1953. To coordinate research on cod, haddock,redfish and halibut by the ten member nations, the Commission is organizing a Cod and Haddock Committee, a Redfish and Halibut Committee, and a Hydrographic Committee.

United States research in the past has been confined largely to New England Banks, but as our vessels extend their fishing farther eastward, we shall expect through our participation in the Commission's work to make greater contributions than we have made heretofore to studies of these other areas. Pooling efforts of all nations and choosing certain nations to emphasize certain research aspects will result in greater accomplishments and lesser costs than would obtain if no program integration existed. Research on mesh selectivity being conducted by this laboratory and Canadian biologists is a good example of the advantages of program integration. Close liaison with Canadian biologists through the group of scientific advisers to Panel 5 of the Commission permitted a division of work between the United States and Canada; Canadians tested certain mesh sizes and Americans others.

Haddock.--The intensive study of Georges Bank haddock, which has been conducted for years, culminated in an international mesh regulation which became effective in this country on June 1. It is 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 the biological effects of this regulation will constitute one of the most important aspects of our research program during the next few years, as the Commission has approved the regulation on an experimental basis and requires its effect to be carefully assessed. Measuring this effect will require observing the fish caught and the fish discarded at sea and maintaining an abundance index of each year class comparable to the one in use before regulation.

To continue sea observations, 2 employees sailed on commercial trawlers to collect data on composition of discarded and landed portions of catches. To maintain a standard index of abundance, 8 large trawlers landing at Boston, Massachusetts, were licensed to used old type trawl nets with the small mesh. An Industry Advisory Committee selected this study group which is licensed for a year. At the end of the year a new similar group will be selected.

Meanwhile, a new study group using the large mesh net is being developed for the time when abundance studies can be conducted without the necessity of permitting use of small mesh gear. A large number of boats, perhaps 25, will be included in this group. The need for fishing with a research vessel to determine strengths of submarketable ages will be much greater when all vessels have converted to large mesh nets.

To obtain an abundance index, an intensive study of the nature of groundfish distribution on the banks has been made and will continue. Data from Albatross III census cruises have been analyzed from this viewpoint and on 2 cruises of the past year were designed to study improvements in sampling methods. The purpose of this work is to develop a practical technique for determining abundance with the use of one vessel.

Haddock landings from Georges Bank fluctuate sharply because of variations in success of different brood years. Although the mesh regulation is designed to increase overall haddock production from the Bank, it will not affect natural fluctuations. Continuous interviews with the larger vessels landing at Boston provide data on sizes and ages of haddock taken from different Bank areas, information necessary for interpreting changes in landings.

Knowledge of dynamics of Georges Bank haddock stock permits catch predictions to be made on the basis of relative abundance of each year class. Predictions were made for the past 2 years with a high degree of accuracy. The prediction for 1953 is for a slight production decrease from Georges Bank provided the same amount of fishing prevails. Scrod are expected to dominate the landings again, as they have done for the past 2 years. Fishing has been so intense during the past few years that the 3-year-old age group has provided the principal support. Successful brood years in 1948 and 1950 have saved the fishery in recent years. The mesh regulation is expected to improve all year classes by saving unmarketable fish now caught and discarded. This will improve production on the banks but will not eliminate fluctuations in landings because of varying strengths of incoming year classes.

Knowing in advance the relative strength of an incoming year class will permit prediction of landings farther in advance than at present. Adequate use of a research vessel may greatly increase forecasting. Adequate trawling surveys in the fall, if a proper estimate of fish under 1 year of age and spawned in the spring of that year can be obtained, may allow predictions 2 years in advance.

Causes of fluctuations in haddock year class strength are unknown. The exact period in the life of a year class when the relative strength is determined is unknown also. Scientific evidence is lacking of the validity of the assumption that the critical time in the life history is the egg or larval stage when haddock drift.

A series of annual surveys was initiated to determine distribution and abundance of haddock eggs and larvae throughout the Gulf of Maine and the general regior of Georges Bank. Hydrographic and meteorological conditions were studied simultaneously with plankton sample collections. A Hardy Plankton Recorder was towed over 9000 miles on 3 cruises from March to June when the 1953 haddock year class was in the egg and larval stages. A census of this year class will be conducted in September after the fish have gone to the bottom and assumed their dermersal existence, an adult characteristic. After several such annual surveys it should be possible to ascertain whether strength of the year class is determined during planktonic stages or later. If the critical period is found to occur during planktonic life, an analysis of hydrographic and meteorological data will be made in an attempt to discover what combination of factors are necessary to insure a successful brood year. Such an analysis is under way for past year classes. Available hydrographic and meteorological data are being compiled and analyzed to ascertain conditions which accompany good or poor brood years.

Since available food variation may have a critical effect during their early life, an investigation of haddock food habits was begun. An analysis will be made of stomach contents of haddock of different ages at different seasons of the year and from different depths and areas.

Redfish (ocean perch).--Work on redfish biology was intensified. Since our method of determining age of this fish has been questioned, special redfish collections were made to resolve this issue. Specimens from the same population of small fish are taken periodically in order to relate fish length to formation of rings in scales and otoliths. If our age readings are correct, redfish growth is extremely slow and populations fished are composed of many age groups. No indication of dominant year classes has been found. If growth rate is as slow as our readings indicate, serious overfishing may be expected with the present fishing intensity. However, only the Gulf of Maine has definite signs of a decrease in redfish abundance.

Results of fecundity studies on redfish which are in progress will be essential to studies of population dynamics when growth and mortality data become available. No racial or specific differences have been found in North Atlantic redfish.

Biologists of the Treaty nations are cooperating in studying various aspects of the redfish problem.

Whiting.--To undertake a whiting conservation program in which fishermen have expressed considerable interest would require determination of many facts on the biology of this fish. A literature survey on whiting and related species was made and a study plan set up in the event support becomes available for a broad research program. The species involved in the fishery will have to be determined and a technique of age determination developed.

Tuna.--Information is being accumulated on growth of bluefin tuna species and on racial differences of various Atlantic stocks.

Herring.--The Service continued to cooperate with the Maine Sardine Industry, Inc., the Maine Department of Sea and Shore Fisheries, and the Maine Sardine Packers Association in the study of the life history of the herring disease and its effect on herring.

Delaware Bay Area.--The survey continues of the offshore marine sport and commercial fisheries, begun last year, to establish a reliable record of normal conditions in the area so effects of industrial waste disposal at sea that may occur may be adequately appraised.

GULF FISHERY INVESTIGATIONS

Albert W. Collier, Galveston, Texas

General.--A comprehensive fishery and oceanographic survey of the Gulf of Mexico is being made to establish its chemical composition and current patterns and to collect organisms, in addition to fish, for taxonomic and distributional studies with their ecological interpretations. The vessel Alaska is used to collect water and plankton samples and physical data for the Gulf Fishery Investigations, 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 materials for pigment extraction, and bottom and water samples for the Geological Survey. Texas A. and M. College collects water samples for determining chlorides, records water temperatures and makes miscellaneous oceanographic and meteorological observations.

Plankton.--Two types of "high speed" plankton samplers collected plankton samples for studying distribution of fish eggs and larval and juvenile fishes. The G-II, a continuous automatic sampler, was used throughout the Alaska cruises. A greater plankton abundance exists over the continental shelf of the Gulf than in waters beyond the shelf.

Pelagic fish.--Most catches were made within the 100-fathom contour in which occurs also a preponderance of fish eggs and larvae. Little tuna (Euthynnus alletteratus) made up over 70 percent of the catch which consisted also of Atlantic blackfin tuna (Parathunnus atlanticus), barracuda (Sphyraena barracuda), dolphin (Coryphaena hippurus), king mackerel (Scomberomorus cavalla), sailfish (Istiophorus americanus) and Spanish mackerel (Scomberomorus maculatus).

Sediments.--The general distribution of pigments, which survive decomposition of plant and animal tissues and join bottom sediments, may be related to currents and productivity of the area in which they originate. Pigment analysis of bottom samples will eventually give a complete quantitative and qualitative picture of mud pigment distribution on the Gulf floor.

Red tide research.--Data collected during the November 1952 red tide outbreak, which also killed millions of fishes off western Florida in 1946 and 1947 and has been ascribed to an excess of the dinoflagellate Gymnodinium brevis, show that Caloosahatchee River effluents are important agents in such blooms, and that organic content and physical attributes cause such activity. Experimental tank work indicates a mass growth of dinolfagellates as well as other organisms, requires high light intensity, vitamin B12 and sulfides.

An examination of tidal streams, marshes and estuaries produced Gymnodinium brevis in Barfield Bay, south Florida. Field culture of this species was unsuccessful. Water from Lake Okeechobee was heavily loaded with dissolved organic materials.

Daily collections and physical and chemical observations were made of dinoflagellates in Galveston, Texas, lagoons. Gymnodinium splendens, used in experiments as nearest to Gymnodinium brevis, was found.

Chemical.--Routine analyses of samples collected on 6 Alaska cruises were completed.

Chlorophyll was identified as the major constituent coating of "floating sand" from Boothbay Harbor, Maine. The Cary spectrophotometer made possible determination that "N-ethyl-carbazole carbohydrates" produced by organisms in tanks are the same material as that being measured in the Gulf and estuaries. Progress is being made in separating carbohydrate substances by ion-exchange and dialysis.

Homogeneity of oceanographic samples was studied by a special series of collections at sea. Nitrate analysis improved in speed, accuracy and economy of material.

Special analyses of the United States Geological Survey indicated Gymnodinium brevis while in mass bloom might have concentrated titanium and zirconium.

Microbiology.-- Light levels above those generally reported for algal culture have been found necessary for culture of some dinoflagellates indigenous to the Gulf coast. A ten-fold increase is now in use. Large-scale tank studies have proved valuable adjuncts to standard tube and dish cultures.

Experimental ecology.--These experiments have been confined to a study of red tide. Large tanks have been set up for use as a "stepping stone" from test tube to open sea. Findings on light level and value of certain inorganic nutrients result from this approach. These are important in analyzing interspecies on relationships. This work provides a basis for advanced studies of larval shrimp and fish behavior, survival and growth.

ICHTHYOLOGICAL LABORATORY

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

Four papers, listed in the Publications Section of this report, were prepared as a result of studies on the families Carangidae, Gobiidae, Eleotridae, Scombridae and Scorpaenidae.

Species of the family Percophididae that inhabit eastern United States and the West Indies were studied also.

A study continues of the whitings belonging to the genus Merluccius which includes species marketed in large quantities in the United States and in other parts of the world. Despite abundance of these species, publications concerning them contain many errors. For instance, they treat the commercially important whitings of northeastern United States and Canada as belonging to one species. Mr. Ginsburg has found two distinct and easily separable species of whitings in this region.

SOUTH PACIFIC FISHERY INVESTIGATIONS

John C. Marr, Stanford, California

General.--The Service, the Scripps Institution of Oceanography, the California Department of Fish and Game, the California Academy of Sciences, and the Hopkins Marine Station of Stanford University, with the support of the industry (through the California Marine Research Committee) 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 races.-- Growth data from 1938-1939 through the 1951-1952 seasons continue to show "northern" and "southern" types. A "bay" type appears to exist. If these forms are distinct, it seems logical to associate the northern type with southern California spawning grounds, the southern type with central Lower California spawning grounds, and the bay type with fall spawning in Sebastian Viscaino Bay and other Lower California bays.

In experiments designed to determine the nature of certain growth characteristics, pure strains of two closely related species, Xiphophorus maculatus and X. helleri, are used. The present experiment involves 4 tanks for each species held at 24° C $\pm$ 0.5° with 16 fish in each tank. Two

feeding levels are maintained, with a replicate of each. Fish of each species all came from single broods. Total length of each fish is measured at monthly intervals. This experiment will yield information on growth characteristics of these fishes, their limits of variation, and especially, differences between two closely related species and within species at different food levels.

Sardine population size.--Work continues on refining two methods used to estimate population size; one is based on total annual egg production and fecundity data and the other on catch, effort and age data.

Estimates of total numbers of eggs spawned are available for 3 years:

1950	286×10^{12}
1951	611×10^{12}
1952	146×10^{12}

To convert these to numbers of spawning fish, it is necessary to divide by 100,000 (estimate of annual egg production per female) and multiply by 2 (to account for males). The error associated with these estimates is not fully known and may result from sampling error and/or inadequate fecundity data. Special grids of closely spaced stations have been occupied but collections have not been completely analyzed. This should be done by the end of 1953 and will provide sampling error information.

The main problem of fecundity studies is to determine the number of spawnings per season, i. e., do the several modal groups of ova represent separate spawnings within a single year? Sections were made from two samples of ovaries; one of which was believed to be developing prior to spawning and the other which appeared (visually) to be a spent ovary. Detailed examination of sections did not reveal clear evidence of atresia in any of sectioned ovaries; there was no marked difference in appearance of presumably developing and spent ovaries. Dispersion of oil vacuoles was evident in all sections which indicated all ovaries may have been in an early atresia stage. Stained sections are essential for detecting early atresia. (This process cannot be detected in its early stages by gross microscopic examinations using our present methods and materials.) If sardines from these collections had spawned previously, which was possible, the resorption process had not advanced sufficiently to be easily detected, or remaining eggs were developing for further spawning during that same season.

Degenerating eggs were scattered through ovaries of gonad samples collected in September at Monterey, California. These were easily seen macroscopically.

Examination of gonad samples from San Pedro and Ensenada commercial fisheries and from various localities by the vessel M/V Yellowfin continues. At San Pedro, gonad weights increased from 1/2 to one gram in the fall resting stage to 4 to 6 grams in the advanced granular stage which occurs in late winter. At this time fish in maturity stages later than the advanced granular stage leave the usual fishing grounds. This was particularly noted at Ensenada where the fishery continues the year round.

Sardines from Lower California mature at a smaller size than do fish from southern California. The California Department of Fish and Game indicates San Pedro sardines reach first maturity at 190-200 mm. Our samples from central Lower California contain a large proportion of fish maturing at 150 mm. It is estimated that most sardines in central Lower California mature at 170 to 180 mm.

Several running ripe females from Lower California and southern California had eggs, diameter modes ranging from .3 to .5 mm. remaining in their ovaries. Gonads appeared to be in the granular stage. The only differences in appearance between these and normally maturing ovaries, with eggs of the same diameter, were a lack of turgidity and looseness of the ovarian capsule. Hence, recently spawned ovaries are difficult to differentiate from ovaries maturing for a first spawning of the season.

Whether the atretic process develops soon after the first spawning or after subsequent spawnings is still to be determined. Future work will be concentrated on detecting atresia in ovaries to determine what portion of the spawning population is undergoing this degeneration and resorption process each month of the spawning season. Collections on hand are being examined to learn how to recognize atresia in early stages. Eventually samples from the spawning population, selected upon a close time scale, will be required.

Egg diameters and egg counts can be accurately and rapidly made by spreading ova on a slide and projecting the image through the "scale reader" at magnifications of 30 and 137 diameters. Projection in the scale reader also aided examination of stained sections.

The method of estimating population sizes from catch, effort and age data employes a regression of instantaneous rate of total mortality on fishing intensity. The y-intercept of the regression indicates natural mortality (if this be assumed to be constant), fishing mortality is total less natural, and availability anomalies are represented by deviations about the regression. Application of the method yields minimum estimates of population sizes ranging from 5 to 11 billion fish during the period 1932 through 1951. If availability is assumed constant, then natural mortality must vary through a wide range and population estimates are much larger, 3 to 40 billion. Availability probably varies through a greater range than does natural mortality and has accounted for a large part of the anomalies. In either case, exploitation rate is less than we previously believed.

An example of one way in which availability may act accrues from two information sources on adult distribution: adult distribution during spawning season may be inferred from egg distribution, and data on adult distribution in the fall is obtained by "scouting" conducted by the California Department of Fish and Game.

Year	Percent of Fish North of United States-Mexico Boundary	
	Spring	Fall
1950	11%	63%
1951	3%	44%
1952	2%	0.5%

In 1950 and 1951 some 40-50 percent of the fish made a net northward movement across the International Boundary. In 1952, however, the northward movement was virtually absent, thus accounting in large part for failture of the 1952-1953 season.

To understand availability phenomena, it will be necessary to understand pilchard behavior which will require study of their sensory systems (anatomy), studies of the functions of the sensory systems (laboratory experiments), and finally, translation of these findings to the sea. Only the anatomical work has started.

During the past year the anatomy of the air bladder, the ear, the lateral line, and the relationship between these systems have been investigated in the pilchard and the anchovy. Particular anatomical features of the above species have been compared to findings of other workers on closely related species. Physiological and experimental literature pertaining to these systems in fishes has been reviewed and experiments to delimit their functions have been tentatively designed.

Other workers have characterized the clupeoid air bladder as a primitive type among teleosts. It is connected to the digestive tract by an open duct and has poorly developed gas secreting or absorbing glands. Pilchard and anchovy represent extreme types among clupeiods. In the pilchard, the pneumatic duct arises from a pneumatic bulb at the posterior end of the cardiac stomach, the air bladder is long and tubular and its posterior end opens directly to the exterior beside the urinary duct. In the anchovy, the duct arises from the middle of the esophagus, without intervention of a pneumatic bulb, the air bladder is 2-chambered, and there is no posterior opening to the exterior. Functions of the pneumatic bulb and posterior opening in the one and the transverse septum in the other should be investigated experimentally.

In all clupeoids there is a precoelmic capillary extension of the air bladder to the carnium, within which it produces air vesciles that are closely connected with the ear and lateral line system. Wohlfahrt has

described this mechanism in detail for Sardina pilchardus. Details in the pilchard agree almost exactly with his work while in the anchovy there are superficial differences in the mechanism, probably due to differences in form of cranial bones rather than to any functional difference. A series of experiments has been designed to determine whether air vesicles are accessory auditory structures.

Investigation of the lateral line system has been started. Literature has not been reviewed and the following description is based on examination of the two local species.

There is no canal along the side of the body, but canals are elaborated on the head. In the sardine, each of the six primary canals has a considerable number of branches, most of which show secondary and tertiary bifurcations. In the anchovy, primary branches can be distinguished, but ramifications beyond this are interconnected. Thus, each primary canal forms an anastomosing network of canals over part of the head.

Sensory end organs, composed of columnar cells, are located in primary canals only. The anchovy head has 94. Although there is considerable evidence of membranes mounted on these organs, it is unknown whether they are true cupolae.

Canal pores have not been completely enumerated, but at least there are pores in close association with the sensory organs. Certain pores also have secreting cells around their margins.

End organs are innervated by branches from nerve trunks underlying the canals. The opercular canal, which contains no end organs, does not have an underlying nerve trunk. Nerve trunks from the dorso-anterior and lateral surfaces of the head originate from the trigemino-facial ganglion located just behind the eye in a large ganglionic recess of the prootic bone. Proximal organs of certain canals are innervated by nerve branches arising directly from the ganglion. The innvervation of certain canals located posterior of the ganglion has not yet been charted. Of these, only the innervation of the short lateral canal has been traced to the lateralis component of the vagus nerve.

When gross features of the system have been defined, pores, end organs and nerves will be studied on the cytological level. A search will also be made for other cutaneous sense organs.

Variation causes in sardine year-class strength.--Broad features of sardine spawning distribution during 1952 were similar to those outlined in previous reports for 1950 and 1951. Sardine spawning is mainly confined to two major spawning centers, one off central Lower California, the other off southern California and adjacent Lower California. During 1952, only three percent of sardine eggs and less than 5 percent of sardine larvae were obtained in the more northern center; importance of this center has progresively declined during the past four years.

The following table (in billions) gives estimated abundance of the 1950, 1951 and 1952 year classes at various stages during egg and larval periods:

	1950	1951	1952
Sardine eggs	285,700	610,800	145,700
Yolk-sac larvae	11,850	12,083	12,473
Larvae 4.75 mm.	10,778	9,327	10,091
5.75 mm.	5,590	7,153	5,792
6.75 mm.	6,197	6,852	5,757
7.75 mm.	5,031	7,979	5,085
8.75 mm.	4,834	6,233	3,779
9.75 mm.	3,378	7,015	3,469
10.75 mm.	2,880	5,938	2,872
11.75 mm.	1,942	6,152	2,438
12.75 mm.	2,214	4,600	2,282
13.75 mm.	1,701	4,281	2,008
14.75 mm.	1,198	4,676	2,065
15.75 mm.	1,046	1,509	841
17.25 mm.	750	1,128	531
19.25 mm.	337	550	309
21.25 mm.	253	688	138

On the basis of survival per equivalent number of eggs spawned (we use 100,000, the estimated spawning of one female sardine), the survival rate was better for the 1952 year class than for the two preceding years. Survival to 19.25 mm. was about two in 1,000 in 1952, as compared to one in 1,000 for both 1950 and 1951 year classes. Despite better survival, however, actual population size at the 19.25 mm. stage was only half as large in 1952 as in 1951.

The apparent high mortality rate from eggs to the 5.75 mm. larvae may be real or result from newly hatched larvae's passing through plankton net meshes. Towing a conventional plankton net, covered with a fine mesh, will determine the correct alterantive.

The apparent increased mortality rate among the largest sizes may result only from net dodging. Simultaneous hauls of a conventional net and bridle and of a conventional net not preceded by bridle or towing wire will obtain this data.

Rearing marine fishes.-- Work continues on developing methods of rearing marine fishes in aquaria so various problems can be attcked experimentally. Many failures in rearing trials on different species have shown

larvae developing the following symptoms: failure to hunt and feed, improper kidney function, and failure of gas bladder to function properly. Although causes of these failures have not been determined, possible causes may include use of too small containers and temperature variations between water in which eggs were collected, the period of transit to the laboratory and in the laboratory (since the "correct" temperatures cannot be anticipated). The temperature difficulty can probably be overcome by holding adults in the laboratory and this will be done with Oxyjulis californica and Citharichthys sordidus, which are available locally. Techniques for collecting and rearing Atherinopsis californiensis have been so developed that this fish can be used as an experimental animal.

Larvae in black containers avoid the walls, which they do not do in white containers, and suffer fewer injuries and develop more rapidly.

Sand dollar eggs have been used as a food source for rearing trials. placing their eggs, when they are morulae or in earlier cleavage stages, in calcium-free seawater and shaking them vigorously results in separating the blastomeres and independent development of the latter. This results in yolk-rich, motile embryos ranging from as small as 0.02 mm. in diameter up to 0.16 mm. in diamater. Many are anomalous and live only a short while but pradtically all will live for 2 or 3 days at around 15° C. This offers the larvae a spectrum of sizes of food organisms and shows much promise as a food source for small larvae.

Other fishes.--Lengths of northern anchovy, Pacific mackerel and jack mackerel larvae are being measured. During 1952 anchovy larvae were about 2-1/2 times as abundant as sardine larvae and were exceeded in abundance only by hake larvae. Jack mackerel larvae were about as abundant as sardine larvae; each made up about 5 percent of total larvae taken. Pacific mackerel larvae taken represented only 0.2 percent of total larvae. A study has been begun of jack mackerel survival rates during early stages.

Bait samples.--Scales from bait samples (pilchard) collected through the Inter-American Tropical Tuna Commission have been examined. Eighteen samples from Galapagos Islands contained 1939 fish ranging in length from 43 to 120 mm. By scale reading standards as applied to California and Mexican sardines these fish were all in their first year and were taken during the period August 1952 to January 1953. Seventeen samples were taken from the Santa Maria Bay area (including Almejas Bay and Magdalena Bay) of Lower California in 1951 and 1952. Because of preponderance of fish of the year in many bait samples the sampling method for scale samples is not random. Fish under 100 mm. are not used unless there are none or few larger ones in the sample. Probably about half of the sampled fish from Santa Maria Bay area were fish of the year. Of the older fish, 52 percent were one ring fish; 37 percent, two ring; 8 percent, three ring, and 3 percent, four ring. Remaining seven bait samples were taken at scattered points along Baja California coast and were, for the most part, fish of the year.

Gray whales.--The gray whale census at La Jolla and Point Loma, California, and in the Baja California calving lagoons showed 966 adults and 190 calves.

PACIFIC OCEANIC FISHERY INVESTIGATIONS

O. E. Sette, Honolulu, Hawaii

Research has continued on three major projects. Study of tuna distribution and abundance in the equatorial Pacific included assistance to two commercial fishing ventures for equatorial tuna. Study of the skipjack fishery around the Hawaiian Islands was reorganized and both hydrographic and biological work in island waters was intensified. Artificial bait studies were expanded to include sea trials of chemicals which had successfully attracted fish in Coconut Island ponds of the University of Hawaii marine laboratory.

One major hydrographic cruise and five experimental fishing and biological cruises were made to the equatorial region. Two comprehensive hydrographic cruises were executed around the Hawaiian Islands and 12 weekly hydrographic sections made for recording short-term changes in hydrographic conditions in the vicinity of the Hawaiian Islands. Four scouting cruises were completed around the Hawaiian Islands to observe seasonal changes in skipjack school distribution.

Nineteen longline fishing traverses across the 3600-mile segment of the equator from the 180th meridian to 120° W. longitude were designed to obtain data on tuna abundance and distribution along the equatorial belt during various times of the year. Results indicate greatest yellowfin tuna abundance occurs from 145° to 170° W. longitude, declining in numbers toward both ends of this equatorial belt. Abundance fluctuates with indication of a late summer peak and a winter decrease. Sales transactions have proved Hawaiian or West Coast canneries do not desire fish above 150 lbs. because of their somewhat darker meat although fish up to nearly 200 lbs. sometimes have light-colored acceptable flesh. Tuna are larger and, hence, less desirable commercially toward the eastern part of the equatorial region under study, with smaller fish from 80 to 120 lbs. occurring west of 140° W. longitude. Last year's equatorial cruises nearly complete distributional aspects of the planned survey and emphasis may shift to fluctuations.

Oceanographic studies of the equatorial Pacific included analysis of the oceanic circulation at the equator in a meridional plane and investigations of short-term changes in the equatorial current system of a deep countercurrent at the equator, and of the equatorial front, a phenomenon often associated with horizontal convergence, near the equator.

Hydrographic sections, in a report completed on the fundamental basis of circulation in the meridional plane in the central equatorial Pacific, show clearly the well-known equatorial upwelling but do not support the thesis that upwelling is also occurring at the northern boundary of the equtorial countercurrent.

An equatorial hydrographic section along the 140° W. longitude from 9° N. to 7° S. latitude was repeated 4 times in 3 weeks to provide information on rate and degree of short-term changes of the physical, chemical, and biological environment near the equator. Changes proved to be of considerable magnitude. Such short-term fluctuations in the equatorial circulation system may have caused variations in tuna distribution and abundance noted in experimental fishing cruises.

First indications of an eastward current at the equator beneath the westward south equatorial current came originally from the drift of long-line fishing gear used from our research vessels. Direct observation of surface and subsurface current drags have proved this eastward flowing subsurface countercurrent occurs in a narrow zone near the equator and has a velocity exceeding one knot.

One of the phenomena associated with horizontal convergence near the equator has been described as an equatorial front; this front at which cool, dense upwelled water is in contact with warm and relatively low density water was found generally in the surface layer of the south equatorial current and not necessarily at the equatorial countercurrent boundary. The role played by fronts in the convergence region and associated zooplankton and tuna distribution is not clear.

Zooplankton abundance studies in the equatorial Pacific evidence a rich productive band paralleling the equator, with peak concentrations occurring variously from 5° N. to 5° S. latitudes. These concentrations are almost twice as great as those in Hawaiian waters. An equatorial abundance analysis by longitude shows greatest zooplankton amounts occur between 120° to 150° west longitude. Abundance is at a minimum during winter while it is nearly constant at all other times.

In the vicinity of the Hawaiian Islands slightly less plankton occurs in winter than in summer; however, abundance is remarkably similar during most of the year. Winter minimum zooplankton abundance and decreased commercial skipjack catch may mean same environmental factors influence both zooplankton and fish. Geographically zooplankton abundance is also nearly uniform around the Hawaiian Islands. On the average, southeastern waters, i. e., the area adjacent to the island of Hawaii, yielded lowest zooplankton volumes. Comparisons of zooplankton volumes with hydrographic data, such as surface temperature, inorganic phosphate, chlorinity and oxygen, showed no obvious direct relationship.

Two equatorial commercial fishing trials were conducted. To test commercial possibilities of equatorial tuna stocks, the West Coast purse seiner Cavalieri fished on a semi-commercial basis with longline gear is the equatorial Pacific. Although the West Coast purse seine boat is readily adaptable to longlining, the catch of only 48 tons of tuna in 33 fishing days proved some method of fishing more hooks per day is needed to make this fishing method attractive to American fishing boats.

A second commercial trial occurred when a Honolulu-based sampan, Tradewind, which the POFI vessel, Hugh M. Smith, supported logistically, fished with live-bait method in the vicinity of the Line Islands near the equator south of Hawaii. This was the first commercial attempt to capitalize on results of POFI's 1950-1951 live-bait fishing surveys. Despite a mediocre catch of 14 tons of yellowfin and 2 tons of reef fish, sampan fisherman concurred that a live-bait fishery in the Line Islands might afford profitable off-season fishing.

Modifications along two general directions leading toward increased longline fishing gear efficiency have been tested. First, hook droppers were increased from 6 to 11 per basket and shortened from 16 to 2 fathoms each. Although the catch per 100 hooks dropped, the catch per hour's fishing increased over 50 percent. Second, a mainline of steel cable would directly on a drum with the hook droppers detached as the line came on deck was substituted. Steel gear may be fished at considerably increased speeds over the cotton mainline and may help to fish more hooks per day. Results indicate longline fishing gear can be so improved that American fishing vessels can equal the Japanese practice of fishing 2000 hooks per day. Experiments have been made with pre-tarred hemp to increase fiber gear life.

Tuna larvae, like adult tuna and other plankton forms, abound along the equator. Considerable progress has been made in identifying larvae of various tuna species found near the equator.

Yellowfin and bigeye tuna age and growth are being studied by the size frequency method and a report on bigeye tuna growth is in progress. Like the yellowfin, the bigeye grows at a rapid rate, exceeding 50 lbs. per year during its most rapid growth period. Progress is also being made on studying vertebrae rings as indicators of yellowfin, bigeye and skipjack age.

Yellowfin tuna taken on longline gear along the equator from Asiatic waters are smaller than those in the western Pacific, averaging around 60 lbs., while in the eastern Pacific near 120° W. longitude the longline caught yellowfin averaging close to 150 lbs. The size gradation cause is being studied.

Study continued of relationship of Pacific tuna stocks, with completion of a Pacific yellowfin tuna comparison. This work has turned to skipjack and indications are they can be separated into several distinct stocks on the basis of morphometric differences.

A tuna bait substitute search continued with emphasis on sea trials. Last year some success was made in attracting tuna in ponds with fish extract. These experiments have been repeated and expanded with captive tuna. While many additional fish extracts have been found which will attract captive tuna, the attracting chemical substance has not been identified. Extracts have not been as successful at sea as in ponds. Various visual stimuli are being used in connection with chemical extracts in an effort to combine

visual and chemical stimuli which will not only attract fish but hold them at the vessel stern so they can be taken by pole and line. Sea trials have shown there is much to learn before a practical bait substitute can be developed.

The local Hawaiian program centers on skipjack distribution and abundance throughout the year. Skipjack form the basis for the principal fishery in the Hawaiian Islands, but the catch is seasonal with most of the annual 10,000,000 lbs. being landed during June, July, August, and September. Besides large seasonal fluctuations, wide yearly variations occur from as high as 13,000,000 lbs. landed in 1951 to a low of 7,000,000 lbs. in 1952. These drastic catch peaks and valleys prevent development and expansion of a stable fishery industry in the Hawaiian Island. Quantitative tuna scouting has shown skipjack populations around the Hawaiian Islands extend far beyond the present sampan fishery range. Tuna schools have been located over extensive areas about 200 miles south and west of the Hawaiian Islands at times when fishing success was unseasonably low on the usual fishing grounds within 50 miles of the main islands.

SOUTH ATLANTIC FISHERY INVESTIGATIONS

W. W. Anderson, Brunswick, Georgia

GENERAL

The South Atlantic Fishery Investigations, which was activated in July 1952, with headquarters in Brunswick, Georgia, the Navy Hydrographic Office and the Office of Naval Research conduct research on biology, chemistry and oceanography of those ocean waters lying between Cape Hatteras, North Carolina, and Jupiter Light, Florida, from the beaches to, or possibly beyond, the axis of the Gulf Stream. The Navy Hydrographic Office is responsible for the physical oceanographic part of the program, the Office of Naval Research for certain special studies and the Service for the biological part of the program.

The Service has a cooperative arrangement also with the States of the area under investigation; however, only Georgia and Florida are actively participating in the program. Georgia has assigned a biologist and a chemist and Florida a biologist.

Until January, the South Atlantic Fishery Investigations spent much time in arranging proper facilities in the new quarters, purchasing equipment and supplies, closing the Sarasota, Florida, station, planning the program, recuriting personnel, readying the vessel T. N. Gill and accomplishing numerous other items which establishing a laboratory requires.

RESEARCH

Oceanography.-- The T. N. Gill with a 10-man crew, completed two cruises, one during February and March, and the other in April and May. Cooperators from the Navy Hydrographic Office and the Office of Naval Research went on both cruises in which a biological, chemical and physical oceanographic survey was made of waters along the South Atlantic coast.

Chemistry.--Because of lack of personnel the chemical program has a large backlog of unfinished work. Despite these difficulties all salinity titrations and computation of salinity values have been completed for cruise one. Salinity titrations for cruise two have been completed and salinity values are in process of completion. All inorganic phosphate determinations were completed for cruise one and calculations for concentrations are in process.

Biology.--All plankton samples obtained on cruise one have been sorted for fish eggs and larvae. Good progress is being made on larvae separation and indentification from cruise one plankton hauls, dip net operations from cruises one and two, and from seining operations. Tentative assignment of this material to 52 families of fishes has been made and developmental series are being assembled.

ATLANTIC SALMON INVESTIGATIONS

James E. Mason, Orono, Maine

An agreement between the Service and several State of Maine agencies provides for research on Atlantic salmon. The Research Committee representing these agencies and the Atlantic Sea-Run Salmon Commission established a biological investigation program for Little Falls Stream and the Machias and Narraguagus Rivers. Objectives of the program were to establish the most efficient possible facilities for producing certain quantitative data in a routine fashion and to collect said data. Initial steps were to determine the number of smolts that leave the research streams and adults that enter them. Certain biological data were collected and progress was made in determining sampling methods.

Machias River.--While the Machias River is specified as a research stream, no work yielding quantitative results was undertaken. The research work for the stream was dropped because of watershed size in relation to available personnel and difficult passage conditions at Center Dam.

A two-pen thermograph station was established on the West Branch of the Machias and has been maintained since the fall of 1952. Temperatures of free flowing stream water and temperatures about a foot below the surface of the river bottom were recorded. In general, gravel temperatures showed less diurnal variation than did free water temperatures, with extremes of gravel temperatures occurring later in the day.

Center Dam in Machias River was surveyed and photographed at a variety of water levels for background data for fishway design. Information shows the best location for a fishway would be at the left bank end of the main dam structure.

Periodic inspections of the natural gorge area have shown that the Salmon Commission's improvements were beneficial. Occasional inspections of headqaters have failed to reveal salmon spawning areas positively identified as such.

Little Falls Stream.--Routine operations continued at the weir. A total of 320 smolts and seaward migrant parr were counted as compared to 1389 in the spring of 1952. Practically no relation exists between the two figures because of differences in numbers planted in preceding years.

A recording water gauge shows the normal flow is about 5 c.f.s. The discharge reaches high peaks of short duration during precipitation periods, but the watershed has little ability to store water.

The Moosehorn Refuge installed the dam and fishway at Hobart Bog and built a graveled road into the weir site. The experimental fishway, which has

passed a few alewives, needs to be readjusted in order to discharge 5 c.f.s. at the water level desired by the Refuge. Steel picket grids installed on the weir to minimize effects of floods failed under ice and flood conditions and the wooden grids initially used were reinstalled.

Narraguagus River.--A recording thermograph was installed last fall in the main river near Sordum Brook. Charts exhibited diurnal variations as shown on the Machias and, in addition, illustrated some wind effects on Beddington Lake.

Base structures for an adult weir were installed last fall near Stillwater Pool. An ice flood in early spring damaged the structure beyond repair during the season when adults were expected.

Two experimental fyke nets were tried in several areas to catch smolts for population enumeration. The nets were unsuccessful and a fishing gear, patterned after the so-called "rock fish slides" of the Delaware River, was installed. The gear has proven reasonably successful and it is believed the smolt enumeration will be satisfactory next season.

Craig Brook Hatchery.--Failure of the outlet dam at Craig Pond resulted in extensive flood damage to the hatchery and losses of fingerlings and eggs. A total of 102,580 yearlings survived the flood and natural losses out of 140,000 that were to be held over the winter.

A small-scale holding experiment carried on at the hatchery showed 3/8-inch monel strap tags applied to posterior portion of dorsal or caudal fins would work satisfactorily for smolt enumeration. Such tags would be retained for about a month and would slough off with minimum discomfort to the fish.

Samples of about 100 fish from the small, medium and large salmon groups graded in the fall of 1952 were examined for sex ratio. Within practical limits there was no objectionable separation of sexes brought about by grading although the total sampled was 64 percent males, significantly different statistically from a 50:50 ratio.

Other watersheds.-- Steps for rehabilitating Passagassawaukeag and Ducktrap Rivers were presented to sportsmen's clubs of the area because personnel and money were unavailable for government development. Since the basic problem is stream flow stabilization, the sportsmen were to secure legal permission to utilize flowage rights and to operate old dam sites with fishways.

Low water levels in the fall of 1952 stopped adult silver (coho) and Atlantic salmon from entering Ducktrap River. Twenty-one silvers (some 4 and some 5 years old) and two Atlantics were seined and then liberated above impassable areas.

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

SHAD INVESTIGATIONS

Chesapeake Bay.--Shortage of personnel and statistics delayed analysis of data obtained in 1952. Through cooperation of the Maryland Department of Research and Education and the Fish and Wildlife Service's Branch of Commercial Fisheries shad statistics are being made available for the States of Maryland and Virginia. Preliminary work shows a high fishing rate on the James River of 70 percent.

Susquehanna River.--The cooperative program with the State of Pennsylvania to determine spawning success and mortality of shad placed above dams in the river was not completed until tags were returned in 1953. No evidence was found of spawning above the dams.

Connecticut River.--Experiments with the pressure-lock fishway designed by the Holyoke Water Power Company were not completed because of high water. About 500 fish of all species, including 35 shad, passed in 1952. Tests were continued in 1953.

St. Johns River.--The early run (November-December 1952) appears to constitute the major portion of St. Johns River shad population. Present opening date for commercial fishing (December 1) and Christmas holidays keep down catches from the early run by fishermen in the lower river (North of Lake George). With an anticipated legal closure of the upriver fishery, an earlier opening season for the downriver fishery would be practical from an economic standpoint. Data indicate an earlier fishing season is also biologically sound. A careful study of catch and effort records would detect changes in future runs.

Neuse River.--Incomplete log returns from fishermen indicate the fishing rate is 59 percent in the marine fishery area--Pitch Kittle to Turnagan Bay--where the catch totaled 165,245 pounds. Fishermen complain that the fishing in 1953 is worse than that of 1952. Freshwater fishing continues.

Test netting at Goldsboro Fishway shows shad are using the structure. Cooling water from the steam-electric plant enters just above the fishway and raises the fishway water temperature 10° F. above normal river temperature. Shad stop moving at temperatures above 90° F. which occur in the fishway when low river flows prevail. The shad which passed while tests were being conducted totaled 105.

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 taxonomy, in migratory and spawning habits, in reaction to environment, and in mortality factors between many individual stocks are more easily detected and understood. Defining factors which limit their range provides a basis for interpreting survival fluctuations occurring erratically and infrequently in other salmon streams.

Pink salmon in Southeastern Alaska.--Last fall a severe flood which struck certain northern streams in southeast Alaska extensively scoured stream channels and resulted in pink salmon egg destruction. A comparison of pink fry migrating from Katlian and Humpback Creeks (near Sitka and Hoonah, respectively) reveals a low survival.

Flood condition effect on salmon eggs at Mill Creek, a Sacramento River tributary, was even more devastating. Excessive December rains increased Mill Creek flow to 25 times that experienced at spawning time; during January the flow exceeded 100 times this initial flow. Mortality to chinook fry and eggs increased from 14.6 percent in November before the floods to 63.3 percent in December. All eggs in the experimental area were killed during extreme January water conditions.

Similarly, winter temperature conditions have long been recognized as a detriment to egg and fry survival. Temperatures were mild in southeast Alaska last winter and accordingly pink fry survival in all index streams, except two flood-affected ones, was better than average. In Okanogan River, however, blueback salmon nests exposed during low water in winter and subjected to freezing conditions experienced up to 98 percent egg mortality. A combination of temperature and water conditions in early stages of salmon life is essential to good survival.

Nature seems to have adjusted pink salmon normal spawning habits to meet extreme environmental stream conditions. For a number of years pink salmon have spawned in the intertidal zone where eggs are exposed for varying lengths of time to salt water. Recent studies show eggs survive well above the plus 4-foot tidal level and survival above the 7-foot level was better than that in the stream proper.

Red salmon in Alaska.--Fresh-water survival depends upon minute food organism production at the right time and in an adequate amount. In turn, lake productivity depends upon phosphates, nitrates and other chemical "fertilizers" necessary for starting the food chain. In certain Alaskan lakes and in Karluk Lake especially, the chemical nutrient level has been declining over the past 20 years and speculation relating to this change in

water quality with coincident decrease in size of runs has long been voiced.

Because of its smaller size, Bare Lake, near Karluk Lake, has been tested to determine increased nutrient effect on available food and on survival of young red salmon, sticklebacks, Dolly Varden, and other associated fish stocks. Results illustrate food organism amount can be increased many times after adding certain chemicals, but it is too early to tell what effect increased food has had on fresh-water survival of red salmon or on other fish.

Predators.--The important role predators play in limiting salmon production has long been recognized. Although a study of salmon predators has just begun in the Bristol Bay area of Alaska, work on squawfish on the Columbia River is much farther along and age and growth rate have been tentatively established. The most rapid growth occurs in the first three years when squawfish average nine inches. From then on these fish average an annual growth rate of about 1-1/2 inches.

Home stream theory.--That salmon return to the "home" stream where they were hatched has long been accepted. However, many believed this behavior in pink salmon was not as consistent as in other species and was responsible for wide fluctuations in adults returning to an area. Recent experiments in southeast Alaska discount possibility of any extensive pink salmon straying. In 1951 marked fish were released in Old Tom and Herman Creeks. An examination of 20,707 dead fish revealed 234 marks in their home stream. In neighboring streams only two marked were found among 8,184 dead salmon examined.

The continued return of salmon to their native streams gradually builds up characteristic races which differ from races entering other streams. This is apparent in Cook Inlet studies being conducted cooperatively by the Service and the Fisheries Research Institute, University of Washington. Racial differences show up in size of returning adults. In 1952, largest red salmon were found at Kenai and averaged about 24 inches in length. Smallest group of red salmon were about 20 inches long and went to Tustemena, Deshka, Kalgin Island, Nancy Lake and Big Lake. In-betweens were found in Grecian and Swanson Lakes, English Bay streams, and Talachulitna Creek. If consistent from year to year, these size differences take on an added importance for an extensive gill net fleet operates in Cook Inlet and would selectively remove certain races.

Electricity uses.--Electricity is becoming a practical fishery conservation tool. Most important is its use in guiding young away from turbine intakes, diversions, and other dangerous areas. Latest silver salmon studies indicate a current pattern with a pulse duration of 60 milliseconds and a frequency of 4-8 pulses per second is most effective.

A method is being developed to paralyze mature chinooks for hatchery spawning. Fish are completely narcotized and can be easily sorted and spawned. However, too much electricity kills the eggs. Experiments run last year demonstrated that a voltage drop between electrodes of more than about 2-1/2 volts per inch will kill the eggs.

Enforcement officers use electricity, too. A method has been developed which will establish the time of death of a fish and thus provide a means for detecting fish taken illegally prior to opening of a season. Body of a recently dead fish reacts to electric shock and by applying electricity to fifferent parts of the body time of death can be established. Silver salmon display a reaction from pectoral fin up to one hour and 20 minutes after death; all movement ceases after about 5 hours.

Alaska herring.-- Herring fishery was for a number of years a very important Alaska industry. In the past few years the catch has dropped to a low level but at the same time quantities of fish appear erratically in different areas (without reason); this was illustrated this year when exceptionally good fishing was discovered on outside waters of Kruzof Island, where few herring have ever been taken.

To learn more about this fluctuating availability, exploratory fishing was done in southeastern Alaska between November 4 and December 20. Herring in good abundance were located at Silver Bay (near Sitka), Kendrick Bay (Southeast coast Prince of Wales Island), and at Ketchikan in Tongass Narrows.

Herring spawning areas of both British Columbia and southeastern Alaska have for the first time been surveyed as a single unit. In cooperation with personnel of the Pacific Biological Station of Canada, our biologists examined 8,800 miles of beach between March 18 and April 16--3,300 in British Columbia and 5,500 in Alaska. Spawning was found to be heavier in British Columbia, about .013 mile of spawn for each mile examined as compared with .004 in Alaska.

SECTION OF SHELLFISHERIES

SHELLFISH LABORATORIES

I. WOODS HOLE SHELLFISH LABORATORY

Paul S. Galtsoff, Woods Hole, Massachusetts

Oyster ecology.-- Observations were conducted in Cape Cod area which contains a great variety of ecological conditions. Areas unexploited by oystermen along the southern shore of the Cape produce clusters of small, narrow oysters undistinguishable from coon oysters of the southern states. Oyster spawning and setting studies continued in Chatham and Onset regions and in Weweantic and Wareham Rivers.

Toward the end of June, the majority of oysters in the Chatham area had poor gonad development despite a mild winter and high spring water temperatures. Oystermen were told to expect no setting of commercial importance this summer and were warned against planting oysters from muddy New Jersey creeks. Several hundred bushels of these oysters planted in April 1952 were of poor quality and infested with Nematopsis. They have not increased in length or bulk and are gradually dying. By the end of June some had well-developed gonads but did not discharge spawn.

Among fouling organisms in the Chatham region, Bryozoa occupy a prominent place. Because of their rapid growth they interfere with oyster larvae attachment and may seriously impede oyster seed growth. Some organisms (Schizoporella, Callopora) encrust shells and pebbles in the tidal zone while others (Parasmittina sp.) form large-sized nodules around pebbles and broken shells.

II. MILFORD LABORATORY

Victor L. Loosanoff, Milford, Connecticut

Long Island Sound oyster spawning and setting.--Oyster setting began near mid-July; the maximum setting of the first wave occurred within a few days after the beginning. The first wave continued until about August 23, and a hiatus in setting, an unexplained condition that has prevailed for years, continued until approximately August 11. The second wave of setting reached its maximum on August 19 and gradually declined until it ended in early September.

From a commercial viewpoint the 1952 oyster set was a failure; since the last good oyster set occurred in 1945, Long Island Sound oyster growers need young oysters.

Statistical studies have been made of data on oyster spawning and setting during past years and of factors that may affect these activities. Among factors studied were air and water temperatures, solar radiation, salinity, precipitation, river discharges, moon phases, and wind direction and velocity. No definite correlations have been found for the 15-year observation period. A correlation may appear to hold true for several years but then fails. The only promising correlation is that of high winds with homogeneity of set intensity among all Long Island Sound stations. Conversely, stations show a highly divergent intensity when water and wind mixing appears small. A method based on oyster gonad layer condition and thickness is being developed for quantitative representation of spawning progress of the oyster population.

Because of need of seed oysters for the North Atlantic oyster industry and frequent failures of the Long Island Sound set, studies were made in several semi-enclosed salt-water ponds of Gardiner's Island to evaluate the possibility of using this type of pond for producing seed oysters. Results were so promising that several oyster companies may use salt-water ponds on a large commercial scale.

Small clams, Venus mercenaria, grown at Milford laboratory from eggs, have been planted in salt water ponds for studying their growth and survival.

On the basis of laboratory experiments and field observations, suggestions have been made to shellfish authorities and oyster growers to reestablish spawning beds in lower parts of rivers entering Long Island Sound. There are reasons to believe spawn produced in such places is the chief source of larvae reaching setting stage over cultivated beds in the Sound proper. Under the Service's general supervision such beds are being established, one in the Housatonic River.

To determine at what age oysters produce the most viable spawn, three groups of oysters were conditioned for spawning in early spring and induced to spawn, their larvae grown, and their survival and growth rates ascertained. Some members of the oldest group, estimated to be between 30 and 40 years of age, measures 233 x 102 x 63 mm. in length, width and depth, respectively. The middle group consisted of oysters of marketable size between five and seven years of age; in the young group were small oysters of the 1951 set. Experiments showed no significant difference in development percentage from fertilized egg to straight hinge stage among the groups. No consistent difference in size of straight hinge larvae of the three age groups was found at two days although in some cases youngest oysters seemed to produce straight hinge larvae of small size. A correlation appears between the size of the early staight hinge larvae and their subsequent growth rate, smaller larvae requiring a longer time to mature.

No significant difference occurred between oysters of different groups in respect to time needed to develop ripe gonads or in their larvae survival. Oysters of the oldest group usually responded to spawning stimuli more willing-

ly than others. Sex ratio of the oldest oysters was approximately on a 50-50 basis. Many of the largest oysters showed good shell growth during the conditioning period, one oyster growing 1.7cms. in about three weeks. Experiments show adult oysters of all ages may be safely used as spawn producers, and that there is no significant difference in quality of spawn produced by individuals of different ages.

Similar studies have been begun on several size-groups of Venus mercenaria.

Spawning requirements and behvaior of oysters of different geographical areas.--Spawning and other aspects of behavior of oysters from Long Island Sound, New Jersey, Virginia, South Carolina and Florida, brought to Milford last fall and conditioned for spawning during late winter and early spring, showed oysters of different districts differed in behavior. One part of the experiment consisted in conditioning oysters at temperatures of 15.0, 18.0, 21.0, 24.0, 27.0 or 30.0° C. and in estimating at certain intervals their condition and ripeness degree. One criterion was the time required for each group to progress to such a stage that about 50 percent of the population could be induced to spawn; another was to determine the number of oysters with physiologically ripe eggs or sperm. Results showed Long Island Sound oysters ripened at all temperatures much sooner than any other group. New Jersey oysters, although only slightly below the Long Island Sound group when conditioned at high temperatures, such as 30.0 or 27.0° C., fell far below the Long Island Sound group when conditioned at 24.0 and 21.0°C., and at 18.0 and 15.0° C. the differences were striking. Virginia and South Carolina oysters, conditioned at the two highest temperatures were only somewhat behind the New Jersey group, but far behind at lower temperatures. Florida oysters usually failed to develop gonads and behaved differently from northern or mid-Atlantic oysters.

The majority of the Long Island Sound oysters conditioned at a temperature of 12.0° C., for 67 days had physiologically ripe cells and some oysters could be induced to spawn by raising the temperature. One of the Long Island Sound oysters conditioned for 68 days at 15.0° C. was made to spawn at 13.2° C. Gonadal layer thickness does not necessarily indicate relative oyster ripeness. Neither sponge nor Polydora appear to inhibit gonad development; oyster crabs, however, usually retard it.

Requirements of oyster larvae, Crassostrea virginica.--Studies on food requirements of oyster larvae indicated they are very selective in their food. More than 15 marine bacteria species proved useless as food. Bacteria were isolated in pure cultures. Oyster larvae utilized to some extent five flagellate species from Plymouth, England. Another marine flagellate, Pavlova gyrans, also from England, was toxic if fed to larvae, while another unidentified chrysomonad had only slightly harmful effect. All these flagellates belong to the order Chrysomonadida and are closely related, yet their oyster food value differs radically. This indicates that such steps as chemical analysis of whole plankton samples or estimates of nutritive substances in

sea water may not help in finding whether water contains or will contain nannoplankton varieties utilizable by oyster larvae. The only reliable approach may be species identification, if possible, and cell counts.

Young oyster larvae did not utilize Chlorella tried in pure culture but larvae of large size assimilated it and grew. None of the food combinations has given evidence of providing a more balanced diet or more rapid larval growth than could be obtained by feeding equivalent quantities of a single kind of food. Effects of all foods tested, including Chlorella, are additive. When equal numbers of cells are fed, different flagellate species induce different oyster larvae growth rates. Flagellate species also differ in number of cells needed to induce maximum oyster larvae growth rate. Maximum concentration of food organisms that can be created in water containing oyster larvae without unfavorably affecting the larvae varies with species. With the number of food organisms equal, oyster larvae growth rate had an inverse relation to number of larvae per unit volume. Variations between growth rates of larvae in cultures receiving same treatment in successive experiments appear caused by some variable sea water factor that affects larvae ability to utilize food. Addition of two vitamins, ascorbic acid and B12, as well as an iodine solution in potassium iodide, and inorganic ions, Mn^{++}, Fe^{+++}, Zn^{++}or PO_4^{++}, to cultures containing oyster larvae showed water factor retarding larvae growth was not one of these substances.

Through use of the millipore filter, a method is being developed for a qualitative estimate of microplankton and for developing a staining technique that will help recognize different groups.

Control of enemies of commercial molluscs.--Observations on starfish spawning and setting found setting began about July 1 and soon acquired an intensity not recorded in the last decade. Contrary to oyster pattern, starfish set throughout summer practically without interruption. Setting did not display well-defined waves as did oysters. The 1952 set was consistently heavier at 30 feet than in shallower water. Heavy mortality occurred among recently set starfish but fast-growing survivors soon overran cultivated oyster bottoms. Fall starfish survey showed the new set increased the population about 600 percent, as compared with the spring of 1952.

Cultivation of lemellibranch larvae.--Larvae of several lamellibranch species not cultured previously were grown to metamorphosis and data on length-width relationship and growth rate obtained. A manuscript is being prepared on cultivation, growth and larvae identification of 16 different lamellibranch species, based on cultures grown at Milford. Data on length-width relationship of each species from the time straight hinge stage is reached until metamorphosis, as well as a series of microphotographs demonstrating different growth stages, have been prepared.

Venus Mercenaria larvae were grown to setting stage within 10-14 days on pure, bacteria-free cultures of Chlorella, Chlamydomonas, Chromulina pleiades, or Isochrysis galbana. Porphyridium, a blue-green alga, did not seem to be utilized. Venus larvae, like adult oysters, show food selectivity, sometimes rejecting small forms such as Prophyridium, which is only about 3 u, while taking in much larger forms, such as Chlamydomonas, about 10 u.

Food requirement studies of Venus mercenaria larvae showed concentration of food organisms giving optimum growth depended upon cell size, as was found for adult oysters. In some cases optimum concentration may lie near 250,000 cells of food organisms per cc., while in others, when larger cells are used, it may be between 12,000 and 25,000 cells per cc. Overcrowded cultures, receiving proportionately the same food quantity as the least dense cultures, grew less rapidly. Heavy food concentrations may kill larvae in a short time. Either filtrate or cells of food cultures, such as Chlorella, may cause larvae death if present in large concentrations. This fact was established by placing larvae in flasks with water filters through millipore filters and then adding to water in different concentrations either filtrate of the food culture that was also filtered through the same filter, or Chlorella cells which were retained on the filter and then resuspended in filtered sea water. These observations, in general, correspond to those made at the Milford laboratory on adult oysters when it was found heavy concentrations of food organisms affected them mechanically because of the presence of a large number of cells and chemically because of metabolic products present in the liquid part of the food media.

Data analysis of experiments in which Venus mercenaria larvae were grown at 18.0, 21.0, 24.0, 27.0 and 30.0° C. showed no significant difference in setting size of larvae at different temperatures.

In examining Venus mercenaria culture, in which mass mortality had occurred, an organism resembling fungus which was apparently responsible for the mortality was noticed. Samples of preserved and living larvae material were infected with fungus. Venus larvae may contain two different genera of fungi, Lagenidium and Aphanomyces, while oyster larvae contain Lagenidium. Various fungicides are being tried. Failure to grow larval cultures and, in the case of Venus mercenaria, mass mortality of recently metamorphosed clams are often due to fungus infection. By finding a control for this malady, clam cultivitation on a commercial scale may become a reality.

A method, in which living larvae fungus was stained with a vital dye, was developed and promises to be of considerable help in detecting fungus appearance in a culture, progress of epidemics, survival rate of fungus-affected larvae, etc.

Introduction of European oyster, Ostrea edulis, into American waters.--This study, begun in 1949 with oysters from Holland, showed this species can survive and propagate in this country. Oysters were kept in Milford Harbor and in several Maine locations, including Boothbay Harbor. Occurrence of a natural set of European oysters on Boothbay Harbor rocks proved they found the new environment favorable.

European oysters were induced to spawn in winter and many cultures were carried to metamorphosis. They were also grown on a much larger scale in the Milford outdoor experimental tanks during the summer. Seed oysters obtained at the Milford laboratory by artificial cultivation were shipped to Pacific coast oyster investigators.

III. BEAUFORT LABORATORY
(SPECIAL SHELLFISH INVESTIGATIONS)

Walter A. Chipman, Beaufort, North Carolina

Studies continue of accumulation of various elements in marine plankton and in bodies of economically important marine invertebrates, their distribution within tissues, their formation into compounds and their retention and excretion.

Estuarine organisms accumulate in their bodies many elements of the surrounding water. Accumulation of considerable quantities of certain elements by marine invertebrates is remarkable when the small amount of these present in sea water is considered. If fission-product elements are present in water, many of these are rapidly taken up by plants and animals and may be retained in high concentration for some time.

The method of entry of many elements, whether from food or by direct absorption from sea water, is still not known for certain in many instances. Small floating marine plants have been shown to obtain their nutrients directly by absorption from sea water. Higher forms, feeding on plankton, may thus accumulate large quantities of those elements which occur in small concentrations in sea water. However, direct absorption through body surfaces or through gills is important in many marine animals. Researches of the project are concerned both with uptake through food eaten and through direct absorption from body surfaces. In the case of shellfish feeding through filtering mechanisms, considerable emphasis has been placed on problems of food selection.

Experiments with strontium^{89}.--Uptake of radiostrontium, one of the fission-product elements of considerable importance when considered from the point of view of pollution, from sea water by various species of phytoplankton tested was rapid. In nearly all cases there was an almost immediate uptake followed by a sustained radioactivity level. When plankton cells containing radiostrontium were returned to sea water, measurable radiostrontium loss to water did not occur, possibly because of great differences in specific activities of strontium within and without the cells and the nature of the compounds formed within the cell. Evidence that exchange was going on was obtained, however, by adding a chelator, sodium salt of ethylene diamine tetraacetic acid, to the sea-water medium surrounding the phytoplankton cells. In such experiments the radiostrontium leaving the cells was firmly chelated and accumulated in the medium.

In experiments where species of Nitzschia, Chlamydomonas and Chlorella were used, radiostrontium uptake was not related to photosynthesis and light. An apparent constant specific activity was soon reached with no further uptake, the total amount of radioactivity reaching the same level in cells kept in the dark as that in cells kept in the light. In the case of a species of Carteria, however, uptake in the light was greater than in the dark, and the uptake was continued with time. Apparently some metabolic processes take

place in this species in which strontium, or a closely related or associated element, is involved. Strontium accumulation in this species was greater than in others.

The amount of available calcium in the sea-water culture medium had a marked effect on uptake of strontium^{89}. A low calcium concentration in relation to strontium resulted in an increased strontium uptake.

Through use of an isotope-dilution method, the accumulation of strontium^{89} by several species of marine algae was followed. If one adds a calculated weight of marine plankton cells to sea water containing radiostrontium of known activity per gram of water, reduction in radioactivity resulting can be compared to that which would result from a comparable addition of an equivalent weight of water. After establishing an equilibrium, increased reduction in radioactivity resulting from addition of plankton cells over that which might be expected from an addition of water indicates radiostrontium concentration by alga.

The number of times strontium is concentrated in cells of various species of marine phytoplankton over concentration in sea water follows:

Nitzschia closterium	250
Nitzschia sp.	302
Chorella sp.	348
Chlamydomonas sp.	360
Carteria sp.	750

Uptake of radiostrontium by direct absorption in marine animals tested is rapid. It is distributed throughout the body with highest concentrations in areas or organs containing greatest amounts of strontium and calcium. In the oyster, clam, and crab the greatest uptake is in the shell. No great accumulation occurs in soft tissues of the oyster and clam but in the crab there is an accumulation in the gills, the hepatopancreas, and the stomach, all of which are known to be areas for accumulation of calcium or they have calcified structures.

Soft tissues of oysters and clams, which are the edible portions, rapidly lose their radioactivity when returned to normal sea water. Only 1.9 percent and 1.7 percent of original activity are present after one week in tissues of clams and oysters respectively. This small amount remaining decreases with a half-life of approximately 4 to 5 days. The shells, however, have 30 percent of their original activity after one week and only about 15 percent after 5 or 6 weeks. Half-life curves may not mean radiostrontium loss, however, for there is a factor of growth and dilution of the radioisotope from new shell formation.

Radioactivity of the edible portion of the blue crab resulting from radiostrontium uptake was rapidly lost when crabs were returned to normal sea

water. Although gills and some other organs accumulated more radiostrontium, the biological half-life was the same as that of the remaining meats--about 5 days. There was, of course, a much more rapid loss initially.

Aside from rapid radioactivity loss from crab shells within the first two days, about 30 percent of the activity remained 10 days in normal sea water without any appreciable decrease.

Experiments with zinc^{65}.--Since many marine invertebrates accumulate a number of metal ions, studies have been directed to determine mode of entry, distribution in organs and tissues, chemical combinations formed, and biological life of a selected number of metal ions. Since the list of biologically important ions is large, only a start has been made on these studies.

Zinc is present in small concentrations in sea water and is considered a trace element for plants. Studies with radioactive zinc show phytoplankton cells rapidly remove it from the culture medium whether in the light or in the dark. Thus, zinc uptake and utilization may have little relation to photosynthesis. Fractionation with trichloracetic acid shows there is only a small amount of zinc incorporated in protein-bound material. Tests of inhibition of growth of cultures showed zinc concentrations of less than 0.25 ppm will inhibit cell division. Amount of zinc entering the cell depends upon concentration in the medium. In filter-washing experiments, the amount of radioactive zinc exchanged from cells increases as zinc concentration in the washing medium increases.

Marine shellfish contain large amounts of zinc in their bodies, concentrating zinc of sea water many times over. Undoubtedly zinc is required in their metabolism in a small amount, probably being concerned with enzyme action. Neither the part zinc plays in their metabolism nor the reason for accumulation of large amounts is known. Through use of zinc-65 experiments showed there is a rather complete exchange between zinc of sea water and shells and tissues of oysters and clams. Injections of radioactive zinc into oyster bodies show its greatest accumulation is in the liver and gills. Accumulation in gills may have a relation to abundance of the enzyme carbonic anhydrase in the gills. Both histochemical methods and autoradiographs are being used in this study. Fractionation of oyster tissues containing radioactive zinc is being made in an attempt to learn the zinc compounds formed. Fractionating with trichloracetic acid shows zinc incorporation into protein-bound fraction is small in amount, the greater part being in the acid-soluble fraction. Studies continue on zinc metabolism in marine invertebrates.

Experiments with manganese^{54}.--Although radioactive manganese has been obtained, studies of this metal's role in shellfish metabolism have only begun. Exchange phenomena and uptake by oysters and oyster tissues have been observed. Studies of radioactive manganese distribution in oyster tissues are being made. Manganese has been thought to play an important part in oyster reproductive processes, but its actual metabolic uses are unknown. Studies

planned for using the radioactive isotope may yield information about the metabolic role of manganese.

Experiments on foods and feeding of shellfish.--To use various species of plankton in feeding experiments, local collections are made and available cultures obtained from other laboratories.

Isolation of one species of phytoplankton from a collection containing hundreds of species has proved difficult. In addition, before any species can be labeled with a radioisotope and fed to an oyster or clam, it must not only be isolated but its nutritional requirements determined.

Skeletonema, Chaetoceros, Navicula, Nitzschia, Chlamydomonas, Chlorella, Carteria, a blue-green species, and a few unidentified species have been isolated and maintained in culture in the Beaufort laboratory. To obtain new species having different nutrient requirements and to increase population sizes of those isolated and in culture, culture medium modifications are being made continually.

To obtain phytoplankton containing radioactive phosphorus in suitable amounts and properly bound within cells for feeding experiments, exchange and accumulation of radioactive phosphorus by phytoplankton cells had to be determined. Results of this study have been submitted for publication.

Although phosphorus uptake to meet metabolic needs of rapidly dividing phytoplankton is great, it has been possible to show some phosphorus exchange occurs between cells and culture medium. Further, it has been shown the amount of exchangeable phsophorus in phytoplankton varies with physiological cell condition. Thus, it has been possible to label a species of phytoplankton with radioactive phosphorus with high concentration in non-exchangeable fraction and, hence, reduce interference brought about by presence of radiophosphorus in medium in feeding experiments. Since oysters and clams can remove phosphorus from sea water, any radioactive phosphorus exchanged from phytoplankton cells during the feeding period could be absorbed by animals and interfere with proper evaluation of experimental data.

Through use of radioactive phosphorus, experiments have shown exchange reactions between phosphorus of sea water and that of bodies of oysters and clams. Exchangeable phosphorus in relation to total amount in oysters is small. Apparently there is a metabolic phosphorus pool available to meet tissue needs. Feeding experiments demonstrate phosphorus compounds of oyster food contribute the largest amount of phosphorus to this metabolic pool.

Phosphorylations enter into carbohydrate, lipid, and protein metabolism of oysters as they do in other animals. Phosphorus also is important in shell formation. Gill tissue phosphorus was 7.5 ug P/mg on a dry weight basis. Of this, trichloracetic acid insoluble fraction, which included protein phosphorus and lipid phosphorus, amounted to 17.6 percent. Of tri-

chloracetic acid extractable fraction, 26.2 percent was in the form of inorganic phosphorus and 74.6 percent as organic phosphorus, chiefly ester phosphorus.

Experiments using radioactive phosphorus showed there was a rapid turnover of inorganic phosphorus, a moderate turnover of ester phosphorus, and a slow turnover of portein-bound phosphorus. Oysters placed in sea water containing radioactive phosphorus quickly became radioactive from uptake involving only inorganic phosphorus fraction. When oysters were then placed in ordinary sea water, they rapidly lost this radioactivity. Because the amount of inorganic phosphorus in oyster tissues is small, oysters accumulate little radioactivity from short exposures. Since incorporation rate of radioactive phosphorus fractions is slow, a long-continued exposure results in extremely radioactive oysters which retain their activity for long periods. This work is completed and will soon be submitted for publication.

There are two important theories as to the chief source of food for ciliary feeders. One theory suggests the principal food is dust-fine detritus from cells and fragments of dead and disintegrating plants and animals. The second and oldest theory is that the most important food source is living phytoplankton organisms. Once food material enters the digestive tract, a question remains as to wehther or not the oyster will digest and assimilate it. Ingestion of a certain species does not necessarily mean it can be used as food. It may only indicate inefficiency of the filtering mechanism. Passage of a plankton cell through a digestive tract which leaves the cell intact and alive does not necessarily mean it cannot be digested. It may only indicate that the oyster ingested more cells than it could digest and assimilate in the time required for the cell's passage through the tract.

Through application of radioisotopic tracer technique to the study of food and feeding of oysters the number of organisms ingested and the number utilized can be estimated. If radioactive isotopes have been chemically combined in protoplasm of phytoplankton which are detected in oyster tissues after a feeding experiment, this particular plankton must serve as a food.

Phytoplankton consisting of species of Chlorella, Chlamydomonas, Nitzschia, Skeletonema, Carteria, Navicula, Nannochloria and Pyromimonas and protozoan Plagiocampa were made radioactive with P^{32} and fed to oysters. Different species were then compared as to their acceptability as food for oysters. Some plankton forms settled more rapidly than others and, therefore, fewer were suspended and available to the oyster. The amount of fed cells entering the digestive tract were compared with those in the pesuodfeces. Results agree with previous work that sorting of particles for ingestion by the oyster depends in part on size, shape, and abundance at one time.

However, selection of certain plankton species as food by the oyster involves factors other than size and shape. Cell abundance of a small species in the rejected material of the pseudofeces was greater than that of

cells of certain other larger species that were fed.

Because of accurate quantitative measurements made possible by use of radioactive tracers, further work will give a more complete understanding of the extent of sorting that takes place.

Experiments demonstrated digestion, absorption, and assimilation of all species of plankton cells fed experimentally to oysters except Chlorella. Though large numbers of Chlorella cells were in the digestive tract, the oyster utilized almost none as food. Phosphorus of plankton cells utilized by the oyster was assimilated and incorporated into organic phosphorus-containing compounds of oyster tissues. Though feeding experiments continue, preliminary results will be published soon.

IV. PENSACOLA LABORATORY
(GULF OYSTER INVESTIGATIONS)

Philip A. Butler, Pensacola, Florida

Oyster investigations.--Observations on spatfall in the summer of 1953 were designed to differentiate set stratification of the three oyster species well established in the collecting area and preference of larvae for upper or under surfaces in setting. For the fifth consecutive season evidence shows oysters prefer upper or exposed surfaces. Other investigators obtained opposite result. Difference probably arises from data based on survival rates rather than on initial setting rates.

Interpreting data is difficult because of concurrent setting of the three species. The set is being enumerated by species on representative cultch pieces. The total set, during three consecutive one-week periods, showed a consistent stratification diminishing from top to bottom (9' of water sampled at 1' intervals) but with a minor peak at mid-depth. During a 7-day period setting rates varied, depending on cultch position in water, from 0.03 to 30.0 oysters per square centimeter.

Setting rates obtained at different stations or different localities are not comparable without strict technique uniformity. Many instances occur of setting rates varying from two to 20X on opposite sides of the same cultch piece, depending on its physical position in water. Cultch position control can determine relative setting rates.

A new high in setting intensity occurred during July 22-29, 1953, when oysters set at the rate of 30 per square centimeter. This number is nearly twice the cumulative oyster set for the 1951 and 1952 season.

Observations of sex change in adult oysters, started in June 1952, ended in the summer of 1953. Initial sex determinations were made by boring a hole through the shell and examining microscopically a smear of

gonad tissue removed with a hypodermic syringe. Total mortality from this treatment in the first six months was less than 5 percent. Oysters covered these holes over quickly. Growth in the following year was excellent and at the same rate in both males and females. Winter storms destroyed almost half of the oysters and only 115 remained at the end of the year. Of the survivors, 44 percent changed sex; 35 percent of the females became males and 50 percent of the males became females. A net increase in females of 13 percent occurred in the year. Despite the small group size, the tendency toward femaleness was pronounced; among the largest oysters, all males became females and only 20 percent of the females became males.

Snail investigations.--In setting up a program for devising better trapping methods, a check was made first to see how far bait would attract snails under local conditions. Chicken wire traps baited with oyster spat and mussels were placed at measured distances from the laboratory island in approximately 4' of water. Survey of the sand bottom with a diving mask showed no crawling snails. Since the rocky island shore seemed to be the snail source, trays were placed in pairs at distances of 25, 50, 100, 200 and 300 feet from the island. During each 24-hour period for 10 days they attracted an average of 12 snails each. Trays nearest the island attracted fewest snails and the middle trays in the row (100' from shore) attracted most. Trays containing blank oyster shells set as controls attracted only three snails while baited traps contained over 1000. Although the daily catch was erratic, it showed no signs of decreasing at the end of the period.

A snail trap has been devised and is being tested. Built on the principles of a crab trap with funnel entrances, it retains snails after they enter and so holds the bait that they cannot get to it.

Further observations on snail biology were made during July 1953 to determine tolerance of snail embryos in capsule to changes in salinity level. Tolerance of embryos to lower salinity levels parallels that of the adult snail, but adverse effects are apparent much more quickly. Batches of two and seven day-old embryos in capsule removed from an environment of 25 ppt salinity were placed in diluted oxygenated sea water at salinity levels varying from 0 to 20 ppt. As with the adult snail, a salinity drop of 10 ppt causes immobility. If exposure lasts for 24 or more hours, embryos die. When they are exposed to salinity decreases of 15 or more ppt and then returned to full sea water, their mortality rates increase with increasing exposure time. Seven minutes' exposure to tap water results in mortalities of approximately 50 percent. Freshets as a limiting factor in snail ecology obviously are of far greater importance in larval than in adult stage.

Hard clams.--In July 1952, one tray of 25 hard clams (out of 2000), was recovered from experimental plantings at Pensacola which drills had missed. These clams came from Rhode Island waters and have been in Gulf of Mexico waters for two years and averaged 2" in length. On the average this growth rate is less than that expected of hard clams in Rhode Island waters. These data seem to indicate the northern Gulf area does not provide an especially good environment for hard clams.

CHESAPEAKE BAY SHELLFISH INVESTIGATIONS

James B. Engle, Annapolis, Maryland

Oyster seasonal spawning and setting.--Upper Chesapeake Bay areas, where oysters set in sufficient abundance for seed use, are scarce. Eastern Bay, one of these areas, produced sets of commercial magnitude eight of the past ten years. Poor setting occurred when Bay water in late spring and early summer had salinities exceeding a normal of about 10 parts per 1000.

Setting in 1952, a year of below normal salinity at the critical time, produced a commercial set of seed oysters in Eastern Bay, which was one of the best within the 10-year observation period. Spat collectors designed to measure optimum setting caught many more oyster spat than shells planted commercially on the same bottom. While this difference was great, the amount caught and surviving on the planted shell was ample for transplanting as seed. Eastern Bay stations show the following set record:

Place (Eastern Bay)	Spat catch per bushel of shells	
	Spat collector	Planted shells
Milhill Bar	377,350	1,172
Parsons Island	103,125	130
Bodkin Rock	74,775	
Long Point	22,800	

Milhill Bar is a designated seed bar and contained shell planted in the late spring of 1952; these shells were relatively clean. Organic matter and silt fouled shells on Parsons Island Bar which were planted several years ago. These figures demonstrate clean cultch importance. Spat collector shells are always clean, current year planted shells usually are relatively clean, but shells or cultch that are on the bottom for any extended time prior to the setting season loses catching efficiency. Setting was continuous from the week of June 23 to the week ending September 29. The heaviest weekly set appeared during the week ending July 28 with an average catch per shell of 685 spat at Milhill on test shells.

Gonad development, following the course similar to that of previous years, reached peak thickness the third June week. Mass spawning occurred during the fourth June week and produced a moderately heavy set. The next major release of spawn took place during mid-July and the heavy setting reported above resulted from this spawning. No mass spawning developed during August and September although enough spawn was released to keep a light spatfall continuously setting on test shells until the last September week.

Oyster larvae abundance in the plankton followed closely the evidence of spawn discharge shown by shrinkage of gonad thickness throughout the season.

Total oyster larvae amount in the samples did not differ materially from samples of other years, but extent of larvae metamorphosis to setting stage was considerably greater, and is the key factor for heavier setting. At Milhill, where the heaviest setting occurred, each 100 liter water sample contained 30 late stage oyster larvae in 1952 as compared to six late stage larvae in 1951. Test shells in 1952 caught 377,350 spat per bushel of test shells while test shells in 1951 caught about 7000 spat per bushel.

Upper Chesapeake Bay plankton samples contained few oyster larvae and practically no late stages. Oyster setting in this area, which was light on test, planted and wild shells, reflected this condition.

Oyster condition.--Seasonal oyster condition is a useful biological as well as an economical index. Percent glycogen determines market condition or oyster "fatness". High glycogen content produces high yield and desirable flavor. Oysters reached peak glycogen accumulation in January of 31 percent dry weight of meats in Chesapeake Bay proper and 28 percent in Eastern Bay. Glycogen reduction to about 10 percent during and immediately after spawning did not depart from the usual seasonal cycle. Total solids measure dehydrated meat amount per unit measure of whole meat, furnish a means of comparing oysters with other foods on a standard basis, show water content of oyster meats and distinguish bloated oysters from those actually "fat" with glycogen and other solids. Oysters from low salinity waters often show the false "fatness" of bloating. Condition factor, dry weight of meats per unit shell cavity volume, compares bushel yield in the shell with meat yield after shucking. These three methods of determining oyster condition have biological significance in showing effects of ecological changes. The fall and winter of 1952-1953 did not depart excessively from normal in either oyster condition or environment.

Chlorophyll cycle as a measure of grazing potential and its relation to oysters.--The biological and chemical condition of the environment affect oysters. Since the oyster, a plankton feeder, forages at a low position on the food chain, availability of planktonic food materials and nutritive chemicals may limit biological features of oyster production. Tentative evidence indicates survival of oyster larvae to setting is proportional to phytoplankton amount in water during May, June and July.

Larvae survival to setting responds to wetness or dryness of the late spring and summer. For nine years the oyster set in Eastern Bay has fluctuated annually with certain salinity levels. When salinity is high after a dry spring and summer, setting is meager; when salinity is low after a wet period, setting is much more abundant. These salinity differences are not of great magnitude but indicate varying amounts of surface runoff entering affected estuarine waters. Preliminary results of chemical studies point out phytoplankton increases during wet years within limits of our observations. As a result more food is available to larval oysters.

Phosphate cycles and productivity.--To compare phytoplankton levels with some of the nutrient salt levels, water samples preserved in the field by the

Collier freezing method are analyzed for available inorganic phosphate in Eastern Bay waters and at several Chesapeake Bay stations. Availability of phosphate salts is undoubtedly one of the limiting factors inthe food chain picture. The work on this relationship is just beginning and will be reported in detail later.

Methods of determining oyster pouplation changes.--Swan Point bar in upper Chesapeake Bay furnishes oysters for a single community. A freshwater catastrophe in 1945-1946 denuded the bar of oysters. The State of Maryland replanted the bar with a known number of oysters over the years following the freshet. Fluctuations in this oyster population because of fishing mortality, natural mortality and natural recruitment have been followed for the past five years to ascertain fate of the oysters. Since natural recruitment has not added materially to the numbers of planted oysters, fishing and natural mortality account for fluctuations measured. From estimates of these fluctuations the number of oysters needed to keep the bar for a known number of fishermen exploiting its population can be estimated.

To accomplish the population survey, it was necessary to evaluate the efficiency of various sampling gear. Experiments indicate superiority of the dredge as sampling gear on oyster bars similar to the Swan Point bar. Tongs, though perhaps more efficient, require in their operation added manpower and much more time. Principal problems of dredge operation are development of the greatest repeatable efficiency while sampling, which we believe now attained, and estimation of dredge efficiency, which we consider to be calculable. We tentatively estimate our dredge efficiency between 10 and 20 percent, and expect a closer measure after working up results of operations this spring and early summer.

Inventory of oyster resources in Maryland and Virginia, a cooperative study with the conservation agencies of the States of Maryland and Virginia.--Biologists and technicians from this laboratory, Chesapeake Biological Laboratory and Maryland Department of Tidewater Fisheries examined about 100 oyster bars in the Maryland portion of the Chesapeake Bay and tributaries from October 15, 1952 to January 15, 1953. Their objectives were to determine approximately the number of marketable oysters available for present season cropping, number of smaller oysters available for future crops, and the current natural recruitment as indicated by the 1952 spatfall survival.

Areas	No. Stations	Market	Small	Yearling	Spat 1/
Chesapeake Bay Proper	27	63.4	38.4	25.8	6.5
Choptank River	11	37.1	38.5	54.2	49.6
Eastern Shore Trib.	36	103.4	132.1	28.9	59.2
Potomac River	19	77.8	60.6	52.7	25.3
Average all stations	93	78.7	79.2	35.9	46.6

1/ Oyster quantities per bushel of bottom material.

These figures show roughly the production which may be expected for the next few years. Small oysters indicate the 1953 crop; yearlings enter the 1954 crop, and the 1952 spat will begin to be a part of the 1955 harvest, provided no catastrophe occurs. Leaner years appear ahead after 1953.

River flow effect on oyster seed beds in the Delaware River.--A report was completed on the possible effect of proposed changes in the river flow on the present status of oyster seed production in the Delaware River. Any material change in utilization of water from the Delaware River system would affect salinity level at the seed beds. If proposed amounts of water were removed from the system, salinity would increase and permit an up-river migration of the oyster drill into the seed areas. Any utilization of river waters must be compensated by a return to the system of enough fresh water to keep the salinity at its present level. Oyster drill invasion into the seed areas would be disastrous to the New Jersey and Delaware oyster industry.

CLAM INVESTIGATIONS

John B. Glude, Boothbay Harbor, Maine

Clam farms.--Town action which opened Doctor's Creek to commercial digging terminated Wells soft clam (Mya arenaria) farm.

Green crabs may have decreased the population of the 1951 clam planting in Sagadahoc Bay farms which is less than five to a square foot. Polinices appeared also in late 1951 samples. Few planted clams have reached legal size (2 inches). Survival of the 1952 planting, which was planted 50 to a square foot, was nearly 25 to a square foot and showed good growth. Polinices and green crabs occurred also in the 1952 samples.

June 1953 sample of the Jonesport farm shows clams planted in the spring of 1951 average just under the legal size. When they were planted in 1951, their size was 24.5 mm.; in the winter of 1951-52 it was 36.9 mm.; in the winter of 1952-53 it was 46.0 mm.; it now is 51.4 mm.

Clam census.--Results of 1949, 1950, 1951 and 1952 soft clam census were transformed by logarithms to permit statistical analysis. Population changes from year to year were statistically significant in some areas. A continued decrease was indicated in Sagadahoc Bay soft clam population. Decrease of smaller sizes may indicate green crab predation on them.

Field work for 1953 census was completed for Sagadahoc Bay and Robinhood Cove.

Ecology.--Sampling Love's Cove continued. Soil, elevation and predators seem to influence major species distribution.

Mya larvae.--Weekly samples were collected year-round in Robinhood Cove. Mya straight-hinge larvae first appeared in early June 1952 after a 10-day period in which average clam-flat temperatures increased 6.2° C. and maximum temperatures increased 13° C. Occurrence of the greatest abundance of both straight-hinge and advanced larvae during the last half of September and first half of October indicated a late-season set. The over-all magnitude of Mya counts in 1952 samples was less than in 1951.

A new high-speed sampler designed and built at the station has obtained 300 gallon weekly samples. This unit permits accurately (to 0.1 gallon) pumped plankton samples to be obtained from nearly any depth in shallow inshore waters while traveling at speeds up to 6.5 knots in small craft. Extensive sampling has been done to show effectiveness of the sampler in obtaining a representative sample from an area.

Mya set.--Weekly set samples were taken in Robinhood Cove and monthly samples in Sagadahoc Bay. A good late-season set was indicated in Bedroom area of Sagadahoc Bay, but the 1951 set, abundant in early summer, had largely disappeared by fall. In Robinhood Cove, the 1952 set first appeared in early July and occurred fairly regularly until October.

Flat modifications.--Various materials were placed on shifting sand flats of outer Sagadahoc Bay to stabilize conditions for newly setting Mya and wandering juveniles. Coarse gravel lasted one month, coarse sand three weeks, and coarse crushed rock two weeks. No set or wandering juveniles were found, although set occurred in other parts of the bay during the period.

Tidal spat trap.--An automatic filtering device to collect clam larvae and hold until setting was designed, built and tested. Incoming tide fills the 170-gallon plywood tank through a check valve in the side. During outgoing tide water passes through a four square foot sand filter in tray. Location of overflow maintains 8" water over sand tray at low tide.

A trap set up at Boothbay Harbor Wharf on May 26 for testing made the following catches per square foot:

Larvae or spat	6/4	6/12	6/18
Mytilus	1000 - 2000	5724	9687
Mya	None seen	648	952

To determine its efficiency, the trap was moved to Robinhood Cove, where plankton studies are conducted. Promise of this device to provide a practical means of collecting Venus spat is important since seed lack is a limiting factor in Venus farming.

When a plankton net replaces the sand tray, the trap becomes an automatic plankton sampler filtering water collected during each flooding tide.

Survival of clams buried at various depths.--Soft clams of three sizes were buried 50 per plot at depths 1", 3", 5 " and 9" in sand, sandy-mud and mud, and placed upright, horizontal or inverted. Plots were exhumed two weeks later and survival was determined. Experiment was repeated in winter to compare effect of time of year. A summary follows of results which are important in determining commercial clam digging effect on sublegal clams left in flats.

Average percentage survival:

1" depth	90%
3" "	74
5" "	43
9" "	3
Upright	75%
Horizontal	72
Inverted	56
Summer	71%
Winter	84

Biology of the green crab, Carcinides maenas.--At almost monthly intervals crabs were collected with traps and a small beam trawl, and from marsh banks. Data were collected on size frequencies, sex ratios, and female gonad condition. Plum Island Sound population was apparently over 70 percent female in summer and the reverse in winter. Determining complete behavior patterns and reproductive cycle of crabs was difficult because of their tendency to segregate according to size, sex and egg condition. In Hampton River, N. H., on May 25, 71 females, most of them carrying eggs, and 27 males were dug from a bank while another bank, 1000 feet away, yielded 50 males and 50 females, with only one female carrying eggs. In Merrimack River, trawl and trap samples in early June indicated a 50-50 sex ratio. Females had developing gonads but were not carrying eggs; however, 4 or 5 percent had recently hatched eggs. A large suction dredge pumping sand from the same place brought up many crabs, 96 percent of which were females, most of whom were berried.

Electric barriers for green crabs.--Preliminary experiments were conducted during April and May to ascertain if an electric barrier might keep green crabs from clam beds. Experiments were made in a small aquarium in the laboratory and a large aquarium at the University of New Hampshire. Field experiments should be made. Laboratory experiments showed:

1. An electric field in sea water can repel green crabs.
2. A voltage gradient between wires of 0.5 volts per inch repel

about half of the crabs while 0.8 volts per inch repel 80-100 percent, regardless of salinity .

3. A current drain at these voltages depends on salinity. Salinity reduction from 27 o/oo to 14.5 o/oo reduced current by half.

4. In moderately saline water (28 o/oo), power consumption of 1000 feet of fence would be 3120 watts to repel 80-100 percent of crabs if field results are similar to laboratory results.

5. Electrode position and current pulsation affect barrier efficiency. Pulsations at three per second reduced barrier effectiveness, but higher frequencies might be effective. Further work on this is needed.

Love's Cove project.--Green crab traps were fished weekly 10-15' at low water to follow seasonal abundance. Part of population migrated to intertidal zone the first of May. Migration to deep water, 5-20' at low water, occurred in early winter.

While more males than females were caught in winter, more females than males were caught in early summer. Berried female green crabs are more numerous in the early winter catch than at other times. Thirty-seven percent of females held in tanks at the station spawned from September 15 to December 15. Berried females survived a 5° C. water temperature.

Eighteen traps at Love's Cove were tended every 24 hours in an attempt to fish out the area as a control method for a 12-acre area. Over a 36-day period the average area daily catch was 938 green crabs. First day's catch was 1,330, the last day's 1,400.

Soft crabs appeared in the May-June catch. Many cast shells were collected in Sagadahoc Bay during May. Only small "casts" were evident in mid-May. Catching green crabs with large barnacles all months indicate some do not molt annually.

Green crab eggs held at Boothbay Harbor laboratory at 4-6° C. showed:

Salinity	Day's Survival
0	3
5	4
10	10
15	23
20-30	over 30

A study of green crab survival at lowered temperatures and salinities found crabs held at 1.7° C. in salinities 0, 5, 10 o/oo were dead at the end of three days; those held at a temperature of 1.7° C. in salinity 15 o/oo were dead at the end of 7 days. Seventy percent of the crabs held at a temperature of 1.7° C. in salinity 20 o/oo were alive at the end of 14 days, and 60 percent of those held at a temperature of 1.7° C. in salinity 25 o/oo were alive at the end of 14 days.

Green crab abundance and temperature trends.--Abundance, indicated by interviews with clam diggers and lobstermen and records of the Essex, Mass., clam warden and compared with the mean monthly air temperature for the coldest month of winter from New Haven and water temperature from average of Boston, Boothbay Harbor, Eastport and St. Andrews, appears correlated with short-period warm cycles. Range extension appears correlated with long-term temperature increase.

A green crab trapping program was initiated in June to provide a better estimate of relative abundance. With cooperation of Maine Department of Sea and Shore Fisheries three traps are fished two days per month from June to October in five locations from Jonesport, Maine, to Ipswich, Mass. Catch comparison should give a relative abundance estimate and provide a base for estimating mortality from a cold winter should one occur.

Green crabs appear to cause decreased soft clam abundance in many areas.

Greenwich Bay Studies.--In the third annual sampling survey of Greenwich Bay, which was completed on July 16, 1952, 258 stations were made. The 600-foot grid used in the previous two years was modified for this survey to overcome some objections to the grid and to sample more heavily in high density areas.

Population estimates for three years indicate a steadily increasing total population of all sizes. The commercial population (over the minimum legal size), however, remained relatively stable under an almost steady yearly removal for the three years. In general, the geographic distribution remained nearly the same over the sampling period since 1950. Areas of relatively high density continue at the mouth of Apponaug Cove, mouth of Greenwich Cove and in the center of the eastern section. The central part of the bay, north of Sally Rock point, remains nearly barren. The first evidence of a fairly heavy set in Greenwich Bay was obtained in 1952. Samples taken within a 1000-foot circle in an area of high density gave set samples with concentrations as high as 600 per square foot. This compares with heavy sets in certain Maine localities.

A composite chart of the bottom type was prepared from the three surveys. The bay appears to be primarily sand, overlaid with a layer of mud or silt. This mud extends in a tongue from the two coves in the western part well out into the mouth of the bay proper. The intertidal areas are almost all sandy. Areas of shell, both living and dead, are scattered over the bay. Available data do not reveal the reason for these shell concentrations and their location. These three basic bottom types (e. g. sand, mud, and shell) occur in all possible mixtures. Studies of the relation of bottom

type to number of quahaugs indicate higher densities in areas having shell quantities. Shell effect is unknown. It may be direct by catching the set better or indirect by reflecting some other environmental condition, such as a current eddy.

Age reading of shells collected in the survey was continued; however, accurate readings beyond four years do not seem possible in this region. False checks appear to be formed under the slightest adverse condition; in older quahaugs these obscure true winter marks. Growth for the first year was 20 mm., second year 15 mm., third year 12 mm. and fourth year 8 mm.

Length frequency diagrams indicate the 1949 and 1951 setting and survival were relatively poor as compared to other years present.

Interviewing continued and the catch per man day again remained nearly the same as in previous years. There was a slight shift from "necks" to "large".

The fourth survey began June 17, 1953.

Larval and setting studies.--Collecting and examining plankton samples from Wickford Harbor and Greenwich Bay were continued to assess larval abundance of Venus mercenaria and Mya arenaria during the 1952 spawning season. Mya larvae first appeared near the end of April, increased to an abundance peak by late May and disappeared in early July. In late September and early October a few young larvae were in the water for a few days. Venus larvae appeared for the first time on May 20, reached an abundance peak in mid-June and disappeared except for occasional small numbers by the end of July.

Venus mercenaria set-of-the-year was determined for Wickford Harbor by examining 136 one square foot samples taken at various bottom types. The average density for the Harbor was 1.5 per square foot. In general, the density was higher in sand or gravel bottoms and lower in mud.

Predator studies.--Past observations made in connection with other projects indicate small sizes of Venus, i. e. up to 15-20 mm., are frequently subject to severe predation by oyster drills, Urosalpinx cinera and Eupleura caudata. Therefore, a series of laboratory experiments have been started to determine drill predation degree. Experiments will include tests of predation by other suspects, such as the green crab, Carcinides maenas, the mud crab, Neopanope texana, the blue crab, Callinectes sapidus, the horseshoe crab, Limulus polyphemus, and the sand dollar snail, Polynices duplicata.

An interview survey to determine relative green crab abundance in Rhode Island waters at present as compared with their past abundance was made. Green crab fishermen and bait dealers stated that except for year to year fluctuations abundance had not changed during the last 10 years. This is in sharp contrast to the tremendous increase in numbers north of Cape Cod during this period.

Milford, Conn., studies of parasites and diseases of soft and hard clams.--Studies on clam parasites were restricted during the past quarter to life history aspects of certain of previously noted forms. The gonad parasite of Mya, Cercaria myae, was found in Hiatella (= Saxicava) artica at Boothbay Harbor; experimental infection of Mytilus edulis as second intermediate host was accomplished. Determining vertebrate host(s) is in progress. Morphological studies of Paravortex sp. in Mya indicate this turbellarian is not specifically distinct from P. gemellipara from Modiolus despite pronounced differences in host-parasite relationships. Studies on ciliate parasite of Mya, Trichodina sp. continued, with a specific description in preparation. A cooperative agreement was entered into with Yale University to investigate Venus parasitology.

Exploratory studies were completed on the host specificity of the oyster disease organism, Dermocystidium marinum, and on the nature of the so-called "waterbelly" condition in Mya from Maine areas. In addition, partial life histories were determined for five species of trematode parasites. Cercariasis in Mytilus edulis was studied and described.

Studies have not demonstrated that a single etiological agent alone has been responsible for mass mortality in Mya populations. It is tentatively concluded that environmental nature caused the 1949 mortality. Until such time as Mya mortality is again apparent, pathology studies will be restricted in scope. Investigation of parasites and diseases of the green crab, the major Mya predator, is projected. Effort will be made to explore possibility of virus pathology in clams in cooperation with a suitably equipped agency.

Newburyport, Mass., studies of parasites and diseases of soft and hard clams.--By means of dissection and histological preparation, biweekly clam samples from Newburyport area have been examined for parasites or diseases. No evidence of diseases of pathological condition was noted. There were no cases of mass mortality in clam flats. Seasonal abundance peaks of three common parasites were noted, but these could not be associated with clam mortality.

Clam farming.--Clam transplanting experiments were concluded in August 1952, as they had demonstrated clams can be grown in concentrations sufficient to produce good commercial digging if predators are kept off by chicken wire over plots. Four successfully protected plots produced 27, 16, 23 and 9 legal size clams per square foot, with more smaller clams "coming along." Production in unprotected plots was negligible.

A manuscript is being prepared on clam farming experiments from 1949 to 1952, which will include growth and survival data from monthly sampling.

On June 3 a circular, one-inch mesh wire fence, 300 feet in circumerence, 18 inches high, with a flange on top of 1" x 6" boards, was built. It encloses some moderately good native set and keeps out horsehoe crabs and most of the green crabs. This protection method may prove economically feasible, as cost per unit area can be much less than that for wire laid on flats.

Clam movement studies.--Sampling of square-foot trays, clamless mud (screened and replaced biweekly) and controls over two summers and one winter ended in November. Data have been tabulated but not completely worked up. Trays always contained clams of same size as those in surrounding flats and the numbers increased and decreased when those in the flats increased or decreased. This shows byssus clams 2-14 mm. are not permanently situated in flats.

Experiments were conducted at Boothbay Harbor Laboratory in February to determine current effects on 350 juvenile clams. Clams 2-19 mm. long burrowed easily while exposed to currents up to 17 cm./sec. Above this velocity, clams are moved about too violently to burrow readily, although six of 350 did burrow in a current of 25 cm./sec. (1/2 knot). Clams 2-10 mm. burrowed more rapidly than those over 10 mm.

Clams (2-10 mm.) attached to wooden surface by byssus threads withstood currents up to 46 cm./sec. before being dislodged. Clams 2-10 mm. burrowed ahead of rapidly eroding substrate for short periods of time before being washed out.

Five hundred clams 2-13 mm. were allowed to burrow and were observed daily for movement signs. Current velocity set at 10 cm./sec. After a week, 4 or 5 came up and moved one to four inches by use of the foot. After several weeks mussel sediment from the water system built up the "flat" about a half inch and clams accordingly raised themselves to a higher level. They have continued to come out and move about on different occasions. A few were washed into the sedimentation basin as a result.

A few current-velocity measurements were made with a specially made "chip log" on Hales Cove flat in about 18" of water. Current velocity ranged from 13-16 cm./sec. Measurements are planned through a tidal cycle.

Limulus population and migration studies.--Disc tags were pinned on 1050 Limuli during the summer of 1952 in Plum Island Sound and Essex Bay; the animals were mostly mature ones which were presumed to have stopped molting. Sixteen tags have been recovered. Tagging operations will be resumed.

Studies on reproductive cycle of Mya arenaria.--Two years' records, based on histological examination of gonads from biweekly samples, were completed. Newburyport area clams showed a greater reproductive potential in 1952 than in 1951. Greater numbers of byssus clams in 1952 seemed to corroborate these observations. Gonads in early 1953 seemed to reveal an even greater reproductive potential.

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