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(July 1, 1954 through June 30, 1955)

BRANCH OF FISHERY BIOLOGY
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SECTION OF INLAND FISHERIES W. F. CARBINE, CHIEF

GREAT LAKES FISHERY INVESTIGATIONS

James W. Moffett, Ann Arbor, Michigan

SEA LAMPREYS

The United States and Canada have ratified the Great Lakes Fisheries Convention. Implementing U. S. legislation will be introduced in the next session of Congress.

Lamprey control efforts were concentrated in Lake Superior, the only one of the Great Lakes in which the lake trout population has not been destroyed. By June 30 the take of lampreys of the 1955 spawning run amounted to 9,341 from 26 Lake Superior tributaries and indicates a doubling of the number of adult lampreys since 1954. Lamprey runs were discovered in 7 additional Lake Superior streams. The take of lampreys amounted to 11,700 in 1 experimental control structure in a northern Lake Huron tributary and 46,191 from 17 northern Lake Michigan structures. The figures for Lakes Huron and Michigan merely show a continued high abundance of the predator.

Tests of more than 4,000 chemical compounds were conducted in a search for a substance lethal to larval lampreys but relatively harmless to other fish. Eight promising compounds are being studied to learn their safety margin and toxicity to animals other than fish. Field tests will follow.

LIMNOLOGICAL SURVEYS

The research vessel Cisco completed in November a fishery and limnological survey of southern Lake Michigan which it began in May 1954. Gill nets identical to those used by the vessel Fulmar in 1930-1931 were used to evaluate changes in the fish populations since the lamprey became abundant in the lake in the 1940s. The 7 species of chubs that inhabit the deep, cold waters of Lake Michigan with the lake trout, showed a mixed reaction to the presence of the lamprey. Although the lake trout must have fed heavily on small chubs of all species, the slower-growing bloater, Leucichthys hoyi, which is characteristically small at advanced ages, probably served as the major food supply of the lake trout. With the lake trout gone, the bloater is relieved of predation. Because of its small size, the commercial fishery and the lamprey do not utilize it. The bloater increased over 400% between the 1930-1931 period and 1954.

The 2 species of chubs that attain the largest size, L. johannae and L. nigripinnis, were common in the nets fished in 1930-1931 but virtually absent in nets fished during 1954. These large chubs probably serve as a major food item of the lamprey. Fishermen have actively sought them because they have a higher commercial value than all other chubs. The 4 remaining chub species, L. reighardi, L. kiyi, L. zenithicus and L. alpenae, are intermediate in size and probably now serve as the basic source of food for the lamprey. They are the only abundant species of fish inhabiting the cool, deep water portion of the lake where the lamprey undergoes its major growth. These chubs also make up practically the present commercial chub catch which has increased from about 2 million pounds in the early 1940s to

over 11 million pounds in 1953. Comparisons between 1930-1931 and 1954 show these species are now about 1/2 to 1/6th their former abundance. The 1954 catches of all species of chubs contained smaller percentages of large fish than the 1930-1931 catches as a result of the lamprey and commercial fishery preference for large fish.

A similar investigation of northern Lake Michigan was begun in May 1955.

LAKE TROUT

Investigation of the life history of the lake trout, principal victim of the sea lamprey, was continued. A study of lake trout reproduction in southern Lake Superior revealed fish of this species mature at about 24 to 26 inches; that mature fish showed a marked proclivity to return in later years to spawning grounds on which they were tagged; and that lake trout or siscowets (commonly considered a subspecies of lake trout) may spawn from June through November (although usually or principally in October). Early returns from a fin-clipping experiment in Lake Superior indicate a markedly higher rate of recapture of fingerling lake trout stocked in the spring than of those stocked in the fall.

Lake trout are nearing extinction in Lake Michigan. Five fishermen who lifted 1-1/2 million linear feet of 2-1/2-inch nylon gill net during April and May took only 7 lake trout. The rate of capture for the same mesh in the less efficient linen nets of the Fulmar in 1930-1931 was 10.8 small trout per 1,000 feet or 16,200 per 1-1/2 million feet.

WHITEFISH

Analysis of data was completed and a manuscript prepared on a species of fish new to the Great Lakes--the pygmy whitefish, Coregonus (Prosopium) coulteri--which the Cisco collected in large numbers in 1953. This fish, previously reported only from northeastern North America, was widely distributed in Lake Superior, had a bathymetric range of about 10 to 50 fathoms and an extraordinarily slow growth rate (the length and age of the largest of 1600 specimens was 5.9 inches and 7 years) and matured sexually at a length of about 4 inches.

STATISTICS

Analyses of commercial fishery statistics have added another year's data to the laboratory's increasingly valuable record of production, fishing intensity and catch-per-unit-effort of principal species in local fishing areas. For few fisheries is it possible to make such discriminating estimates of fluctuations as in the Great Lakes.

WESTERN INLAND FISHERY INVESTIGATIONS

I. CALIFORNIA-NEVADA INLAND FISHERY INVESTIGATIONS

Reed S. Nielson, Reno, Nevada

TROUT SURVIVAL

Trout survival in streams.--Study of survival of fall-spawning, catchable-size, hatchery-reared rainbow trout initiated August 1, 1952 terminated November 1, 1954. Trout age from hatching date was 33 months and their residence in Convict Creek 27 months. Table 1 shows their survival.

The sex ratio of the 18 trout recovered November 1, 1954 was 1:1 and all were in good condition (K= 0.798). Two males were in advanced stages of sexual maturity; there was no evidence of gonad development in the other fish. Stocking for the final period of this experiment, May 1, 1954-November 1, 1954, was at the rate of 35.5 pounds per acre; recovery was at 18.8 pounds per acre. Results indicate greatest mortality occurred during their second year of residence in Convict Creek. Over-summer and over-winter survival of the first year was excellent and better than that for the over-summer period of the third year.

Study of the survival of fall-spawning, catchable-size, hatchery-reared rainbow trout only stocked at a common density of 120 pounds per acre in each of the 4 experimental stream sections at monthly intervals beginning August 2, 1954, and terminated June 7-10, 1955, with the results as shown in table 2.

Considering that these fish, except for the August 2 group, were planted in the fall, survival was excellent except for the lot stocked October 1 in Section No. 3. Since the trout used were taken from the same lot of fish in the hatchery, the only explanation for the poor survival in this section must be due to its inferior quality (lack of suitable pools) to carry fish through the winter. Results of previous experiments in which this section was used during comparable winter support this assumption.

Data on weight, length and condition of the trout at the time of planting and recovery are presented in table 3.

Decline in condition was drastic for all lots of fish regardless of planting time and stream residence. Despite drastic weight loss, small gains in length occurred except for the group stocked November 1, 1954. The relationship between weight and length of recovered fish is interesting and reduction in weight to a common level of all trout regardless of length of stream residence seems significant. This condition suggests that among many adaptations hatchery fish must make to natural stream conditions, they must streamline to survive in rapidly flowing water characteristic of Convict Creek; it suggests also that once this adaptation is made it is maintained.

There was no initial mortality immediately following planting. Losses, consisting of individual fish, were first observed about 10 days following planting and continued sporadically during the experiment except heaviest losses in Section No. 3 were coincident with extreme winter conditions during late December and all of January and February. Snowfall and duration of snowpack were about average for the area but temperatures were lower and ice formations heavier and persisted longer than in previous winters.

Trout starvation.--Results of 2 trout starvation experiments are shown in table 4.

Table 1.--Trout survival

Period	Number stocked	Number recovered	Percentage survival	Progressive survival (percentage)
8-1-52 - 11-1-52	337	287	85.2	85.2
11-1-52 - 4-29-53	311*	240	77.2	71.2
5-1-53 - 11-1-53	206	82	39.8	24.3
11-1-53 - 5-1-54	79	25	31.7	7.4
5-1-54 - 11-1-54	24	18	75.0	5.3

* Additional trout from same stock and same period of residence in Convict Creek were added to bring stocking density to 50 pounds per acre for over-winter study.

Table 2.--Survival of rainbow trout in 4 experimental stream sections

Section	Planted		Recovered			Known loss		Unknown loss	
No.	Date	No.	Date	No.	%	No.	%	No.	%
1	9/3/54	200	6/9/55	133	66.5	37	18.5	30	15.0
2	11/1/54	161	6/10/55	103	64.0	26	16.2	32	19.8
3	10/1/54	228	6/8/55	86	37.7	58	25.5	84	36.8
4	8/2/54	234	6/7/55	122	52.1	37	15.8	75	32.1

Table 3.--Weight, length and condition of trout at time of planting and recovery

Planted			
Date	Mean length (cms.)	Mean weight (gms.)	Mean condition "K"
8/2/54	18.7±1.5	68.6±18.2	1.031
9/3/54	19.2±1.3	70.4±14.8	0.992
10/1/54	19.6±1.3	71.4±11.9	0.940
11/1/54	20.7±1.3	84.7±15.9	0.939

Recovered					Difference between Planted & Recovered	
Date	Days	Mean length (cms.)	Mean Weight (gms.)	Mean condition "K"	"K"	%
6/7/55	310	19.8±1.6	54.9±12.4	0.700	-0.331	32.1
6/9/55	280	19.5±1.3	54.7±13.1	0.724	-0.268	27.0
6/8/55	251	19.9±1.3	54.7±10.8	0.690	-0.250	26.6
6/10/55	222	20.7±1.1	59.6± 9.5	0.673	-0.266	28.3

Table 4.--Results of 2 trout starvation experiments

	50 Rainbow Trout 10/15/54				60 Brown Trout 10/28/54			
	Cumulative mortality		"K"(Total length)		Cumulative mortality		"K" (Total length)	
Days	No.	%	Mean	Range	No.	%	Mean	Range
1			0.940	0.788 - 1.134			0.734	0.656 - 0.836
75	2	4.0						
90	2	4.0	0.821	0.637 - 0.926				
120	4	8.0			1	1.7		
180	5	10.0			5	8.4		
210	8	16.0			12	20.00		
230	11	22.0			21	35.0		
235					22	36.7		
240	15	30.0						
245	21	42.0						
248	25	50.0	0.646	0.531 - 0.797	24	40.0	0.609	0.462 - 0.759
	Terminated June 20, 1955				Terminated June 28, 1955			

Both trout groups were carried in indoor, food-tight enclosures to exclude macroscopic stream-food forms and aerial insects. Water was supplied from the stream and was the same temperature. The experiment was terminated when 50% of the rainbow trout group and 40% of the wild brown trout group died. Specimens of trout that died during the experiment were retained in a frozen state for bio-assay to determine physiological condition for comparison with pre-experiment specimens. While rainbow trout losses were not spectacular, they increased with time. In contrast, most brown trout mortality occurred during the last 45 days.

Since termination of the experiment, surviving rainbows and browns are being fed natural stream food organisms to determine ability to recover from prolonged starvation. All fed avidly but mortality rate has been high--10 rainbows and 11 browns had died by June 30, 1955. Post-mortem examination indicated all had taken food--the stomach of 1 brown trout contained 30 freshwater shrimp (Gammarus sp.)

Mortality associated with lack of food during a long period, including severe winter conditions, is lower than might be expected when compared with mortalities among trout under natural conditions. Results raise questions as to the importance of competition between planted and wild trout in streams with respect to stocking density and carrying capacity.

Three groups of 50 trout each (2 hatchery rainbow trout and 1 stream resident brown trout) are being held in food-tight enclosures in the stream for observation to determine survival during summer when stream temperatures and food requirements are higher.

Spawning of hatchery brood trout under natural conditions.--On October 7, 1954, 8 pairs of mature, fall-spawning, rainbow trout were transferred from spawning pens at the hatchery to previously prepared holding areas in Convict Creek. Four 2-year-old and four 3-year-old females and eight 2-year-old males were used. Water tempera-

ture was 54.0° F. at the hatchery and 50.0°F. (minimum) at Convict Creek. Nuptial and general pre-spawning activity was passive; redd building desultory. Fish failed to spawn under natural conditions during the 2-month period at the conclusion of which 6 males and 2 females had died and observations were terminated. Survivors were left in the stream and 3 females in good condition were recovered June 10, 1955. Examination indicated 2 apparently had spawned after December 7, 1954. Neither contained retained or resorbed eggs and ovaries indicated normal development for the season.

Chemistry of hatchery water supplies.--Chemical analyses of water samples from hatchery sources and through raceway systems being utilized at peak capacity by trout indicated a few prominent changes in water chemistry because of fish occupancy. These changes follow:

Item	Water source	Terminus of raceway
NH_3	0.046	1.470
NO_2	0.003	0.007
HCO_3	130.000	136.000
Na	23.000	25.000
SO_4	11.000	12.000
Cl	6.500	12.000
$CaCO_3$	71.000	68.000(hardness)
Conductance	243	273 (Micromhos at 25°C.)
pH	7.4	7.1

Results in parts per million except for conductance and pH.

None of these results indicate changes that might be deleterious to trout. The most marked difference is in the level of ammonia nitrogen (NH_3) and this is well below the level of toxicity (2.5 - 8.0 p.p.m.) especially in these waters which indicated an absence of carbonate (CO_3). The increase in chloride (Cl) from 6.5 to 12.0 p.p.m. can be accounted for, at least in part, by the use of salt (NaCl) in diets fed the fish.

PRODUCTIVITY OF HIGH SIERRA LAKES

Laboratory analysis of periphyton samples from Convict Lake through ten 25-day sampling periods (1953-1954) and from Lakes Edith, Genevieve and Cloverleaf (August 1954) has been compiled. A new collecting apparatus was used successfully. Mean level of periphyton depends upon combination of physical and chemical characteristics of the lakes; seasonal fluctuations are due to temperature changes. Analysis of data for 7 sampling periods in Convict Lake indicated a high correlation (r=0.966) between attached organic material and temperature summations on a lake mean basis indicating sensitivity of sampled material to environmental heat.

Microscopic examination of periphyton collected at Convict Lake in November 1954 indicated presence of:

Chlorophyceae--at least 3 filamentous algae including Spirogyra and a probable desmid of the form Netrium
Diatoms--several, including Encyonema, Fragilaria, members of Cymbellaceae, Naviculaceae and probably others

In addition to these, there is an investing mass of yellow-brown, amorphous substance that does not show cellular structure at a magnification of 450.

II. ROCKY MOUNTAIN FISHERY INVESTIGATIONS

Oliver B. Cope, Logan, Utah

Research this year featured some new approaches to life history on the Yellowstone cutthroat and the Montana grayling, and an intensive program of marking and recovery of rainbows in the Madison River Drainage.

Yellowstone Lake studies.--Regulations of fiscal year 1954 prevailed in the 1954-1955 season. No eggs were taken for general planting or for shipment. The only fish-cultural activities involved taking eggs from Arnica Creek for an experimental plant back into Arnica Creek. The fishing season on Yellowstone Lake opened June 15 and the daily catch limit remained at 3 fish.

Table 5 summarizes the characteristics of the lake and river fishery.

Low effort and good success were characteristic of the 1955 fishery.

Spawning runs into trap-equipped tributaries, counted to July 15, 1955, are indicated in table 6.

Escapement for spawning was good in 1953, 1954 and 1955. Counts of immatures in streams showed egg and fry survival 4 times as good per egg up to September 1954 as in 1953. The 1955 counts have not been made.

Studies on the extent of homing of Yellowstone cutthroat were started in 1955 in the north and south ends of the lake.

Madison River.--Returns of marked rainbows planted in Madison River in 1954 have indicated the catch of legal-sized fish is lower than was expected. A plant of 25,000 rainbows, 3 per pound, was made in June and July. Of 9,334 rainbows caught in the Madison River in 1954, 3,864 or 41.4% were from the 1954 plant. However, this number is only 15.4% of the number planted and suggests fishing pressure should be increased or the size of plant be reduced if this type of plant is made in the future. This test was repeated in 1955 but results will not be available until the end of the season.

Results of marking and planting smaller rainbow and brown trout are not available yet since they are not entering the fishery. Electro-shocking will be done in 1955 to determine survival of these groups.

Grebe Lake.--A report recently completed on the 3-year study of Grebe Lake suggests that the present management of this water is sound, and that a larger harvest of grayling may be indicated. This work is being extended, with emphasis on survival, food and planting site studies.

Table 5.--Summary of lake and river fishery characteristics

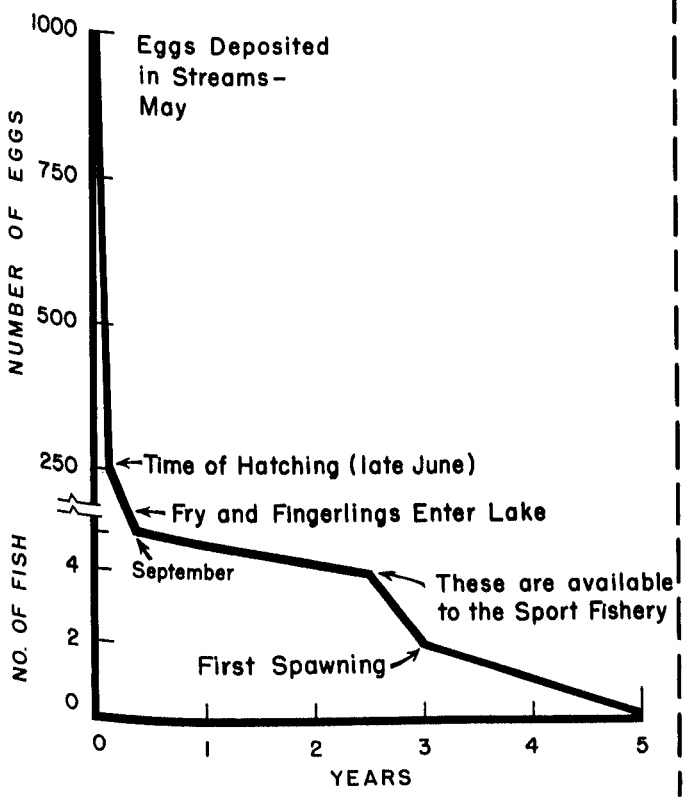
Year	Effort in hours	No. of fishermen	Catch	Catch per hour
1951	436, 704	196, 757	227, 984	0.510
1952	494, 426	193, 409	265, 880	0.519
1953	413, 348	185, 472	223, 805	0.508
1954	408, 138	156, 796	251, 845	0.584

Table 6.--Spawning runs into trap-equipped tributaries, counted to July 15, 1955

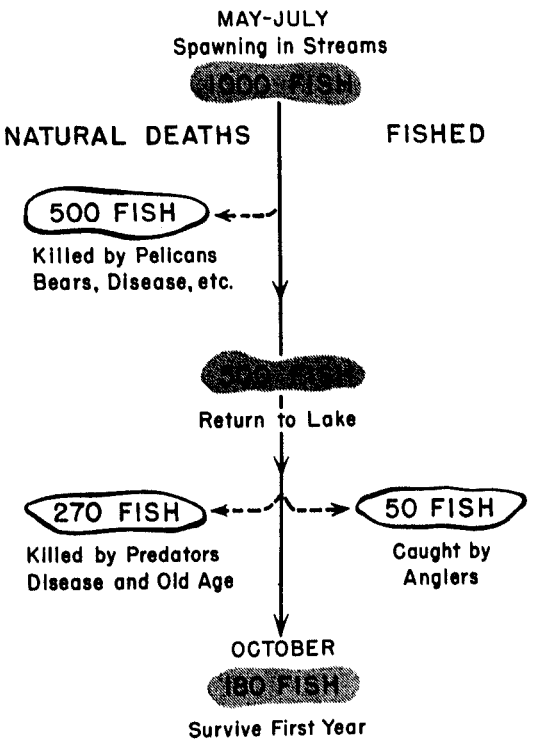
Year	Pelican	Cub	Clear	Chipmunk	Grouse	Arnica	Total
1950	15, 076	2, 179	10, 459	12, 255	9, 635	3, 881	53, 485
1951	9, 423	2, 676	16, 879	12, 585	12, 188	4, 755	58, 506
1952	6, 521	2, 056	10, 269	9, 989	6, 949	3, 523	39, 307
1953	12, 418	3, 848	10, 323	7, 836	7, 441	4, 524	46, 390
1954	10, 340	3, 446	3, 161	5, 371	3, 756	6, 200	32, 274
1955	12, 400	2, 558	7, 929	3, 880	565	4, 700	32, 032

CUTTHROAT TROUT - YELLOWSTONE LAKE

5 Year's History of Fish from 1000 Eggs



1 Year's History of 1000 Fish Spawning 1st Time



FRESHWATER BIOLOGICAL LABORATORIES

I. TROUT NUTRITION LABORATORY

Arthur M. Phillips, Jr. Cortland, New York

Trout vitamin requirement.--Vitamin omission studies have shown only pyridoxine and riboflavin are necessary for normal growth and survival of brown trout. No need has been shown for either folic acid or niacin for brown trout, although both are necessary for brook trout. These experiments were conducted at a temperature of 47° F., which precludes rapid growth of brown trout. At warmer water temperatures brown trout may need the other vitamins. Experiments are in progress in waters at 51° F. to determine if increased growth rate which results from warmer water will show a need for other members of the B complex.

Dietary supplements.--Phospholipid cephalin appears to stimulate brook trout growth. Interaction between fatty acids of cod liver oil, cod liver oil concentrate and cephalin indicates cephalin may not be the sole growth stimulator in cod liver oil. Experiments have been designed to determine more fully the roles of cephalin and lecithin in brook trout diet.

Metabolic studies.--Fish size, sodium amytal, water temperature and starvation effectively reduce the metabolic rate of trout (as measured by ammonia produced and oxygen consumed). The interaction of all 3 variables is the most efficient means of metabolism control.

Applying proper interactions of metabolic studies makes it possible to transport exceptionally large loads of fish over a 12-hour period. Up to 62.4 pounds of fish per cubic foot of water may be carried successfully under proper conditions.

Hatchery diets.--Experiments have been completed in which trout were carried over a 6-month period on a diet composed of pellets heavily fortified with purified vitamins at the level found in Wolf's synthetic diet. Results have not been summarized yet.

Growth and survival studies are under way in which a product of the butyl alcohol industry is being compared with distiller's solubles commonly used in trout diets. The diet under test is considerably cheaper than the product in use.

Radioactive isotopes.--Radioactive calcium used as a tracer revealed small non-feeding brook trout absorb calcium from water; amounts absorbed over a 96-hour period depend on the chemical composition of the water. Distribution of absorbed calcium within the body is a function of the calcium content of the body parts and is independent of the water. The distribution rate of absorbed calcium is a function of metabolic activity which depends upon physical composition of the water. The distribution rate of calcium increases in concentrations of less than 50 p.p.m. in distilled water. Increased concentrations of minerals other than calcium in water increases the ability of the fish to absorb and metabolize calcium.

Non-feeding brook trout absorb radioactive cobalt (cobalt^{60}) from water through the gills. A larger amount of cobalt is deposited in the digestive tract (with the pyloric caeca) than in the liver. This may be a function of elimination or the formation of a complex cobalt compound which has been described as present in the caeca of fish.

Experiments are in progress to study the factors involved in the absorption of cobalt from water (water temperature, mineral content of the water, and the level of cobalt in the water).

The experimental results of this laboratory are described in detail in the Annual Report of the Cortland Laboratory, published by the State of New York Conservation Department. This work is done under a cooperative agreement between the Fish and Wildlife Service, The State of New York Conservation Department, and Cornell University.

II. SALMON NUTRITION LABORATORY

John E. Halver, Cook, Washington

GENERAL

Emphasis has been placed on testing the capabilities of facilities of this laboratory and orienting its staff members in problems of fish nutrition, biochemistry, metabolism, serology and histology. Outbreaks of fish pathogens which have masked feeding results have interrupted the hatchery feeding program. The contribution of the new all-steel spring-water-supply line of ferrous and ferric ions to the water, results in a high galvanic activity wherever this water contacts reducing substances. To remove these difficulties, iron valves and stainless steel, rubber or plastic materials have been installed.

RESEARCH

Chinook salmon vitamin requirements.--Through use of the river water portion of the experimental hatchery, the qualitative fat-soluble vitamin requirements of chinook salmon were investigated. Unfortunately, extremely cold water temperatures prohibited sufficient growth for exhaustion of stored fat-soluble vitamins within a 20-week period. Some growth inhibition and lack of development of deficiency syndromes may be attributed to octomitus infection prevalent in most groups of fish in the river water system.

Salmon amino acid requirements.--Introductory work has been completed on developing an amino acid test diet. The cooperative research project with Purdue University for qualitative amino acid requirements of chinook salmon has progressed rapidly. Eighteen lots of chinook salmon have been fed amino acid test diets deficient in 1 of the 18 amino acids in the protein component of the complete vitamin test diet. Prior to initiating the qualitative amino acid study, a tentatively satisfactory amino acid test diet was developed using as the protein component mixtures of pure l-amino acids corresponding to the amino acid content of the complete vitamin test diet and that found by analysis of yolk sac chinook salmon fry and fingerling chinook salmon. After 12 weeks of feeding, these diets have indicated sufficient growth for testing qualitative amino acid requirements of chinook salmon fry. Even though the extremely cold water has reduced the growth response, initial feeding results with amino acid test diets indicated some favorable results could be obtained provided feeding experiments were conducted for a sufficiently extended period.

Establishment of inorganic test conditions for chinook salmon.--Water from ion exchange columns at the laboratory has been analyzed and found to contain sufficient copper to deny its use in raising fish. The copper content is believed to arise from brass valves in the effluent line and red brass pipe within the ion bed. Toxicity of the water was sufficient to nullify all attempts at establishing suitable conditions for a reconstituted water supply.

Chinook salmon inorganic requirements.--A severe infestation of octomitus obscured results of the 1954 and 1955 mineral feeding studies. The 1955 feeding trials were designed to determine (a) if a low dietary calcium:phosphorus ratio would produce a calcium deficiency as it does in mammals and (b) effect of a calcium-enriched water supply on the dietary calcium:phosphorus ratio.

Normal histology of salmonids.--About 3,000 non-moribund wild and hatchery salmonids, representing all important species on the Pacific coast, have been collected. The majority of this material has been sectioned and stained; about 30% has been examined.

This collection of fish tissues probably represents the most complete collection of normal fish tissues in this country and will be the basis for extensive studies on the normal anatomy and histology of fish. It will serve as valuable control material for experimental and moribund fish which other laboratories and production hatcheries send for diagnosis.

Histology of salmonids under defined nutritional conditions.--In fatty acid studies, fish receiving diets with the fat component being stearic, palmitic and oleic acids at a level of 9% and linoleic and linolenic acids at a level of 0.2% developed massive liver necrosis. The condition is histologically identical to acute yellow atrophy which has been observed experimentally in mammals. The observation is of interest as a clue to the possible importance of fats in fish nutrition.

The Cortland, New York laboratory provided brook trout which had been fed Wolf's synthetic diet for a 20-week period. There were marked histological differences between these fish and fish fed a standard production diet. These changes were most striking in the liver which was in a remarkably advanced condition of fatty degeneration. This is another indication of abnormal fat metabolism in experimental fish.

Histological comparison of wild and hatchery-reared salmonids.--A study to compare characteristics, in general, of wild fish and hatchery fish is being made with material collected for studies on normal histology. Approximately 75 groups of wild fish from different streams are being compared to an equal number of hatchery fish from different hatcheries. This study, which is about 75% completed, will determine the comparative degree of disease incidence, parasitism, muscle degeneration, liver and pancreatic fatty infiltration, et cetera of the two groups.

A study to compare a specific group of hatchery fish with a comparable group of wild fish is being made with the Washington Department of Fisheries at the Minter Creek Biological Station. A predetermined number of adult coho salmon were allowed to spawn naturally in Minter Creek. An equal number of adults from the same population were spawned artificially and the young reared in the Minter Creek hatchery (which uses Minter Creek water). At 3, 6, 9 and 12-month intervals hatchery fish were planted in Minter Creek. At each planting time, all groups in the stream were sampled. Determining changes which occur in hatchery fish after planting in relation to wild fish and in relation to the period of artificial rearing should be possible. The Washington Department of Fisheries is conducting a survival study on the same populations and has collected all samples, and the Willard Laboratory is doing the histological and chemical analyses. The fish have migrated to the ocean and all sample collections have been completed. The histological preparation is about 25% completed.

Library of histological material of salmonids.--The slide collection of fish tissues, normal and abnormal, numbers over 25,000 and is available on a loan basis to interested investigators.

Salmonid neoplasms.--Work has been limited to diagnosis of abnormal cellular growths. A malignant small cell carcinoma from an ocean-caught adult chinook salmon was of particular interest because little is known about the causes of mortality of fish

in the ocean. An apparently infectious papilloma was observed also in Atlantic salmon from Sweden.

Salmonid histopathology.--Considerable work was done in diagnosing and describing the histopathology of diseases from material obtained from production hatcheries and other laboratories as follows: Fish and Wildlife Service laboratories in Seattle, Washington, Kearneysville, West Virginia, and Cortland, New York; diagnostic specimens have come from Sweden, Australia (via Kearneysville, W. Va.), New Hampshire, Alabama, Oregon, Montana, Washington, West Virginia, California, Massachusetts, New Mexico, Wyoming, Idaho, Vermont, New York, Arkansas, Michigan and Alaska.

Salmon intermediary metabolism and cellular physiology.--A cytological study has been made of salmon erythrocytes demonstrating that they normally contain mitochondria and some reticular material.

Salmon serological studies.--The objective of this study is to demonstrate the serological properties which are characteristic of species and races of salmon. Techniques which were selected for extensive application and study are:

1. Formation of agglutinins in rabbits, chickens, carp and rainbow trout by injecting red cells of the salmon in question. Cross-reacting antibodies formed will be removed by absorption.

2. Studies of possible usefulness of heterogenetic relationships. For this purpose, antisera to the red cells of several other species of fish are being prepared and tested for cross-reactions with red cells of sockeye salmon. In addition, antisera which are commercially available are being tested for agglutinative activity for sockeye salmon red cells.

3. Agar diffusion studies with serum proteins of salmon and antisera prepared against them.

4. Isoimmunization studies. Rainbow trout are being used for studying this technique. When adult bluebacks or kokanee are obtained, isoimmunization experiments will be started with the species of greatest interest.

Certain technical problems have been solved which should facilitate the program. High titer antisera in rabbits and chickens have been obtained. Salmon red cells have been held at 2° to 4° C. for 4 weeks without deterioration through use of small amounts of Alsever"s solution as the preserving medium.

III. WESTERN FISHERY DISEASE LABORATORY

Robert R. Rucker, Seattle, Washington

VIROLOGY

A disease of possible virus origin has caused serious losses of sockeye salmon fingerlings at some hatcheries for the last few years. Because no therapeutic measures were known, an experiment was conducted to determine infection source. Sockeye salmon for the 1954 rearing season at Leavenworth and Winthrop, Washington stations were put on a carefully controlled experiment in which diet composition was the variable. Resulting data indicated that the probable virus infection source was adult sockeye salmon viscera used in food for fingerlings. Since this source was eliminated from the diet used during the 1955 rearing season, the disease had not appeared as of June 30.

If frozen viscera is indicated as the source of hatchery outbreaks, knowing if the infective agent can withstand storage is important. For that reason, an experiment has been started to test the titer of a given batch of virus on a monthly basis under two different cold-storage conditions. (From the viewpoint of epizootiology, however, a high titer is unnecessary to start a widespread infection. As recent experience with human vaccine has demonstrated, even a few virulent particles can cause trouble.)

The recovery of virus from fish surviving the 1954 Winthrop outbreak demonstrated a carrier state or virus latency. While apparently healthy fish could carry viable virus, this finding needs confirmation.

Sockeye salmon virus was demonstrated from adult fish taken from Fraser River and Lake Washington, Lake Wenatchee and Lake Whatcom systems. Adult fish livers were blended and injected into healthy fingerlings was filtered and injected into other healthy fingerlings and material from diseased fingerlings was filtered and injected into healthy fingerlings. Mortalities among these fish were used as a criterion for the presence of virus. The apparent number of virus-infected adult fish was far below the number expected from findings of the previous year--60% of the groups tested from Lake Wenatchee the previous year were considered to be virus carriers. This work will be expanded to give definite information on the extent of virus infection among adult sockeye salmon.

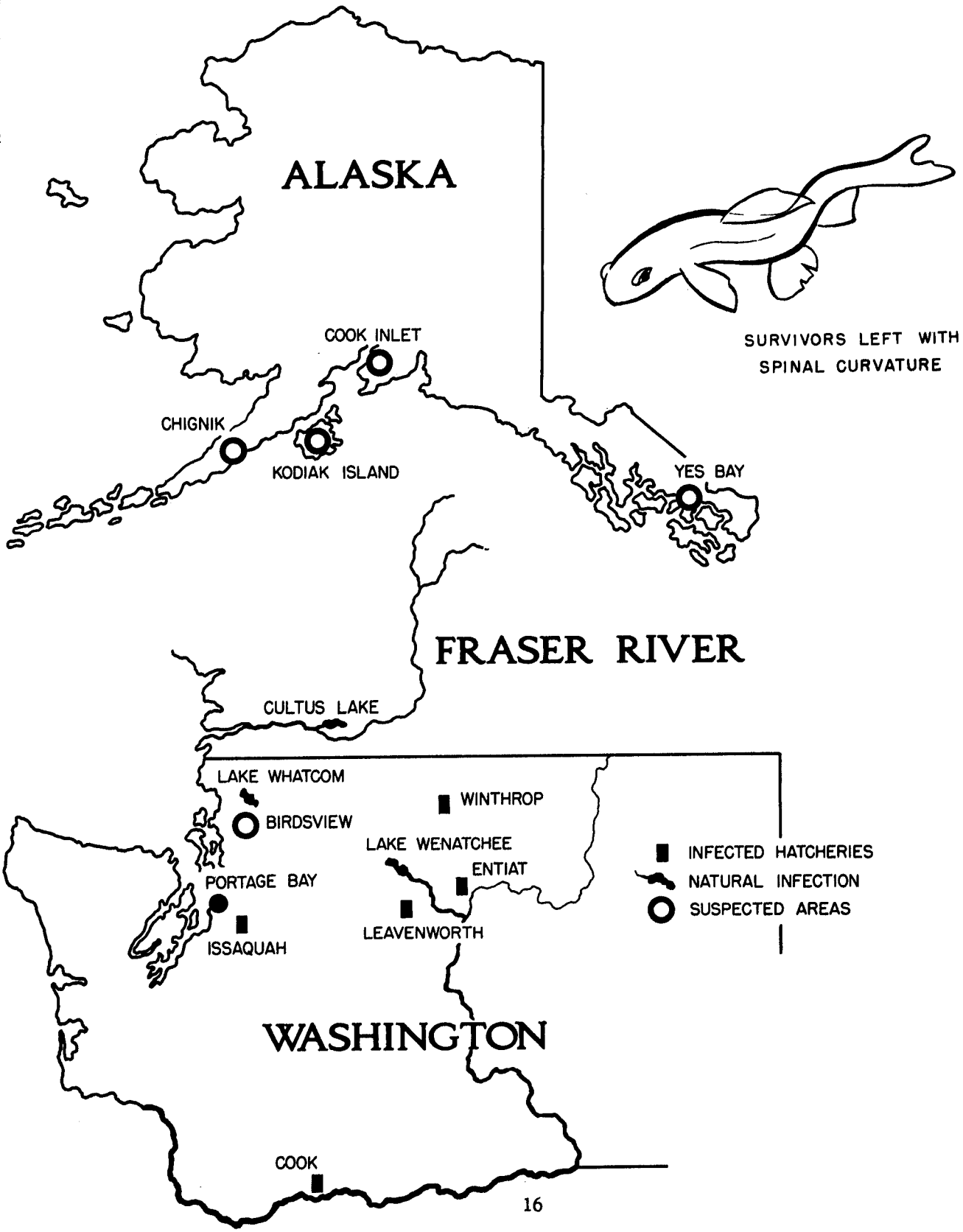
Studies on the pathogenesis of virus infection are under way.

Experiments in the field of tissue culture have shown embryonic salmon tissues can be easily cultured in a synthetic medium with added horse serum. Non-embryonic tissue failed to grow under the same conditions.

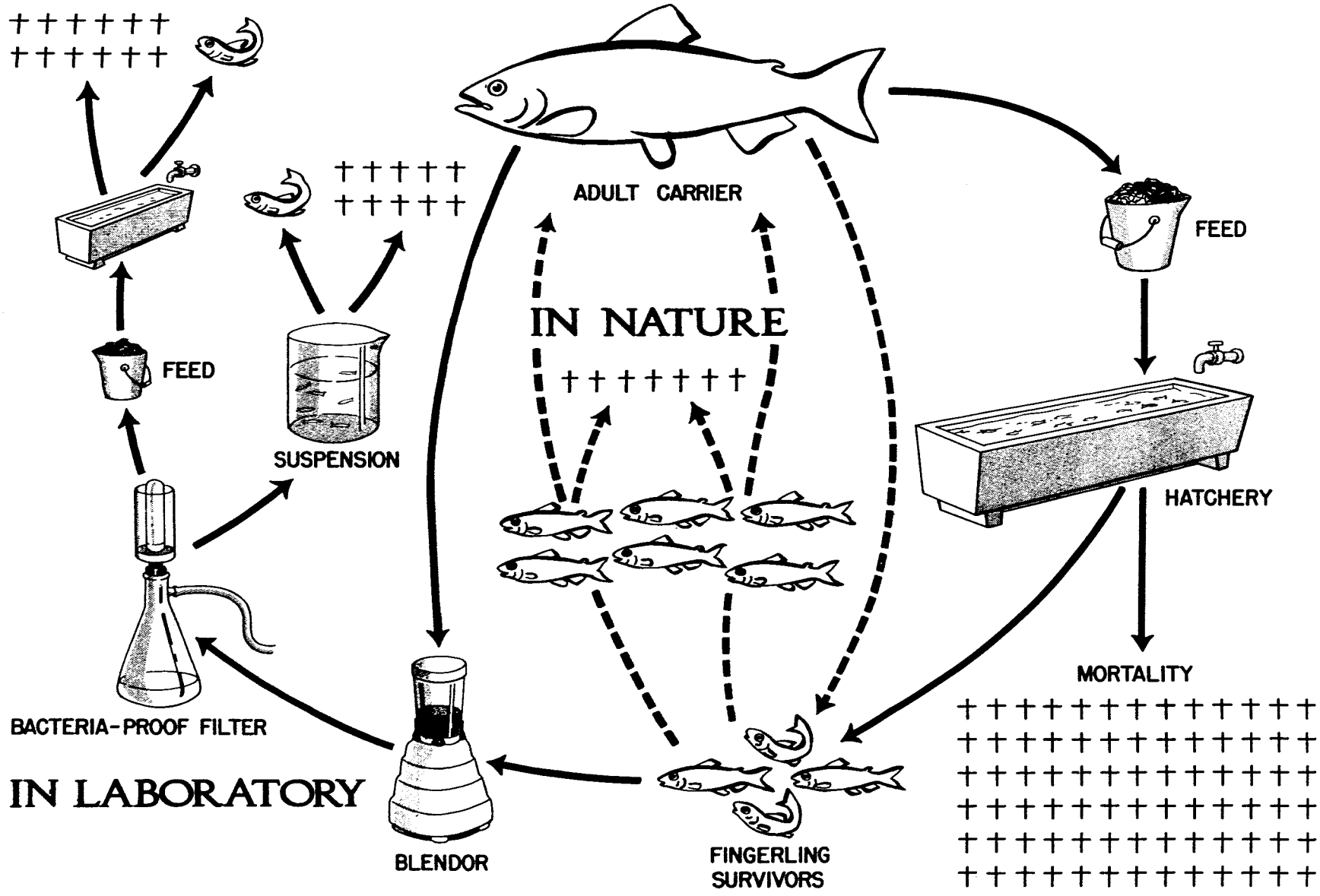
BACTERIOLOGY

Kidney disease caused by a fastidious, Gram positive, non-motile bacterium is often a limiting factor in salmon and trout rearing. It is one of the most prevalent diseases in this area and probably a cause of many unreported mortalities. The source of this disease could be in the water supply or food or both. Adult salmon are often used as food for the young. Kidney disease occurs in adult spring chinook salmon in the Willamette River, a Columbia River tributary. Viscera were collected from 4 lower Columbia River sites and fed to experimental groups of fish which did not develop kidney disease.

SOCKEYE SALMON VIRUS AREAS



SOCKEYE SALMON VIRUS DISEASE



Sockeye salmon fingerlings maintained on an all-meat (fish-free) diet at the Winthrop station developed kidney disease. Therefore, whether or not the etiologic agent was present in the food or water supply, or was present as a latent infection which became manifest after certain stimuli or debilitating conditions, was not determined.

A Pseudomonas sp. infection caused a high loss in some ponds of fall chinook salmon fingerlings at Spring Creek station. Hemorrhagic areas were at the base of the fins and eyes, the spleen was enlarged and dark red, and the liver a yellowish color. A histological examination indicated tissues were normal nutritionally but that the organism occurred in great numbers in every tissue. Sulfamethazone (Sulmet), aureomycin (Aurofac) or terramycin therapy did not control this infection. Pseudomonad infections have often been considered secondary agents and notorious for not responding to therapy. A more thorough investigation of these infections will be made.

A Mycobacterium (tuberculosis) was found in a few adult fall chinook salmon at the Spring Creek and Little White Salmon stations on the Columbia River. There was some concern about its effect on adult fish and their progeny. Material was frozen for later study but when tested, it did not appear viable. This organism also aroused interest because it occurred in a few fish dying from a serious disease known as "coagulated yolk"; coagulation areas developed in the yolk material before death of the fry and fingerlings.

A Bacillus sp. recovered from chinook salmon fingerlings at Coleman, California station was shown to be pathogenic. It will be studied further because it apparently causes some pond losses every year. The infection develops early in the year when fish are small and the mortality rate may reach 60%. Mortality is less if infection does not develop until the fish are larger in size. Infection subsides when water temperatures go above 50° F.

PARASITOLOGY

A survey of parasites of chum salmon, Oncorhynchus keta, was begun recently as part of the International North Pacific Fisheries Commission program. Examinations have been limited to downstream migrants but eventually will include adult fish as they become available. Two species of nematode parasites have been found in Japanese fish while similar samples from the State of Washington were parasite-free.

Wild sockeye salmon fingerlings, O. nerka, from Idaho and Washington, showed a varied fauna among which is a protozoan parasite previously unreported from salmon. The parasite belongs to the Class Suctorea and is tentatively referred to the genus Trichophyra; it is of interest because of its potential as a hatchery disease organism.

IV. MICROBIOLOGICAL LABORATORY

Stanislas F. Snieszko, Leetown, (Kearneysville,) W. Va.

Inherited resistance to furunculosis and ulcer disease among several strains of brook trout.--In the fall of 1953 brook trout eggs were received from Berlin, New Hampshire and Bellefonte, Pennsylvania. While trout from the Berlin eggs suffered great losses due to ulcer disease, during the summer of 1954, those from the Bellefonte eggs are free from ulcer disease of furunculosis.

Bellefonte and Berlin brook trout, which were kept in separate troughs, became infected with ulcer disease and furunculosis when diseased fish were added to the troughs. During the 234 days of the experiment, 87% of the Berlin trout and 51% of the Bellefonte trout died.

A similar experiment was performed with brook trout from Berlin, Bellefonte and Maryland. The trout were fin-clipped and mixed in equal numbers in each trough. When the 205-day experiment ended, 75% of the Berlin trout, 63% of the Bellefonte trout, and 49% of the Maryland trout had died of ulcer disease and furunculosis.

Results of these experiments show considerable differences exist in susceptibility to furunculosis and ulcer disease among different strains of brook trout. No methods of treatment may be satisfactory in a susceptible population. Control methods may be exceptionally effective when used for controlling mortalities in fishes which have a higher inherited resistance.

Development of new treatment methods for fish furunculosis.--Investigations have shown sulfisoxazole (Gantrisin) was effective in treating kidney disease and had no unfavorable effect on brook and brown trout growth rate if used at the rate of 8-10 grams per 100 pounds of fish per day. In a 40-day experiment in which yearling brook trout (furunculosis-resistant Bellefonte strain) were used, infection was started by feeding tissues of trout inoculated parenterally. The results of this experiment are shown in table 7.

These results show sulfisoxazole apparently has no specific therapeutic value in treating furunculosis in yearling brook trout and that a high dosage of it is toxic to treated fish.

Treatment and prevention of kidney disease in trout.--A problem in studying this disease is the ways in which it spreads. To learn them, possible carriers must be tested for the presence of specific microbes. Since this testing requires suitable culture media for isolation and identification, research is carried out to develop such media; so far the Maitland-type tissue cultures are the most promising. No new experiments were carried out during the past year on methods of treating this disease. Determining ecological and genetic factors contributing to resistance to this disease is desirable. They must exist because this disease causes insignificant losses in some hatcheries and great losses in others. Progress has been made only in treating this disease with sulfonamides and cultivating the specific microbe in media containing living tissues.

Blue-sac disease.--Eggs for blue-sac investigations came from Winthrop, Washington, Creston, Montana, and Hagerman, Idaho. Experimental results from attempted induction and control tended to confirm earlier work but were not conclusive. The comparatively short incubating time which remains for eyed eggs shipped long distances is believed inadequate to give clear-cut results.

Infectious pancreatic necrosis (acute catarrhal enteritis).--Results of a new series of epidemiological observations carried out during the winter of 1954-1955 have not been fully evaluated. There is some reason to assume this virus disease was transmitted twice to Leetown with eggs from a Pennsylvania hatchery. Older fingerlings are probably more resistant to this disease.

Fish tissue culture.--Tissue culture methods have been adapted to research on fish diseases and are used for research on kidney disease and infectious pancreatic necrosis.

Table 7.--Results of 40-day experiment using yearling brook trout (furunculosis-resistant Bellefonte strain)

	Dosage (milligrams per kilogram of fish per day)			
	Controls	50 mg	200 mg	800 mg
Percent fish died due to furunculosis[1/]	15	25	50	12
Percent fish died apparently due to toxicity of the drug[2/]	0	0	0	27

1/ A. salmonicida was isolated from dead fishes.

2/ A. salmonicida was absent in dead fishes.

V. SALMON CULTURAL LABORATORY

Roger E. Burrows, Entiat, Washington

FEEDING TRIALS

The 1954 feeding trials with blueback salmon resulted in the development of several excellent economical diets devoid of salmon viscera which cannot be used because of the danger of introducing a virus disease. A number of producing hatcheries are using these diets. Tests with various diets containing 50% dry meals indicated such diets, in the combinations tested, were unsatisfactory for chinook salmon.

ACCELERATION OF SEXUAL MATURATION OF ADULT SALMON

Two phases of this problem are being explored--use of gonadotropins and the effect of light. Pituitary glands from chum salmon have been lyopholized, fractionated and pelleted in combination with cholesterol. The pellets which contain the equivalent of 1-1/2 pituitaries will be injected intraperitoneally in various numbers into adult blueback salmon. The effect of artificially foreshortened light periods simulating advanced fall conditions will also be tested.

The 1954 experiments utilizing lyopholized whole salmon pituitaries contained in gelatin resulted in an acceleration in maturation but also indicated the superabundance of hormones other than gonadotropins produced a stress reaction resulting in premature aging and death prior to spawning in many instances.

DIVERSION AND RETENTION OF ADULT SALMON

Further tests of the electrical diversion weir indicate that this type of barrier is the most practicable and economical of any method developed to date for diverting adult salmon. Properly installed and operated, it will divert migrating salmon from a stream into holding ponds with a minimum of delay and injury.

VERTICAL INCUBATOR

The entire egg take of the Entiat station amounting to more than 1,000,000 eggs was incubated to the feeding fingerling stage in the vertical incubator. Two alternate types of equipment were developed to meet the varying operating conditions. A 4-screen filter was developed for use in the top distribution tray to remove excessive amounts of silt and debris from the water supply. A full horizontal outlet screen for the egg basket may be substituted for the shorter screen of the original design in order to eliminate the neccesity for screen cleaning during the hatching period if large egg takes are anticipated. This type of incubator requires only one fourth the floor space and water supply of that of the most efficient of conventional methods, with a minimum of attention, and is highly efficient in operation.

EFFECT OF STREAM TEMPERATURE PATTERNS ON SURVIVAL OF SALMON EGGS AND FRY

The purpose of this experiment was to determine if variations in stream temperature patterns during the incubation period encountered between years would serve as an index of freshwater survival of pink salmon. Subjection of Alaska pink salmon eggs and fry to average weekly water temperatures of Sashin Creek, Alaska for 2 years of good survival and 3 years of poor survival, indicates water temperature is not responsible for the variation.

EVALUATION OF REARING POND DESIGN

Model studies are being conducted on a new type of rearing pond. This pond, rectangular in shape, utilizes turning vanes to direct water flow. Hydraulicly, it appears comparable to the circular pool but would be cheaper to construct and require less space if used in batteries. Tests are continuing on the model to determine optimum operating conditions.

SPECIAL INVESTIGATIONS

I. BIOLOGY OF GREAT LAKES FISHES

John Van Oosten, Ann Arbor, Michigan

The report covering the field investigation of young lake trout conducted on Lake Michigan in 1930-1932, described in the annual report for 1954, was submitted to the Washington Office in August 1954, revised in January 1955 and resubmitted in June 1955. It will be published in one of the Fish and Wildlife Service series.

Considerable progress has been made in the study on abundance, distribution and length frequencies of Lake Michigan chubs which were taken in the experimental gill nets employed for capturing lake trout by the vessel Fulmar.

Work has begun also on mesh selectivity of Lake Erie trapnets and gill nets. These field studies were made in 1927-1932. Lifts were examined from some 1,552 trapnets, 669 pound nets, 151 shoal gill nets and 115 bull nets on 598 days.

II. EASTERN FEDERAL WATERS

Robert E. Lennon, Leetown (Kearneysville), W. Va.

Shenandoah River.--A survey, in cooperation with West Virginia biologists, was made on the lower section of the Shenandoah River in July 1954. A large electric shocker apparatus, with direct current, collected numerous smallmouth bass, sunfish, minnows, suckers, carp and channel catfish. The amounts of fish taken at the several survey sites indicate a high degree of recovery from former pollution damages to the river.

Fish and Wildlife Service observations on the Shenandoah River may be further reduced, or discontinued, because Virginia and West Virginia are assuming their responsibility toward the river, and the major industries concerned are treating and carefully checking their effluents to prevent a recurrence of toxic conditions in the waters.

Great Smoky Mountains National Park.--A post-angling survey of fishery conditions in about half of the major park watersheds was completed in November 1954. More than 7,000 brook and rainbow trout - 2 to 20 inches long - were collected, examined and returned to the water. Great improvements in trout stocks were noted in most waters, especially in numbers of young-of-year and yearling fish and in survival of mature fish.

A creel checking station was operated on Little Pigeon River in 1954 and reopened in 1955. A station was established for collecting creel census returns on Big Creek in May 1955.

In April and June 1955, park streams were stocked with 28,000 trout from the Erwin, Tennessee Fish Cultural Station. Included were 18,000 legal-size brook and rainbow trout and 10,000 marked fingerling brook trout of Appalachian strain. Fingerlings were stocked in flood-damaged streams where previous plantings of legal-size trout had failed to restore fish populations.

Shenandoah National Park.--Severe effects of flood and drought which have plagued Shenandoah streams in the past 2 years were apparent in surveys completed in December. Results indicated only 88 trout per acre in Piney Run, 15 per acre in Big Run, and 8 per acre in North Fork of Moorman River. Studies centered on these watersheds since they are important as fishing waters and representative of other park streams.

In May 1955, 25,000 fingerling brook trout, Appalachian strain, from the Erwin Fish Cultural Station were marked and stocked in selected, drought-damaged streams. Their survival and growth will be followed closely to determine their contribution to trout fishery restoration.

Shenandoah Park streams will remain closed to fishing in 1955.

Chemo-fishing experiments with cresol compound.--Improvements have been made in the use of cresol (cresylic acid compound, phenol coefficient 30) as a fish collecting medium. More efficient use of this fish anaesthetic is accomplished by securing accurate determinations on water chemistry, temperatures and stream-flow rates at each survey station prior to applying the chemical agent. Repeated treatment permitted evaluations of dosages used. As many as 250 trout, in addition to hundreds of rough fish, have been collected and processed from a single dosage with as little as 2% mortality. Accurate estimates of population densities have been obtained by using cresol over

measured areas in streams. The extremely rough nature of some streams in the Shenandoah and Great Smoky Mountains National Parks, or their inaccessibility, may preclude the use of anything but a chemical agent in collecting fish. Therefore, improvements in cresol application are important.

Electro-fishing experiments.--A cooperative effort with members of the New York State Conservation Department led to development of electro-fishing apparatus which works efficiently in the extremely soft waters of the southern Appalachian Mountains. Petty-type, alternate-polarity electrode systems were built and tested with a 230-volt, AC generator; trials were successful. A back-pack shocker (230-volt, AC) was also constructed and is operating successfully.

Measurements were made of electrical resistance in many streams of the Great Smoky Mountains National Park. Readings ranged from 48,000 ohms cm^3 in the headwaters of Little Pigeon River, to 110,000 ohms in headwaters of Little River. These resistivities are among the highest recorded for any natural waters in the United States.

NORTH ATLANTIC FISHERY INVESTIGATIONS

Herbert W. Graham, Woods Hole, Massachusetts

As in past years, research planning has been conducted in close collaboration with the Atlantic States Marine Fisheries Commission and the International Commission for the Northwest Atlantic Fisheries.

Mesh regulation.--The regulation of the International Commission for the Northwest Atlantic Fisheries (ICNAF) requiring a minimum mesh size of 4-1/2 inches in cod ends of otter trawls when haddock fishing on New England Banks has proven highly successful. Large mesh nets are releasing baby scrod precisely as had been predicted on the basis of experiments carried out by the Woods Hole laboratory.

Large mesh nets have proven so efficient in capturing larger sizes of fish that the savings gear has found wide acceptance in the fishing industry.

Proving the benefit of saving small fish is more difficult. ICNAF recommended regulation for Subarea 5 (Georges Bank and the Gulf of Maine), provided the United States would establish a research program designed to assess the effectiveness of regulation. In recommending regulation in other subareas, ICNAF emphasized the need for testing the regulation in Subarea 5, since such testing cannot be made in other subareas because sufficient information on abundance of populations and yields of individual year classes to use as a basis of comparison with future yields is lacking in these regions.

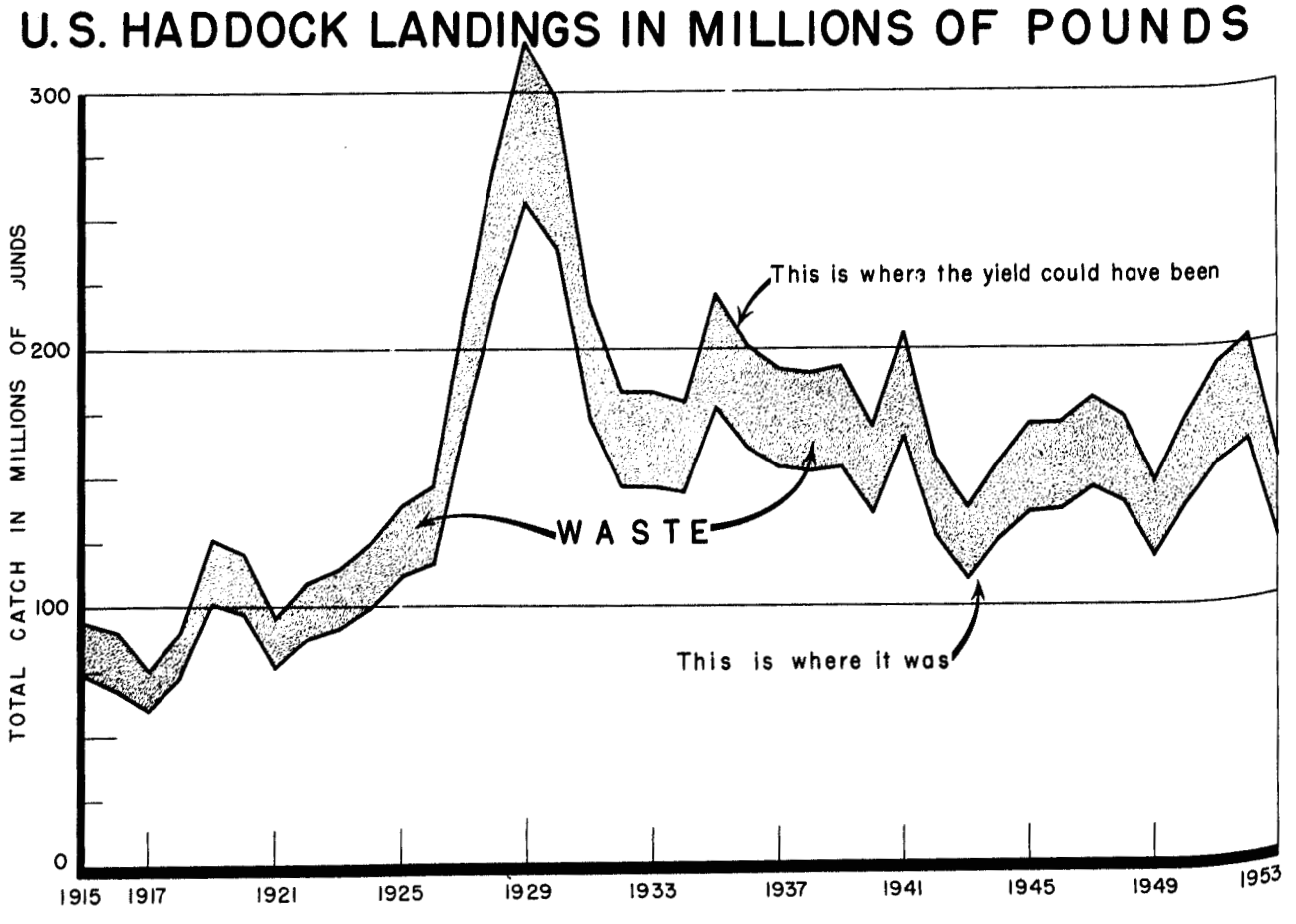
An essential part of the test program is licensing a few vessels to fish with the old small mesh nets. These vessels provide an abundance index of 2-year-old haddock which corresponds to the index obtained in the years before regulation. Increased lifetime yields of year classes of a given relative strength at age 2 will constitute proof of the value of saving small fish.

Biologists of the ICNAF countries, particularly those from the United States and Canada, have analyzed available data on growth and mortality rates of cod and haddock in other subareas. On the basis of these efforts, ICNAF, at its fifth annual meeting in Ottawa, Canada in June 1955, recommended a 4-1/2-inch minimum mesh size for Subarea 4 (Nova Scotian Banks) and a 4-inch minimum for Subarea 3 (Newfoundland Banks).

The principal contribution of the United States to these studies was the analysis of Browns Bank haddock data collected from Boston trawlers working in that area through the years. The United States is making a similar study of haddock from Sable Island. U. S. biologists have reviewed the work of the Canadian biologists in these studies, reversing the roles played by Canada and the United States during the study of the Georges Bank population.

Redfish.--This fish grows slowly, attaining an age of 8 to 10 years before reaching commercial size. Estimating mortality rates depends upon determining relative abundance of each age of fish in the population for a number of years. Until the size of the redfish population and the degree of its stability or migrations are known, calculating its potential productivity will be impossible.

Whiting.--The purpose of this project, supported by Saltonstall-Kennedy funds, is to determine the size and extent of the whiting resource in the North Atlantic and how


U.S. HADDOCK LANDINGS IN MILLIONS OF POUNDS
TOTAL CATCH IN MILLIONS OF JUNDS
300
200
100
0
1915
1917
1921
1925
1929
1933
1937
1941
1945
1949
1953
This is where the yield could have been
WASTE
This is where it was

best to maintain a maximum sustained yield. Since little information on this species is available, methods of aging the species must be developed, number of stocks determined, growth and mortality rates for each established, and calculations made on optimum age of capture and intensity of fishing required for optimum utilization. Experiments on escape of whiting through otter trawls with different size meshes have demonstrated the size net to use to allow various sizes of whiting to escape.

Yellowtail flounder.--This project, which has been inactive for several years, was reactivated with Saltonstall-Kennedy funds in January 1955. To date the catch has been sampled and fish tagged for migration and other studies. Work will be concentrated in the area between Nantucket Shoals and Hudson Canyon.

Sea scallop.--This is another new project under the Saltonstall-Kennedy program. An assessment will be made of the extent of sea scallops in the North Atlantic waters to determine the yield this resource can support on a continuing basis. Population density and structure of the sea scallop grounds are being investigated by sampling the commercial catch at sea and at ports, and by special dredging and underwater photography. Spawning and setting time, and growth and mortality rates are being studied to gain information necessary for designing management procedures.

Industrial utilization.--Utilization of "trash" fish for animal food and for reduction to oil and meal sometimes involves destruction of quantities of small sizes of food fish, species taken for human food at larger sizes. Whiting and yellowtail flounder are the food species most susceptible to this kind of exploitation in New England.

One aspect of the industrial fish problem involves possible effect of this industry on the species which bring a higher price as human food and which might be taken for human consumption. Another involves utilization of the industrial fish species themselves which are no more inexhaustible than the food fishes. Research is directed toward determining the extent of the resource and action to be taken to ensure a continuing supply. Related problems, such as effect of competition among various species of groundfish in the areas concerned, are being investigated. Intensive removal of industrial fish may indirectly affect survival or growth of important food species.

The work on the problem includes an analysis of catches through the year to determine extent of utilization of food fishes and a more detailed study of the biology of the important species, such as red hake and 4-spot flounder.

Delaware Bay fisheries.--Surveys of sport and commercial fisheries off Delaware Bay conducted in relation to pollution problems in that area were continued. A report covering records through 1953 has been completed. In some cases records have been obtained for catches as far back as 1939. The report presents a complete picture of distribution and abundance of important marine species in the area for the period of study.

Herring.--The Branches of Commercial Fisheries and Fishery Biology of the Fish and Wildlife Service are jointly carrying out the Atlantic Herring Investigations at Boothbay Harbor, Maine. The vessel T.N. Gill was transferred from the Service's South Atlantic Fishery Investigations, Brunswick, Georgia to Boothbay Harbor for field work.

As in the case of many other important marine species which have been fished heavily, the size and extent of the herring populations which support the United States industry are unknown. The purpose of this

study is to determine the number of stocks, where they are normally spawned, how they drift in their larval and juvenile stages and why they are not always available to fishermen. A fish detecting device was installed on the Gill which made 3 cruises in the Gulf of Maine, surveying schools of fish.

Studies of pepper-spot disease disclosed strong evidence that it may at times cause widespread herring mortality.

Ecology.--Study of the ecology of the offshore groundfish has been continued. Extreme fluctuations in availability of commercial species are the rule in marine fisheries. These fluctuations must be recorded, and if possible, the factors which caused them determined. Toward this end, dispersion of eggs and larvae from spawning grounds are being studied, with particular emphasis on Georges Bank haddock. With resumption of full-time operation of the Albatross III, plankton-hydrographic surveys, started in 1953, were repeated in 1955. Continuation of this program for several years and comparison of drift of planktonic stages with yields from resulting year classes of fish should produce information on the part that hydrographic and meteorological conditions play in establishing year class strength.

Food relations are being studied also. Calculations show the haddock population on Georges Bank has been so reduced that the amount of food consumed per year by this stock of fish is only a fourth of the amount consumed years ago when haddock were first fished heavily. Research is in progress to determine composition and fate of this excess food.

Important items in the diet of Georges Bank haddock are known and this information will soon be available on fish which inhabit nearby banks. When results of these studies are published, the fish benefiting by reduction in the haddock population will be known.

In line with the ecological studies, quarterly surveys of groundfish populations have been resumed. These surveys will reveal changes in composition of groundfish fauna from season to season and year to year. The pattern of changes is an important and necessary background upon which to superimpose the laboratory's knowledge of relations of fish to various environmental factors.

Subsurface observations.--Inability of the biologist to observe at first hand the fish that he was studying has hampered marine research. New developments in underwater observational devices will in some measure alleviate this difficulty.

Several biologists have taken training in sustained underwater swimming and their aid used in devising special nets to determine selectivity of trawl nets of various mesh sizes. They can observe and photograph action of nets and behavior of fish during capture or escape through meshes.

Underwater photography, another tool in marine research, has not been fully developed. Underwater cameras of the type used by swimmers are on the market but cannot be used at great depths. A camera is being constructed that will withstand pressures at 1,000 fathoms. It will be used to survey the bottom over great areas of the banks, study scallop beds, investigate invertebrate fauna upon which many groundfish depend and study other problems of undersea biology related to commercial fishes.

GULF FISHERY INVESTIGATIONS

Albert W. Collier, Jr., Galveston, Texas

Because knowledge of the potential productivity of the Gulf of Mexico is not extensive, investigations have been designed to derive principles of marine biology and hydrography which the Gulf States can use to conserve the fishery resources coming under their jurisdiction.

Biology and chemistry of the Gulf of Mexico.--The westward movement of the Mississippi River effluents after they enter the Gulf delivers leached nutrients (chemical energy) to the western Gulf from a vast area of the United States. The eastern Gulf does not receive such large quantities of nutrients as the western Gulf and thus has a different level of productivity.

Three different groups of animals have been or are community dominants in the Gulf. Deposits of dead shells indicate the common oyster dominated the estuarial community around the Gulf until recent years when it has declined sharply and is commercially exploitable on a large scale only in Louisiana, Mississippi and Alabama.

As the oyster declined in commercial importance, the shrimp became the community dominant. Within the last 15 years, however, marked changes have occurred in the character of this resource and the knowledge necessary for evaluating these changes is lacking.

The third community dominant is the menhaden which inhabits the waters of the shorewise areas of the Gulf and depends on the planktonic community for its existence. Little is known about conditions which influence distribution, abundance and survival of menhaden populations even though this species forms a major resource of the Gulf.

Gymnodinium brevis is a fourth organism which intermittently becomes a community dominant although it is confined in its range.

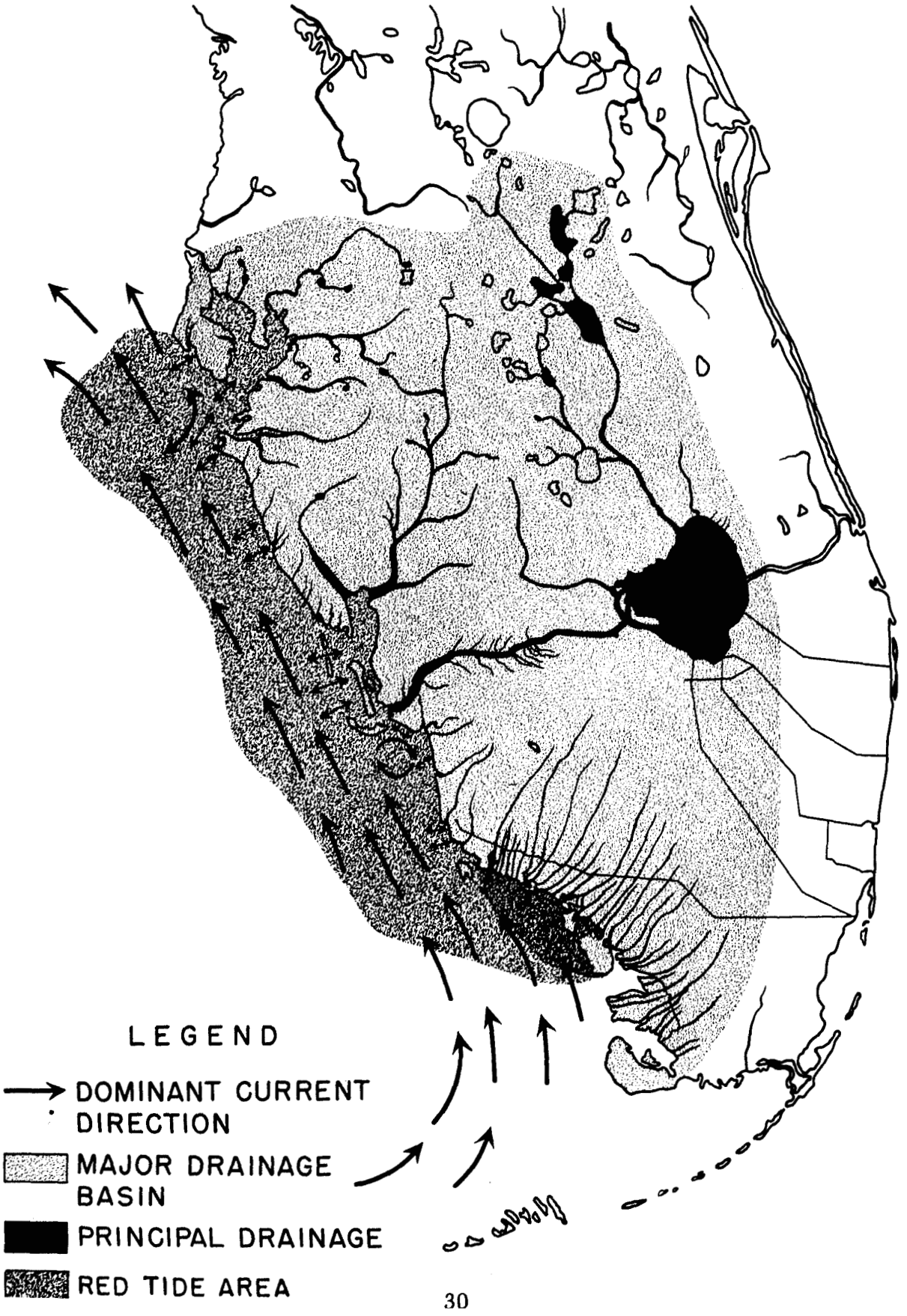
The comparative study of all phases of the lives of these 4 animals and their relationships to each other, particularly those phases that manifest themselves through underlying energy relationships of the sea, will in the end produce the most useful information in deriving principles of organic marine production.

Much effort has gone into general environmental studies and attempts to correlate variations of some of the known attributes of the sea with fluctuations in abundance of commercial species.

Biology of Gymnodinium brevis.--Studies have shown that under certain conditions G. brevis can become highly efficient as a converter of chemical and radiant energy. Because of toxic metabolites, it exerts complete control over its environment, killing all metazoan co-inhabitants of its environment (and probably many protists). The organism has sufficient flexibility and capacity for energy conversion to make use of residues of its co-inhabitants in further and explosive multiplications. Thus, it has the capacity to interrupt the normal flow of energy and become a community dominant almost overnight.

Laboratory studies of G. brevis have helped to define peculiarities of the Florida environment which are conducive to red tides. These seem to be land drainage low in dissolved copper, high in sulfides and rich in organic compounds produced by biological activity of acid peat soils which are char-

FLORIDA RED TIDE



acteristic of the Everglades and other wetlands of the south Florida Gulf coast. High rainfall and low temperatures are critical factors. Wind, tide and solar radiation are also important and work is in progress to quantitatively evaluate these.

A medium has been perfected for mass cultures of G. brevis which does not require the metal binder EDTA; this was accomplished by substituting sodium sulfide. This indicates that sulfides, abundant in Florida coastal drainage, are important in natural blooms. Experimental work demonstrates the organism is sensitive to copper, which is much lower in concentration in the red tide area than in offshore Gulf water.

A technique has been perfected for obtaining bacteria-free isolates of G. brevis. Apparently bacteria and/or their metabolites and/or residues are essential for continued growth and multiplication. Evidence indicates the mass culture medium being used to grow G. brevis is insufficient when bacteria are not present. Out of numerous organic substances tested, peptone and tryptícase have been useful in maintaining viable bacteria-free cultures.

These bacteria-free cultures are necessary for learning what specific organic compounds are critical for survival, initial large-scale blooms and the final explosive blooms of G. brevis. When these are pinpointed by experiment, means can be worked out for detecting and measuring them in the field. This is an important step leading to possible red tide control.

Support for the theory that residues of dead fish compound the division rate of G. brevis comes from an explosive bloom in the laboratory which was created by adding juices from fish killed experimentally by a relatively low concentration of G. brevis. The initial concentration was about 3,000,000 individuals per quart; with the addition of juices they tripled in number overnight.

The south Florida wetlands provide an enormous soil extract factory and when heavy rains wash over these wetlands and into the sea, they must carry some of the unknown substances that make soil extract beneficial to growth of microorganisms. In the laboratory, soil extract has been fractionated and the heavy organic components are believed to be the active agents. Vitamins, auxins and antibiotics are candidates for being critical factors.

Red tide control.--If control is possible, it will come after development of techniques for predicting conditions which are conducive to a red tide outbreak and for economical distribution of chemical or physical agents lethal to G. brevis. Predictions are necessary to make the latter possible.

Prediction will depend to a great extent on climatic studies. Records for daily rainfall, temperature, wind and sunshine for the Caloosahatchee Everglades drainage basin and the Tampa basin since the beginning of record are nearly complete. The next phase will be the study of these records to work out methods of assessing the contribution of each factor to produce a red tide.

A search for lethal agents has revealed that metallic copper and copper salts are most toxic. Copper sulphate at approximately 0.12 p.p.m. (copper equivalent 0.05 p.p.m.) in sea water is lethal to G. brevis. A small piece of copper metal will make a pint of sea water lethal to G. brevis in a few seconds. An experiment in which fine copper sulphate was spread over the sea surface with crop-dusting planes was successful in eliminating the organisms for approximately one fourth of a square mile.

Primary producers (other than Gymnodinium brevis).--The knowledge gained in the work on G. brevis is almost completely applicable to this series of projects. These organisms will be raised in unialgal and pure cultures for (1) controlled feeding of immature shrimp and fish, (2) production of raw materials to be used in identifying organic compounds produced by them and accumulated in sea water and (3) production of organic metabolites to be used in testing responses of immature fishes and shrimps.

An unidentified deep sea planktonic diatom has been isolated and from it a 25-gallon culture of great density was produced. Organic compounds of this crude culture will be extracted and concentrated.

Copepods.--Classification and distributional studies of material from Alaska cruises have brought to light some important facts about differences between small but adjoining segments of the Gulf. Copepods seemingly distribute themselves according to physiological requirements and may not be passive planktonic drifters. An experimental study of the physiology and behavior of this group is being made so that distribution in the Gulf can be understood in terms of general biodynamics.

Shrimp.--Field studies on Gulf shrimp have helped to understand their movements and life history. Histology of developing gonads has been described and attempts at correlating spawning with temperature have yielded some information. Other than this there is almost no knowledge of the commercial shrimp of the Gulf as individual animals.

Two contracts for research contributing to study of the anatomy and general physiology of shrimp were established. Tulane University is preparing an anatomical atlas of the shrimp and first drawings of the external features are in final stages. In trying to find a satisfactory method of marking immature shrimp, the University of Texas Institute has set up tank experiments using vital dyes. A contract for histological studies, which will help to understand shrimp food requirements, is being negotiated with Texas A. and M. Research Foundation.

Research on shrimp physiology will be conducted at the Galveston laboratory and at first will concentrate on those factors which influence hatching of eggs and survival of the young. This work will be supplemented by simultaneous field studies on distribution and movements of the young as they enter nursery areas and while they are there. Complete chemical and physical observations will be made in experimental and field phases of the shrimp studies. This is necessary so various environments may be defined as to fitness for broods of shrimp.

Marine chemistry--inorganic.--Most of the inorganic chemical work was done in connection with the biological investigations. This included studies of inorganic phosphorus, inorganic nitrates, copper, ammonia, sulfide, dissolved oxygen, carbon dioxide and miscellaneous metals.

Marine chemistry--organic and biochemistry.--Results of organic analyses have contributed to the success of the biological investigations.

Study of chemical data from the Alaska cruises indicates a region of biological activity beneath the photic zone. The evidence for this is found in the vertical distribution of carbohydrates whose concentrations are sometimes greater at depths below 200 meters than at the surface. This indicates photosynthetic activity and suggests experimental fishing in these waters might be profitable.

ICHTHYOLOGICAL LABORATORY

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

The Percophididae constitute a family of marine bottom living fishes that are not uncommon in offshore waters. The taxonomic status of the species remained largely uncertain up to the present. Mr. Ginsburg has investigated the western Atlantic members of this family and determined their taxonomic status. A manuscript dealing with this family has been revised and the paper will appear in the Proceedings of the United States National Museum.

Studies of the fishes of the family Scombridae, used in a broad sense, have been continued. Special attention was directed to the difficult task of finding characters that will adequately distinguish the smaller specimens--those that have not developed their adult characters--of the genus Scomberomorus which includes such important species as the Spanish mackerel, the king mackerel, and the zero or cero.

Studies of the Gulf of Mexico fishes and their comparison with cognate populations of the western Atlantic were continued, especially in the families Stromateidae, used in a broad sense, the Serranidae, and the Lutianidae.

Bibliographies of the extensive literature on the species of American gobies were compiled with the object of completing the manuscript on the species of this Superfamily. A complete bibliography for each species will be presented.

MENHADEN INVESTIGATIONS

Fred C. June, Beaufort, North Carolina

A program of investigations was initiated in April under the Saltonstall-Kennedy program to determine the nature of fluctuations in availability and abundance of menhaden stocks along the Atlantic coast and to determine whether such fluctuations are predictable.

Collection and compilation of catch data.--Catch records are being compiled from all menhaden processing plants on the Atlantic and Gulf coasts. Earliest records for Chesapeake Bay and the South Atlantic date back to 1928. Analyses of catch data from New York, New Jersey and Delaware for the period 1939-1954 have been nearly completed. Data from Maine, Massachusetts, Chesapeake Bay, South Carolina, Georgia and a part of the Gulf of Mexico have not been compiled.

Detailed data on fishing locations, effort and catches are being gathered routinely by means of logbooks which have been distributed to the commercial Atlantic coast fleet.

Early life history.--Plankton tows and beach seine collections at different locations in Indian River, Delaware, indicated menhaden larvae recruitment continued from January through mid-April. Plankton samples on ebb and flood tides at Indian River inlet yielded large numbers of larvae on flood but few on ebb tides.

Catch sampling.--A sampling program has been designed to investigate fluctuations in abundance of successive year classes and their influence on the catch. Information on age composition, sex ratio, and sexual maturity is being obtained from ~~stratified random~~ samples taken from the commercial pound net and purse seine catches at 10 locations between Portland, Maine and Fernandina, Florida.

Racial studies.--Scale markings are are being studied to determine whether growth rates distinguish stock components and whether certain peculiarities recorded on scales may be related to different nursery areas. A collection of young-of-year fish from nursery areas from Maine to Florida is being studied also to determine the variation in meristic characters and whether these may be useful in racial studies.

SOUTH PACIFIC FISHERY INVESTIGATIONS

John C. Marr, La Jolla, California

Research of the South Pacific Fishery Investigations is directed toward gaining an understanding of causes of fluctuations in distribution and size of pelagic fish populations, particularly the Pacific sardine. The SPFI is working cooperatively with 4 other research groups in the California Cooperative Oceanic Fisheries Investigations. The Marine Research Committee sponsors the research which is carried out by the SPFI, Scripps Institution of Oceanography of the University of California, California Department of Fish and Game, Hopkins Marine Station of Stanford University and the California Academy of Sciences. Scripps Institution of Oceanography and SPFI carry out extensive oceanographic-biological investigations.

RESEARCH

Sardine subpopulations.--Mathematical models have been developed to express the degree of mixing of adjacent subpopulations. A species inhabiting a fairly wide geographic area will be subjected to varying environments with the result that it may have naturally marked subpopulations (non-genetic) with respect to meristic or morphometric attributes.

Since mixing is a dynamic process, the amount of mixing can only be estimated from differences observed in time at a given locality. Differences will depend not only on the amount of mixing, but also on the amount of difference in the attribute between natives and immigrants. Hence, a basic requirement in assessing the amount of mixing is a quantitative measure of the attribute or attributes in each locality. Individual year classes should be used. This model, thus far, is restricted to separating individuals from 2 subpopulations--if the mixing at a locality involves individuals of more than 2 subpopulations, it is usually impossible to separate them.

Sardine growth characteristics.--Differences in growth patterns in fish from different localities have been variously interpreted. It has not been possible to separate differences due to environment from those due to heredity.

The Walford method of "transforming" length-on-time growth curves to straight lines had been previously applied. A significant difference in level (y-intercept) and no significant difference in slope were found

for transforms of average observed and calculated lengths of several sardine year-classes caught during an early period of successful fishing in 2 widely separated geographical areas--off the Pacific Northwest and off San Pedro. The meaning of differences in these growth characteristics was not clear but appeared analogous to clines or gradients in meristic characters associated with different environments.

Some application of results of an experiment on growth characteristics (next below) may be made in interpreting growth characteristics of sardines from the 2 areas. Difference in level of transforms between sardines caught in the 2 areas is more probably associated with environmental origin than with genetic differences in stocks caught in the 2 areas.

Growth characteristics.--To determine growth characteristics of known genetic strains under 2 differing conditions of environment, an experiment with 2 species of Xiphophorus (swordtails and platyfishes) was carried out. Each species was fed at 2 different food levels with a replicate of each, making a total of 8 tanks. Food level II was twice that of food level I for both species.

Results of these experiments indicate that in Xiphophorus difference in the growth characteristic, slope, is genetic, while differences in level or in ultimate size is related to environment (in this instance differing food intake).

Sardine growth.--The weight-length relation of sardines fed different diets was compared by feeding 2 lots a high protein diet and 2 lots a carbohydrate diet. Weight-length regressions of the two lots of protein-fed fish do not differ in slope or level; similarly for the 2 lots of carbohydrate-fed fish. Weight-length regressions of the protein-fed fish (both lots combined) differed from a control group in level but not in slope. Weight-length regressions of the carbohydrate-fed fish (both lots combined) differed in slope from the control group. The slope of the weight-length regression of carbohydrate-fed fish more closely approximated that of "wild" fish landed at San Pedro than did that for protein-fed fish. These observations could be explained if carbohydrate-fed fish were able to increase their stores of fat and carbohydrate but were not able to add new cells, while protein-fed fish were able to store fat and carbohydrate and add new cells and thus increase in length.

Use of paper chromatography in studying subpopulations.--Environment influence on muscle amino acids is being studied for the purpose of separating variation due to environment from differences due to heredity. The amino acid content of muscle tissue was compared by paper partition chromatography for 5 lots of 25 fish discussed immediately above. An examination of the variability of 2 amino acids (out of 12 identified) revealed that the proportion of fish having free aspartic acid and alanine varied inversely with fish condition. No difference was observed between control (semi-starved) and carbohydrate-fed fish in proportion of free aspartic acid; this proportion was greatly reduced in protein-fed fish. Hence, diet has produced an environmentally induced variation in the free amino acid complement of sardines.

Sardine population size.--A 30-fold increase in the amount of sardines spawning in the "northern" center (off southern California and adjacent Baja California) occurred during 1954 as compared to the 2 previous years. Over twice as many sardines are estimated to have spawned in this area during 1954 as during 1950, the next best spawning year in SPFI series of data.

In recent years, the bulk of sardine spawning has occurred off central Baja California, centering off Pt. San Eugenio.

The following tabulation shows the relative importance of the 2 spawning centers:

	Percentage of season total taken in the two major spawning centers				
	1950	1951	1952	1953	1954
Northern center	17	6	2	1	37
Southern center	82	94	98	99	60
Other	1	0	0	0	3
Total	100%	100%	100%	100%	100%

The plankton collections have been sorted on an almost current basis during 1955. Sardines are spawning in the northern center in about the same abundance as during 1954. However, there has been a notable decrease in sardine abundance in the southern area. No spawning was found through June to the north of Pt. Conception, although spawning occurred as far north as Pt. Conception in June.

The return of sardines to the northern center probably resulted from a change in hydrographic conditions--specifically, an increase in winter and spring water temperatures in the northern spawning center, especially in the southern half of the center.

Fecundity studies.--During the 1945-1946 season at San Pedro, sardine samples were obtained and preserved at about weekly intervals. About 1,200 fish which were examined for gonad development have furnished interesting data on the number of eggs per fish as related to size and age, size and age at first maturity and relation between fish condition and egg production.

A resting ovary contains large numbers of transparent ova, 0.15 to 0.18 mm. in diameter. When development commences, the ova soon become yolked and opaque (at approximately 0.22 mm. diameter). Ova continue to increase in size until about 0.7 to 0.8 mm. diameter. Just before spawning, ova increase rapidly in size from about 0.8 mm. to 0.9 mm. in diameter, probably by taking up water, and simultaneously become translucent. The developing ovary generally contains more than 1 size group of ova. SPFI data on number of eggs per batch are based on estimates of the number of ova of the largest mode.

Considerable variation was found in the number of eggs produced per batch by fish of similar size. Although the average number of eggs produced per batch by a 180 mm. female is approximately 16,500, the range at the one standard deviation level is from 7,750 to 25,250 eggs per batch. For a female 220 mm. in length, the average number of eggs per batch is approximately 37,000, the range at the 1 standard deviation level is from 28,250 to 45,750 eggs per batch. The average relationship between fish length and ova per batch is an increase of approximately 5,000 ova for each 10 mm. increase in length between lengths of approximately 160 to 260 mm.

During February 1946 all female sardines over 180 mm. in length contained developing ova, and about 35 to 40% of the females between 160-180 mm. contained developing ova. The age at first spawning of sardines has not previously been determined: 28% of the 1-ring (1-year old) sardines, 83% of the 2-ring and 100% of 3-ring and older fish were found with developing ova in late February.

Population estimate based on commercial catch and egg surveys.--As pointed out above, egg estimates for the northern spawning center amounted to 114 trillion in 1954; estimates for the southern center are roughly 190 trillion (approximate value since detailed determination is incomplete); total for the 2 areas being 304 trillion. Hence, 37% of the spawning is estimated to have occurred in the northern spawning center. If 3 batches of eggs were spawned per female (average per batch is between 30,000-35,000 eggs), then approximately 2.3 billion fish spawned in the northern center and approximately 6.1 billion north of Magdalena Bay.

The California Department of Fish and Game on their sardine scouting surveys found about 52% of the fish of spawning age (1/2 of fish 2 years old and all fish 3 years and older) to be distributed to the north of Ensenada in the fall of 1954.

The San Pedro and Ensenada fishery took approximately 85,000 tons of fish during 1954, averaging approximately 7,800 fish per ton or 0.67 billion fish. The fishing season at San Pedro did not start until nearly a month late because of a strike and subsequently the fleet fished under severe "limits." It is generally agreed that between 2 and 4 billion fish were available north of Ensenada. Hence, fishing mortality would have amounted to between 17% and 33% of the available population.

If these estimates of 2 to 4 billion fish tons are accepted as the amount available to the Ensenada and San Pedro fisheries, then the total mature population is approximately double this or between 4 to 8 billion fish. SPFI spawning population estimate based on egg surveys falls in the middle of this (6.1 billion).

At spawning time SPFI found approximately 37% of the population in the northern center. The California Fish and Game estimated that 52% of the mature population was in this area during the fall months, hence approximately 15% of the mature population must have migrated into the center after the spawning season had ended. A similar net northward movement of fish following the spawning season was noted in 1950 and 1951 but did not occur in 1952 and 1953.

Availability.--Pilot experiments with schooling fish have been initiated at Marineland of the Pacific (near Los Angeles). So far only crude observations of reactions to physical factors have been made. The first series of experiments is designed to ascertain the efficiency of different types and sizes of tanks for the behavior studies contemplated.

Preliminary to behavior studies are investigations of sensory systems of the sardine and related fishes. At present relative functions of the eyes and the lateral sensory system in perceiving objects in the environment are being investigated.

Anatomical investigations of the eyes of the sardine, anchovy, Pacific mackerel and jack mackerel have been in progress during the past year. Other species have been examined for comparative purposes. Of the 6 oculomotor muscles, the anterior rectus,

which rotates the eye forward, shows differences that probably exemplify behavior differences. This muscle in the sardine is well developed and inserted at the center of the eyeball. In the anchovy, it is also inserted at the center, but is poorly developed. The Pacific mackerel and jack mackerel have a split anterior rectus, the dorsal segment extending to the forward margin of the eye, the ventral segment attached at the center. Various related forms suggest these differences are at the family level. Anterior insertions in the 2 mackerels indicate these species train their eyes forward to use binocular vision in capturing prey whereas central insertions in the sardine and anchovy suggest less specialization for particulate feeding. Perhaps the poorer development in the anchovy means it is exclusively a filter feeder while the sardine resorts to particulate feeding part of the time.

Density of cones in different regions of the retina tends to corroborate the above hypothesis but more precise data must be obtained. In general, the 2 mackerels have a relatively higher cone density in the back of the eye than do the 2 clupeoids. These would be areas of greater acuity and hence, the receptor fields of significant visual axes.

Fish location and behavior studies using echo-ranging gear.--In February 1955, a "Sea Scanar" (Minneapolis-Honeywell Model 1B) was installed on the Black Douglas and tested off Baja California during its April cruise. The instrument had a large range of sensitivity and ability to register small objects individually and in mass. Surface and subsurface swarms of the pelagic crustacean Pleuronocodes planifer were recorded on the PPI screen within the entire scanning arc and out to 700 feet from the ship. From the "blip" pattern on the PPI screen, the observer could get an idea of the irregular distribution of the organisms which a large spotlight verified.

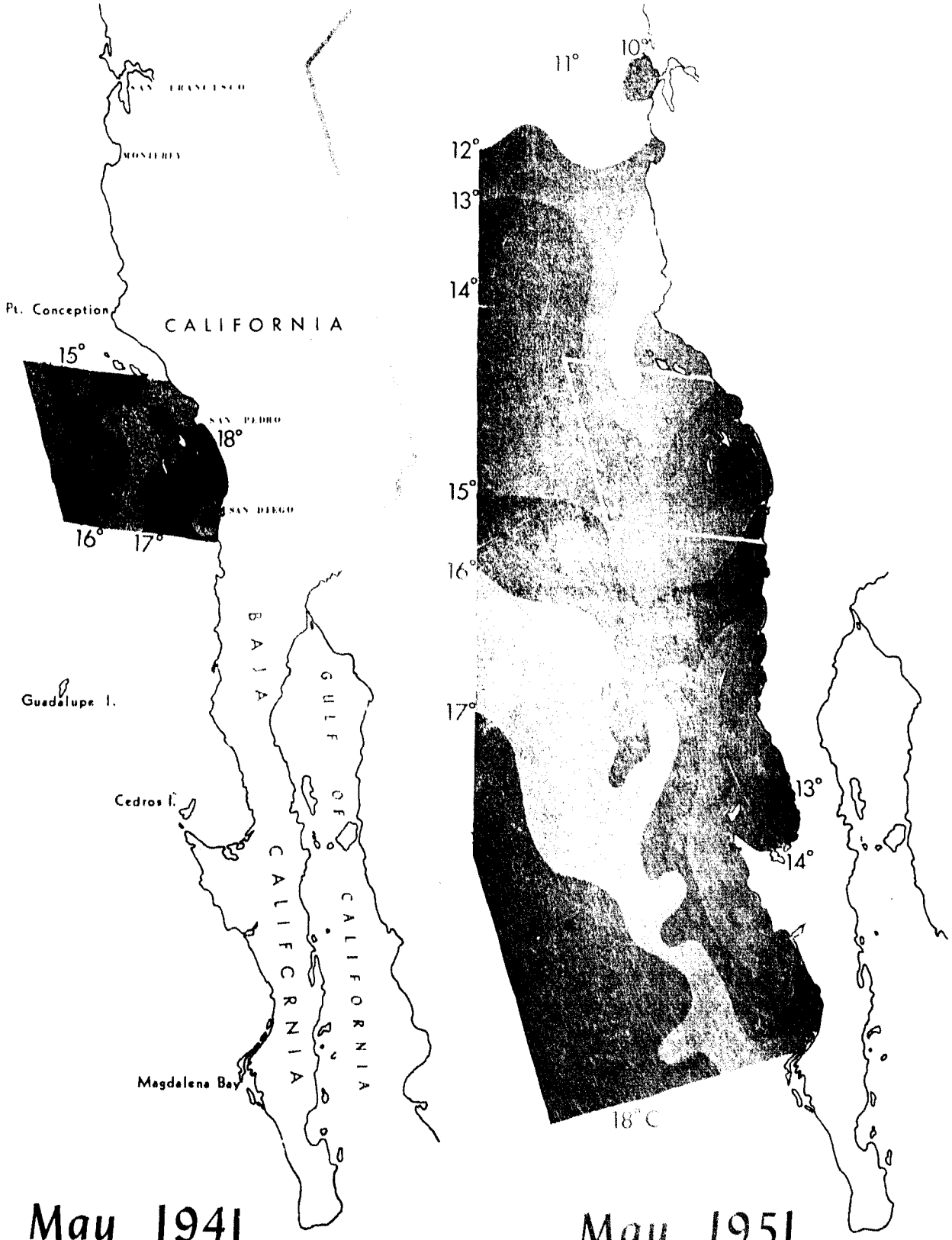
The Sea Scanar makes no permanent record (this is unfortunate). The need for a permanent record was especially noticeable when the Sea Scanar was operated in conjunction with a conventional type recording, echo sounding gear. While anchored at Cedros Island, Baja California, and attracting fish to lights, a continuous record was made on a Raytheon depth recorder of the fish schools under the vessel. The Sea Scanar showed the lateral extent of fish attracted to the light--which amounted to several hundred feet from the light source--but no permanent record was obtained. Hence, for preserving observations for later study a chart recorder is needed on the Sea Scanar. Another improvement could be effected by incorporating a stabilizer for the sound beam.

Causes of year-class strength variation.--Larval population estimates have been made for the 1950 through 1953 year-classes and data on the first 2 years have been published as Fishery Bulletin 93. Larval survival during 1952 was better than during other seasons. The strength of the 1952 year class as 2-year-old fish in the commercial fishery (33% of fish landed) confirms SPFI's early estimate of the relative strength of this year class. The 1951 year class as 3-year-olds was slightly greater (37% of fish landed), but 3-year-old fish are usually fully recruited to the fishery while 2-year-old fish are not. The 1950 year class has contributed considerably less to the commercial fishery than either the 1951 or 1952 year class. Survival during the larval period of the 1954 year class has not been determined.

Climatology.--Records of hydrographical and climatological data for past years, available from several sources, include:

1. Surface temperature, density and salinity data for 29 stations located between

CHANGES IN OCEAN TEMPERATURES



La Jolla, California (S.I.O. Pier) and Queen Charlotte Island, British Columbia, are available for varying periods, up to approximately 30 years.

2. Air temperature data from the Smithsonian World Weather Records have been processed for 15 selected short stations surrounding the North Pacific Basin.

3. Air temperature data from the United States Weather Bureau and the Hydrographic Office of the Navy, - some records covering a span of 100 years - are being processed for the entire North Pacific Basin by 10° Marsden Squares.

These data are being processed for studying weather influence, historically, on distribution and abundance of pelagic fishes, such as the Pacific sardine. Preliminary results show that while temperatures have been warming along the Pacific coast, as in the Atlantic, this trend was reversed in about 1941. In 1954 and 1955, however, warmer conditions have again prevailed. These temperature changes are associated in time with changes in distribution of sardines and other species.

Mortality rates from fishing and other causes.--Although several species of fish have been reared from egg to juvenile stages in laboratory aquaria, no success has been had in rearing fish with pelagic eggs and larvae. Furthermore, morphological studies of cleared and stained material of juveniles reared in the laboratory have revealed a high percentage of individuals have abnormalities in development of vertebrae, supporting structures of the caudal fin, and in development of some fins. For the present, work on rearing fish larvae in laboratory aquaria is being discontinued and means are being sought to rear larvae in a marine environment.

An attempt was made to hatch and rear anchovy eggs and larvae in small containers of plastic tubing and nylon mesh which were floated in Mission Bay. This method was unsuccessful because the water circulation was improper, the mesh became dirty and clogged, and the cell was collapsible, proving detrimental to handling of fish eggs and larvae.

A live car for rearing larvae has been designed and will be built and put to use soon. It is a modification of the type used successfully by A. D. Mead for rearing lobsters and fish in 1908 (Bulletin of the Bureau of Fisheries, 1908, vol. 28, parts 1 and 2).

Plankton volume distribution, 1950-1954.--A study is being made of plankton volumes obtained in routine plankton hauls. Basic data have been published on a current basis (Special Scientific Report: Fisheries 73, 100, 125 and 132). A series of monthly and yearly charts have been prepared, covering survey cruises of 1949 through 1954; these will soon be submitted for publication.

The largest average plankton volumes were obtained in 1950: 554 cc. per 100 cubic meters of water were strained. This is 1.9 times greater than the next biggest year, 1953, and over 4 times greater than the lowest year, 1951. The large volumes were obtained during the first half of 1950 and the volumes after June 1950 were below the average of other years. The average plankton volume per haul in the survey area during the 4 succeeding years follows: 1951, 130 cc. per haul (standardized to 1000 cubic meters of water strained), 1952, 205 cc. per haul, 1953, 292 cc. per haul, and 1954, 167 cc. per haul.

A comparison of plankton volumes by area reveals there is a marked decline in average plankton volumes from the California-Oregon border south to approximately Dana Point (southern California); from Dana Point south to Cape San Lucas the decrease is more gradual. As examples, volumes from northern California averaged 447 cc. per haul, volumes from northern Baja California averaged 197 cc. per haul, while volumes off southern Baja averaged 149 cc. per haul.

A comparison of volumes by months for 1951-1954 shows an increase from January to July and a decrease thereafter. Volumes for January averaged 115 cc. per haul, for July 399 cc. and for December 89 cc.

Anchovy.--In 1953 and 1954 anchovy larvae have been the most abundant pelagic fish larvae taken in plankton collections made on cruises of the California Cooperative Oceanic Fisheries Investigations. Although anchovy larvae are taken throughout the area being surveyed, they are taken in greater abundance off southern California and along Baja California than above Pt. Conception. During the past 4 years abundance has increased throughout the area south of Pt. Conception. This can be simply shown from the average number taken per standard haul during these years. (See bottom of page).

In 1953, 4 times as many anchovy larvae were taken off southern California and adjacent Baja as in 1951 or 1952, while in 1954, abundance was 6 times as great as in earlier years. The increase off central Baja California was greater in absolute numbers but not as marked proportionately: 1954 abundance was about 3 times that found in 1951.

There has been a marked increase in abundance of juvenile and adult anchovies off southern California as well. This observation is based on the commercial catch, the southern California bait fishery and reports of airplane scouting for fish. The 1953 and 1954 year classes seem particularly successful.

Anchovy fishery.--Cooperative studies with the California Department of Fish and Game on age and size determinations of northern anchovy taken in the commercial catch continue. The studies were initiated in 1952; the first paper in the projected series on the age and length composition of the anchovy catch, which is in press, deals with the 1952-1953 and 1953-1954 seasons.

Pacific mackerel.--Distribution and abundance of Pacific mackerel larvae in plankton hauls obtained on survey cruises of the California Cooperative Oceanic Fisheries Investigations are being studied. The "return" of sardines to the northern spawning center in 1954 was paralleled by an influx of Pacific mackerel into the same area, although the increase was not as marked; approximately 8 times as many Pacific mackerel larvae were taken off southern California in 1954 as in 1952. However, the largest concentrations of Pacific mackerel larvae were obtained off central and southern Baja California during 1954. Apparently spawning off southern California is at the northern end of the spawning range of this species.

A study, similar to the one made on jack mackerel, is being made of development of

Area	Average number of anchovy larvae per standard haul			
	1951	1952	1953	1954
Pt. Conception to below Ensenada	15	16	65	98
Punta Banda to San Juanico	43	80	95	141

Pacific mackerel. Development of the 2 species is similar, although a number of interesting differences have been noted in vertebral ossification, caudal development, etc., which will be useful in identifying larvae.

Jack mackerel.--Eggs of jack mackerel from the 1950-1951 cruises are being enumerated and staged. The enumeration is being made so an egg abundance estimate can be obtained, for use both in population estimates and in estimates of survival between spawning and late larval stages. From "staged" sardine eggs, it was found possible to separate the several days spawning present and to determine relationship between water temperature and rate of development of the eggs. A similar study is being made with jack mackerel eggs.

Collection of jack mackerel larvae is not noticeably different in day and night hauls. Unlike sardine and anchovy larvae, there is no evidence that jack mackerel larvae "dodge" the net during daylight hours.

During the April 1955 cruise of the Black Douglas, several series of hauls were made to study vertical distribution of fish larvae. The series differed from most previous vertical series in being taken in water masses where the thermocline was deep (75 meters or so below the surface). The depth distribution of jack mackerel larvae is confined to the upper mixed layer above the thermocline; the larvae being distributed throughout the layer, although by no means uniformly. As a consequence, the depth stratum occupied by jack mackerel larvae appears to vary directly with thermocline depth.

During the past year a paper describing eggs and larvae of the jack mackerel and distribution and abundance of larvae in 1950 and 1951 was published as Fishery Bulletin 97.

Hake.--Eggs and larvae of hake, Merluccius productus, and distribution of hake larvae during 1951 and 1952 were described in Fishery Bulletin 99. Hake larvae taken in 1953 survey cruises have been identified and enumerated (described in Special Scientific Report: Fisheries 155) and similar work continues on the 1954 and 1955 collections. Hake larvae have ranked first (1951 and 1952) or second (1953 and subsequently) in abundance among pelagic fish larvae taken in plankton hauls on survey cruises during recent years. Additional information has been obtained on vertical distribution of hake larvae, which usually occur within or immediately below the thermocline. No commercial fishery exists for this species.

Vinciguerria.--There are larvae of 4 isospondylid fishes that occur abundantly in SPFI plankton collections. In addition to the sardine, these are the northern anchovy, Leuroglossus, a deep-sea smelt; and Vinciguerria, the Panama lightfish. Larvae of anchovy and Vinciguerria are similar in appearance to sardine larvae and in younger stages or poorly preserved material could be confused with the sardine. Detailed study of these 3 species has made it possible to identify even badly macerated specimens with certainty. Vinciguerria, sardine and anchovy larvae occur in the upper mixed water layer, above the thermocline.

The development of Vinciguerria has been studied in detail, as an example of an isospondylid fish with a marked metamorphosis. Fin formation is completed at metamorphosis, marked changes in body proportions occur at this time and light organs are formed.

Gray whale census.--The annual gray whale census was taken from land stations at Point Loma and La Jolla, San Diego and

was conducted on the southward migration only. The count of different gray whales migrating south close to land was 1, 622 and, extrapolating for those passing by during bad weather and at night, 4, 100 is estimated as the number passing south to the calving grounds during the period December through February. This number, together with an estimated 800 born during January, February and March in the breeding lagoons of Baja California and the Gulf of California, make a total of 4, 900 animals and with an estimated mortality of 1/20 of 4, 000 for seniles (based on estimate of 20-year life span) or 200, and of another 200 as an estimate of the normal mortality of other adults and some young, the final estimate for the 1955 population would be 4, 500.

This number is considered sufficient for a limited harvest of about 200 individuals, but there is not pressure now for an open season.

PACIFIC OCEANIC FISHERY INVESTIGATIONS

O. E. Sette, Honolulu, Hawaii

GENERAL

There were several significant developments during the past year. In the equatorial region emphasis shifted from general areal and temporal yellowfin distribution studies to special studies focusing on specific problems raised by past surveys and by initial attempts of American commercial interests to fish equatorial yellowfin stocks.

In the Hawaiian area the scouting program, designed to reveal the extent of the local resource, was modified to permit initiation of an intensive tagging program.

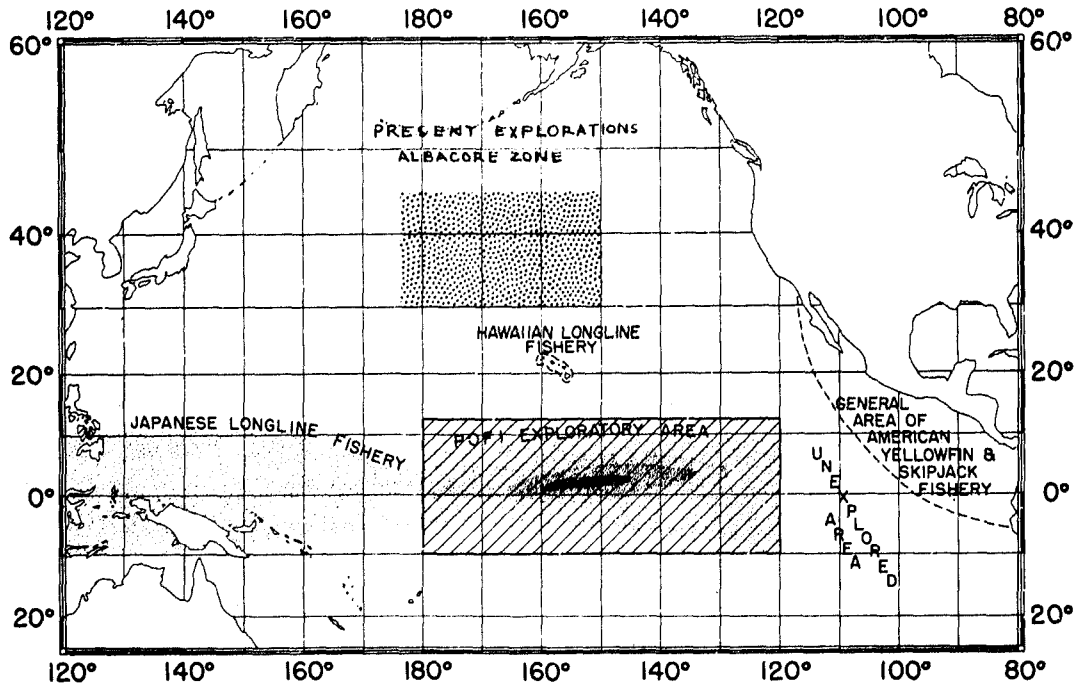
An investigation of albacore resources, begun in October 1954, has given indications of the existence of unexploited albacore stocks in the north central Pacific. A salient feature of this program is the close cooperation of POFI efforts with those of several West Coast agencies.

Valuable contributions on problems, such as artificial tuna bait and electrofishing, were obtained through contracts with the University of Hawaii.

Probably the most significant achievement resulted from developing informally constituted planning groups which comprise the heads of several agencies working on the high seas of the eastern Pacific. Concrete programs that have emerged are Norpac, a synoptic survey of the entire North Pacific during August 1954, and Eastropic, a synoptic survey of the eastern tropical Pacific during September-December 1954.

RESEARCH

Physical and chemical oceanography of the central Pacific Equatorial.--There are long term responses of the equatorial ocean circulation to variations in the trade wind system (Northeast and Southeast Trades). There is a seasonal periodicity in the trades, with the southeast trades at their maximum in August, the northeast in March. This is reflected, for example, in the position of the southern boundary of the Countercurrent, which at 150° W. longitude is near 5-1/4° N. latitude in summer and 3-1/2° N. latitude



Problem: The Pacific Oceanic Fishery Investigations of the Fish and Wildlife Service is based at Honolulu, Hawaii, for the purpose of carrying out Public Law 329--80th Congress, which was enacted August 4, 1947. This law declares:

"That it is the policy of the United States to provide for the exploration, investigation, development, and maintenance of the fishing resources and development of the high seas fishing industry of the Territories and island possessions of the United States in the tropical and subtropical Pacific Ocean and intervening seas, for the benefit of the residents of the Territory of Hawaii and Pacific island possessions and of the people of the United States."

Procedure: Hydrographic surveys to determine oceanic water circulation and to learn where the surface waters are enriched so as to provide more abundant food for tuna. Following the surveys fishing explorations are conducted in zones indicated to be rich in tuna food. Fishing is done by the longline method which captures deep swimming tunas, 200 to 400 feet below the surface.

Results: Abundant yellowfin stocks were found in a broad band along the equator with the greatest concentrations south of Hawaii. Semi-commercial fishing ventures indicate the equatorial zone contains quantities of tuna approximately equal to Central America regions now fished by U. S. fishermen. Development of a new U. S. tuna fishery in the Central Pacific is now open to the U. S. industry.

in winter. The speed of the Countercurrent exhibits a similar periodicity, with the mean maximum speeds during late summer.

During 1950, available meteorological data suggest southeast trades were relatively persistent during the year. The southern boundary of the Countercurrent was between 5° and 6° N. and its speed exceeded 1 knot. Upwelling (as indicated by temperature and PO_4) was relatively more intense and persistent and productivity (between the Equator and 5° N. as measured by standing zooplankton crop) nearly doubled the average.

Shorter term variations were demonstrated during February-April 1953 when the equatorial circulation was nearly at a standstill. Speeds in the Countercurrent and South Equatorial Current, measured by long-line drift and configuration of the isotherms, were nearly 0. The Undercurrent, which lies at the Equator, was at the surface and flowing to the east at speeds between 1.5 and 2 knots. This was the period of a particularly pronounced El nino off the Peruvian coast, suggesting atypical circulation conditions were present over the entire eastern Pacific.

Data further suggest that between approximately 170° W. and 165° E. longitudes there is a transition zone in the equatorial circulation. West of 165° E. the Countercurrent appears to be on or near the Equator. Geostrophic considerations suggest the undercurrent has its origin within this transition region.

Oceanography of Hawaiian waters.--Data from 6 hydrographic cruises (1949-1952) in Hawaiian offshore waters provide information about oceanic circulation features in waters adjacent to the 8 main islands of the Hawaiian archipelago, the region of the most intensive Hawaiian skipjack fishery.

The dominant feature of this circulation was the vortex motion, the eddies, which clockwise and counterclockwise, were most noticeable in the lee waters of the island chain, reaching maximum velocity during summer. During winter, large sluggish vortices were found on the windward side. On the lee side, an association seems to appear between skipjack schools (sighted during POFI scouting cruises) and eddies, with the predominant number of schools sighted around the periphery of the eddies. The average surface temperature showed a seasonal range of approximately 4° F. (78° F. in summer, 74° F. in winter). Waters of the windward side were generally 1 to 2° colder than those of the lee side. Maximum deviations from the average were generally associated with the leeward eddy system.

Productivity studies in the central Pacific

Equatorial plankton.--Studies emphasize the importance of trade winds as a factor in zooplankton abundance and distribution. Zooplankton abundance is greatest at the Equator and declines less to the north than to the south. The unsymmetrical distribution probably results from prevalence of southeast trades.

A secondary plankton peak was observed along the northern boundary of the Countercurrent, particularly evident toward the eastern Pacific. This may be related to the combination of shallow thermocline and strong east to northeast winds which could result in enriching surface waters from wind-induced turbulence.

The average yellowfin distribution roughly coincides with zooplankton distribution along an east-west axis as well as a

north-south axis. Zooplankton increases from 180° to 140° W. longitude, as do yellowfin catches made on longline gear, but east of 140° W. plankton remains high while tuna abundance declines.

Food of tunas.--A comparative study of the food of bigeye and yellowfin tuna shows both feed on essentially the same items, e.g., squid, small fish, etc. There was some indication of differences between the 2 species of tuna in the species composition of their food. The amount of food in yellowfin stomachs bore no relation to catch rates; that is, tuna were about as well fed in areas where they were scarce as in areas where they were abundant.

Vertical distribution of zooplankton in equatorial waters.--Analysis of results of a program utilizing Clarke-Bumpus samplers fishing at 3 levels shows greatest volumes and numbers of organisms were in surface samples and smallest volumes and numbers in the deepest samples. There was no evidence of a concentration of zooplankton in or near the thermocline. The average size of the organisms increased with the depth of sampling.

Study of forage organisms in the central Pacific.--The Isaacs-Kidd midwater trawl was modified to fish at 5-6 knots. Preliminary laboratory analysis of catches shows they comprise a wide range of small to medium nekton including some tuna forage.

Abundance and distribution of equatorial yellowfin

Analysis of 1950-1954 longline survey results suggests variations in abundance of equatorial yellowfin may be related to changes in the ocean environment which in turn can be ascribed to changes in the wind system. Along each longitude relatively cold water was associated with poor fishing and warm water with good fishing. Presumably the cold water is newly enriched by upwelling and has not developed a population of nekton that constitutes tuna forage. The warmer water has "matured" insofar as tuna forage is concerned and presumably contains adequate amounts of forage.

During 1954, commercial vessels, Commonwealth, Oceanic, Brothers and Sea Hawk, attempted to fish commercially in the vicinity of Christmas Island but were not notably successful. Part of their difficulty lay in attempts to use steel longline gear - a radical departure from the cotton gear in general use. The steel gear did not perform well and fish were not as abundant as during previous surveys of the area and during earlier commercial trials of the vessels North American and Alrita in January-May 1954.

Comparison of sea temperature records obtained at the Christmas Island station and catch results shows the poor success of the 4 vessels coincided with a period of unusually cold sea temperatures at Christmas Island. Thus, intensive records from a restricted area yield the same relations between environment and catch as did several years' records well spread in time and space.

Records of Japanese and POFI fishing show that when fishing is poor at the longitude of Christmas Island, better fishing is to be had to the east or west. This suggests these yellowfin stocks move about in the "system", probably in response to changes in the relative adequacy of the environment, though on the average, the vicinity of Christmas Island supports the densest yellowfin population.

To further elucidate these problems, a year-round sampling program, initiated in March 1955, involves obtaining nearly continuous records of yellowfin abundance in the vicinity of Christmas Island for a year. Results of this operation, when analyzed with continuous measures of the environment obtained from Christmas Island station, are expected to more clearly define the relation between changes in environment and changes in catch.

Incidental to this program, yellowfin tuna from the Line Islands vicinity are being tagged to investigate the relation between surface and deep-swimming yellowfins in that area. To June 1955, 500 yellowfins had been tagged.

Relationship of tuna stocks in various parts of the Pacific

Yellowfin races in the Pacific.--Two studies were completed that look toward a solution of relationships of equatorial yellowfin stocks. The first study suggests use of measures of overlap of frequency distributions instead of tests of statistical significance. This method in essence measures the maximum of intermingling which might have occurred between any 2 samples. The second study applies these methods to equatorial yellowfin. Results suggest a high degree of intermingling for geographically proximate samples and little for distant samples, the inference being yellowfin stocks along the Equator in the Pacific are relatively sedentary.

Economical methods of harvesting tunas.

A concerted effort was directed toward increasing the number of longline hooks that can be fished per man per day. Significant improvement appeared to involve use of steel gear so effort was concentrated on increasing the "catching efficiency" of steel and reducing the handling labor.

Trial cruises and experience of commercial vessels showed that steel gear, probably because of the lack of resiliency, failed to retain as many hooked fish as cotton gear retained. To overcome this deficiency, elastic nylon branch lines and small floats were tried in the field. Results are inconclusive, though preliminary results show some promise.

A system of "semi-automatic" gear handling was also developed and tried in the field. These tests suggest that steel cannot be handled significantly faster than cotton gear. However, only about half as many men were required to fish steel gear as are required for cotton gear.

Investigations of Hawaiian skipjack fishery

Distribution of skipjack.--A July-August scouting cruise showed an absence of bird flocks and fish schools beyond 100 miles from land. It showed also a homogeneous distribution of schools in the lee of the Hawaiian Islands to a distance of 100 miles from land. This is in contrast to earlier results which suggested the distribution of schools was related to the presence of eddies in the lee of the islands.

A cruise in January-February found skipjack scarce from the Hawaiian Islands to the Equator; only 6 of 44 schools were more than 100 miles offshore. However, a simultaneous albacore survey cruise encountered what appeared to be large numbers of skipjack to the north and west of the Hawaiian Islands.

To assess their migrations and biology, 886 skipjacks were tagged and 2 tags have been recovered.

Eighteen days were devoted to live bait surveys in the leeward chain, a logical

potential bait source, to support an expansion of the Hawaiian fishery. A total of 2, 100 buckets of bait were observed or an average of about 120 per day. Though the average is substantial, the bait is erratically distributed and more knowledge of its movements and habits is essential before commercial fishermen can utilize it.

Life history and biology of tunas

A study has been completed of early larval and post larval stages of yellowfin and skipjack. Larvae are found in about equal abundance from 180° to 140° W.; plankton samples taken along 120° W. and 130° W. are almost devoid of tuna larvae. Larval tuna can be caught most efficiently near the surface at night. The latitudinal distribution of larvae generally parallels that of general zooplankton and of adult tuna in equatorial waters. While identification is difficult, about 3 times as many skipjack as yellowfin larvae appear near the Equator.

Spawning studies of yellowfin and bigeye tuna indicate yellowfin in equatorial waters probably spawn 12 months of the year with some reduction in numbers of ripening females during November, December and January. Similarly, bigeye tuna spawn in the equatorial region during most months with some lessening of rate during the winter. The size at first maturity of equatorial yellowfin seems to vary considerably, with a few fish maturing between 20 and 30 pounds and the bulk at about 70.

Length frequency studies of bigeye tuna from the Hawaiian Islands area reveal a peculiar alternation of modes from year to year. Modal sizes present in 1 year are absent the next but again present the year after. This 2-year cycle of dominant size groups has held for the years 1947-1953. Larger bigeye grow about 40 pounds a year, ranging in size in the Hawaiian flagline fishery from 100 to 300 pounds.

Length frequency data from yellowfin caught on longline fishing gear by POFI research vessels near the Equator fail to show modal progression through the year and thus cannot be used for age and growth studies. Prominent size groups of fish are present, however, with a smaller group at about 50 pounds, and a larger group averaging about 130 pounds, at all times of the year. Although the analysis is incomplete, it seems reasonable that the longline gear is highly selective and is catching fish only during the restricted periods of the tuna's life.

Contract research projects with the University of Hawaii

In searching for a substitute for live bait to attract tuna to the stern of a fishing vessel, several types of self-propelled artificial lures were designed. Two of the more promising types - 1 powered by compressed air, and the other by a slow-burning powder - will be tested at sea in July 1955, together with a specially designed rifle which will project motile lures some distance from the ship.

An investigation of the possibility of using electrotaxis as a method for harvesting tuna was initiated. From theoretical considerations a formula was developed giving total current and net resistance between 2 electrodes submerged in salt water, knowing the conductivity of the water, radius of the electrodes and the applied potential. Studies of the electrostatic response of "aholehole" in a small tank were continued to discover the minimum current density for positive response over a range of frequencies and duty cycles with interrupted direct current. When results were extra-

polated to apply to larger fish and a large 31 x 15 x 4 foot tank, they indicated a minimum current density requirement of 0.003 amps./cm.^{2} for an optimal on-fraction of 0.060 (6 milliseconds) at an optimal frequency of 10 cycles/sec. An apparatus was designed to meet these requirements. When constructed, it will be used to study the electrotactic response of tuna held in captivity.

Preliminary investigation of the cause of "green" color found in some equatorial tuna loins after precooking indicated this was not due to an abnormally large accumulation of copper in the flesh as had been suspected.

Starting June 1, 1955, three contracts provided for a continuation of electrotaxis research, a further investigation of the possible causes of discoloration of processed equatorial tuna and a comparative morphological and histological study of the tuna eye. The last project initiates a new and important investigation of the sense of vision.

Spearfishes

Because identification of spearfishes from current literature is difficult and confusing, a report was prepared on taxonomy, distribution, size, food and spawning habits of spearfishes. It includes a review of Japanese and other literature, together with new observations of several hundred spearfishes caught in the central equatorial Pacific and previously unpublished data on spearfishes in the Hawaiian fishery collected by the Division of Fish and Game of the Territory of Hawaii.

A morphometric study shows marked variation in all diagnostic characters and allometric growth in many. The species recognized are the swordfish, Xiphius gladius; the shortnosed spearfish, Tetrapturus angustirostris; the sailfish, Istiophorus orientalis; the black marlin, Marlina marlina; the striped marlin, Makaira mitsukurii, and the blue marlin, Makaira ampla.

All are fishes of the high seas, widely distributed in the Pacific, but with different centers of abundance. Swordfish and striped marlin inhabit the more temperate waters, blue marlin the equatorial region, black marlin the coastal regions off Asia, America and Australia. Maximum weights of Pacific forms follow: swordfish - 1,061 pounds; shortnosed spearfish - 114; sailfish - 132; black marlin - 1,560; striped marlin - 483; blue marlin - 1,450. All are broadly carnivorous on fish and cephalopods. Blue marlin probably spawn throughout most of the year in equatorial waters.

Albacore survey of the North Pacific

This study involves 2 problems. The first problem is to investigate waters of the central Pacific from the eastern extent of the present Japanese fishery north of Midway, to about 140° W. longitude or about halfway to the American mainland. A study of oceanographical and biological data indicates this region may contain large populations of albacore as yet not subject to a fishery. The second problem is to investigate causes of the violent fluctuation in the albacore catch off the American coast and to relate tuna occurrence and distribution there with oceanographic features.

This program is being coordinated through the Pacific Marine Fisheries Commission, representing Washington, Oregon and California, to coordinate all fishery research on a coastwide basis.

Hydrography.--Two hydrographic cruises were completed, the first cruise - September to November (Charles H. Gilbert 17) of 49 stations to 45° N. between 160° W.

and 172° E. and the second cruise - January and February (Hugh M. Smith 27) of 72 stations to 40° N. between 160° W. and 170° E.

Hydrographic data collected in the area north of Hawaii during the winter of 1954 and preliminary analysis of hydrographic data taken during the fall of 1954 and winter of 1955 have revealed a region of considerable mixing, as indicated by increased inorganic phosphate, plankton and turbidity, and a sharp surface temperature drop lies well within the North Pacific Drift. Previously it had been thought to lie at the boundary between the North Equatorial Current and the North Pacific Current; however, subsequent analyses of the dynamic topography (geostrophic currents) and temperature salinity-relationships show it to be in the transition zone between the easterly flowing North Pacific and Aleutian currents. The zone of mixing undergoes considerable seasonal migration. For example, on 160° W. it was centered at 35° N. during February 1955 and at 45° N. during September 1954. The majority of albacore catches, by longlining on fishing cruises and trolling on hydrographic cruises, have been made in the vicinity of this zone.

Biology.--Initial albacore surveys have been completed. During the fall large numbers of small to medium-sized albacore were found between 160° W. longitude and 180°. They were at about 40° N. latitude and associated with the transition between the Sub-Arctic and North Pacific waters.

Winter surveys show significant numbers of albacore occur as far east as 160° W. longitude. In a zone lying between 30° and 37° N. latitude large albacore were consistently taken on longline gear though they were not found in sufficient quantities to support an American fishery. The observed abundance is not unexpected for the Japanese have experienced poor catches on their western North Pacific winter grounds during the past 2 years.

A May and June survey, in which POFI collaborated with the California Department of Fish and Game, covered the potential albacore habitat between the Pacific Coast and 180°. Although timed to intercept albacore as they moved into the West Coast fishing grounds, the survey found only a few scattered individuals which were taken along the southern edge of the area. This puzzling result indicates either the coast season will be late in getting under way, or POFI concepts of albacore migrations need major revision.

Relatively high plankton catches have been made in the region of the transition zone: these show a positive relationship with high values of nutrients in sea water and good fish catches, although it is too early to definitely say whether or not plankton itself is a good indicator of albacore-rich water.

Forage fishes which feed on plankton and upon which albacore seem to feed have also been studied. An improved mid-water trawl has been developed to quantitatively sample the amount of albacore food in water. The first look indicates large amounts of sauries in the transition zone where albacore are caught, which suggests tuna distribution may be related to saury distribution. Relationships between currents in the North Pacific, zooplankton or basic food, forage organisms and albacore will be investigated. A preliminary examination of stomach contents of a few albacore taken in the North Pacific show the importance of squid, sauries and other fish as food.

We want to know whether the albacore stock north of Hawaii is related to stocks being fished by the Japanese in the west and

the Americans to the east. Seventy-nine albacore have been tagged. Measurements have been taken of body proportions to compare fish taken in the central Pacific with those taken by commercial fishermen off the Asiatic and American continents. These means may reveal albacore migrations throughout the Pacific and ascertain relationships among various stocks. Means of initiating a Pacific-wide tagging program in the Japanese and American fisheries, as well as the region of the central Pacific north of Hawaii, are being explored.

Material is being collected for life history studies to determine where albacore spawn in the Pacific and whether albacore concentrations can be located through their reproductive habits.

SOUTH ATLANTIC FISHERY INVESTIGATIONS

W. W. Anderson, Brunswick, Georgia

General.--The South Atlantic Fishery Investigations, the Navy Hydrographic Office, the Office of Naval Research, the Georgia Game and Fish Commission are making a biological, chemical and physical oceanographic survey along the South Atlantic coast from Cape Hatteras, North Carolina to the Florida Straits. Waters from off the beaches to beyond the Gulf Stream are studied. The Navy Hydrographic Office and the Office of Naval Research cooperated on physical oceanography and related special studies; the Georgia Game and Fish Commission conducted biological and chemical studies. The Florida Board of Conservation (through the Marine Laboratory of the University of Miami) participated in this program until June 1954.

CRUISES

The last half of Cruise 7 (July), Cruise 8 (August-September) and Cruise 9 (November-December) were accomplished with the vessel Theodore N. Gill which was transferred in March 1955 to the Atlantic Herring Investigations, Boothbay Harbor, Maine. Completion of Cruise 9 ended 2 years of intensive field work over the network of stations from the Florida Straits to Cape Hatteras and from the beaches to beyond the axis of the Gulf Stream. This phase of the program has been halted and efforts are being concentrated on working over the data and material collected.

PRELIMINARY OBSERVATIONS FROM CHEMICAL, PHYSICAL AND BIOLOGICAL DATA OF THEODORE N. GILL CRUISES 1, 2 AND 3

Data have been processed for Cruises 1, 2 and 3 (representing winter, spring and summer) to an extent that comparisons are possible for these seasons. For comparisons, values for salinity, temperature and inorganic phosphates were chosen from physical and chemical data; from biological data values for wet volume of plankton, number of fish eggs and number of fish larvae per cubic meter of water were chosen.

The work area from the Florida Straits to Cape Hatteras is divided into southern, central and northern sections. Each section is subdivided into inner shelf, outer shelf and offshore. In general, the inner shelf area comprises those stations lying between the beach and a point about halfway from the shoreline to the 100-fathom line (mostly waters less than 10 fathoms deep); the outer shelf is the remaining area out to the 100-fathom line. The offshore designation comprises that part of the work area lying beyond the 100-fathom line.

Chemical and physical data presented are averages for each division of the area, either section or subsection. Averages represent all values to a depth of 75 meters (or less in shallower waters). This method was employed because the plankton samples represent oblique tows to a like depth.

Temperatures.--During winter there was a wide range of temperatures from inner-shelf waters increasing to offshore waters, the spread being about 8° with a range of about 14 to 22° C. During spring the spread from inner-shelf waters to offshore waters narrowed, being less than 4° with a range of 21 to 24.5° C. During summer there were no appreciable differences in any of the sections, the spread being less than 2° with a range of 26 to 28° C. However, during summer, coolest waters were on the outer shelf.

Salinities (parts per thousand).--In the southern section during winter salinities from inner-shelf to offshore waters ranged from 36.1 to 36.2; during spring 36.2 to 36.3 and during summer 35.9 to 36.1. In the central and northern sections salinities in the outer-shelf and offshore waters ranged during winter from 35.9 to 36.2, during spring 35.7 to 36.3, and during summer 35.8 to 36.0. Salinities in inner-shelf waters in the central and northern sections during winter were 34.6 to 34.7 but were lower than waters to the seaward. During spring the range in these 2 sections was 34.3 to 34.7. During summer, inner-shelf waters in these sections had values of 35.2 to 35.6.

Inorganic phosphates.--Inorganic phosphate values during winter and spring were highest in the southern section and lowest in the northern section, but in summer, the highest values were in the northern section and the lowest in the southern section. Values were lowest during spring and highest during summer.

Wet volumes of plankton (exclusive of fish eggs and larvae).--During winter and spring, outer-shelf waters had the highest volumes of plankton, followed by inner-shelf waters, which only slightly exceeded the offshore waters. However, the spread between volumes in outer-shelf waters and those in the inner-shelf and offshore waters is much narrower in spring. In summer, inner-shelf waters had the highest volumes, followed by outer-shelf waters; offshore waters had the lowest. Plankton volumes were lowest in the southern section in all seasons.

Fish eggs.--Numbers of eggs were higher during the spring in all parts of all sections than in comparable parts and sections during winter and summer, except for the southern section during the winter. During winter, numbers of eggs in the central and northern sections were very low.

Fish larvae.--Larvae were most abundant in summer. They were more numerous in continental-shelf water than in waters to seaward of the shelf. In offshore waters, they were more numerous than eggs.

ATLANTIC SALMON INVESTIGATIONS

Alden P. Stickney, Boothbay Harbor, Maine

In June 1954 the Clam Investigations of the Fish and Wildlife Service and 5 Investigations of the Maine Department of Sea and Shore Fisheries -- Herring, Marine Worm, Alewife, Smelt and Salmon -- began a research program on the ecology of Maine marine estuaries as related to salmon.

Observations since that date have indicated that the Sheepscot River exerts slight influence on salinity and temperature patterns of its lower estuary and surrounding coastal waters. Since the Kennebec-Androscoggin combination has the highest mean discharge (12,000 cfs) of any river on the Maine coast and since nearly all of it empties directly into the oceans, the seaward influence is relatively great.

Similar but less extensive observations have been made on the Narraguagus River for comparative purposes.

To learn more of salmon migration and survival, adult salmon taken in traps at Small Point, Maine, have been tagged and released. Captured marked fish and tag recoveries indicate salmon from Canada and the Penobscot River are at times included among those passing close to Small Point.

In May 1955 the Fish and Wildlife Service, the Maine Department of Sea and Shore Fisheries and the Maine Atlantic Sea Run Salmon Commission installed a counting weir about 3 miles above the Sheepscot mouth. The passage of only 1 salmon through the weir since its installation indicates few salmon have entered the river this year.

The 1955 salmon runs in all Maine rivers have been inferior to those of 1954. The unusually good 1954 run in the Sheepscot River may be attributed to favorable water temperatures during the entire summer of 1951 and to the generally high water conditions in the river during the summer of return migration.

MIDDLE ATLANTIC FISHERY INVESTIGATIONS

Gerald B. Talbot, Beaufort, North Carolina

SHAD INVESTIGATIONS

Data collected during the 1955 field work, which centered on the Edisto River, South Carolina, are being analyzed. Fishermen reported a poor season.

Where possible the study of streams previously investigated has been continued. These include the Connecticut, Hudson, Ogeechee and St. Johns Rivers and the Maryland portion of Chesapeake Bay. While data for 1954 on the Maryland portion of the Bay are unavailable, data on the other streams follow.

Connecticut River.--As calculated from catch and effort data furnished by Connecticut, the 1954 run totaled 191,000 shad (218,000 were predicted in 1953) and the catch 78,500. The fishing rate was 41%.

The experimental pressure lock at Holyoke Dam has been discontinued but 4,902 shad passed by an unfinished mechanical lift to above the dam.

Hudson River.--New Jersey and New York furnished catch and effort data. The 1954 run totaled 2,752,000 pounds (2,671,000 were predicted in 1953) and the catch 1,189,000. The fishing rate was 43%.

Ogeechee River, Georgia.--The Service's data for 1954 showed a run of 35,508 shad. The catch totaled 23,501 shad, including the sport fishery, and the fishing rate was 66%.

St. Johns River, Florida.--The Service's data for 1954 showed a run of 948,000 pounds. The catch totaled 360,000 pounds and the fishing rate was 38%.

STRIPED BASS

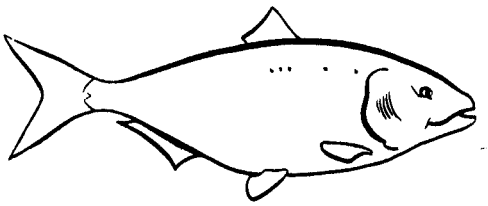
The Atlantic States Cooperative Striped Bass Program continues to progress. Massachusetts, New York, Maryland, South Carolina and Florida are engaging in striped bass research while personnel shortage has delayed participation by Rhode Island and Connecticut. North Carolina is beginning a project and Virginia will continue to cooperate within limits of her capabilities.

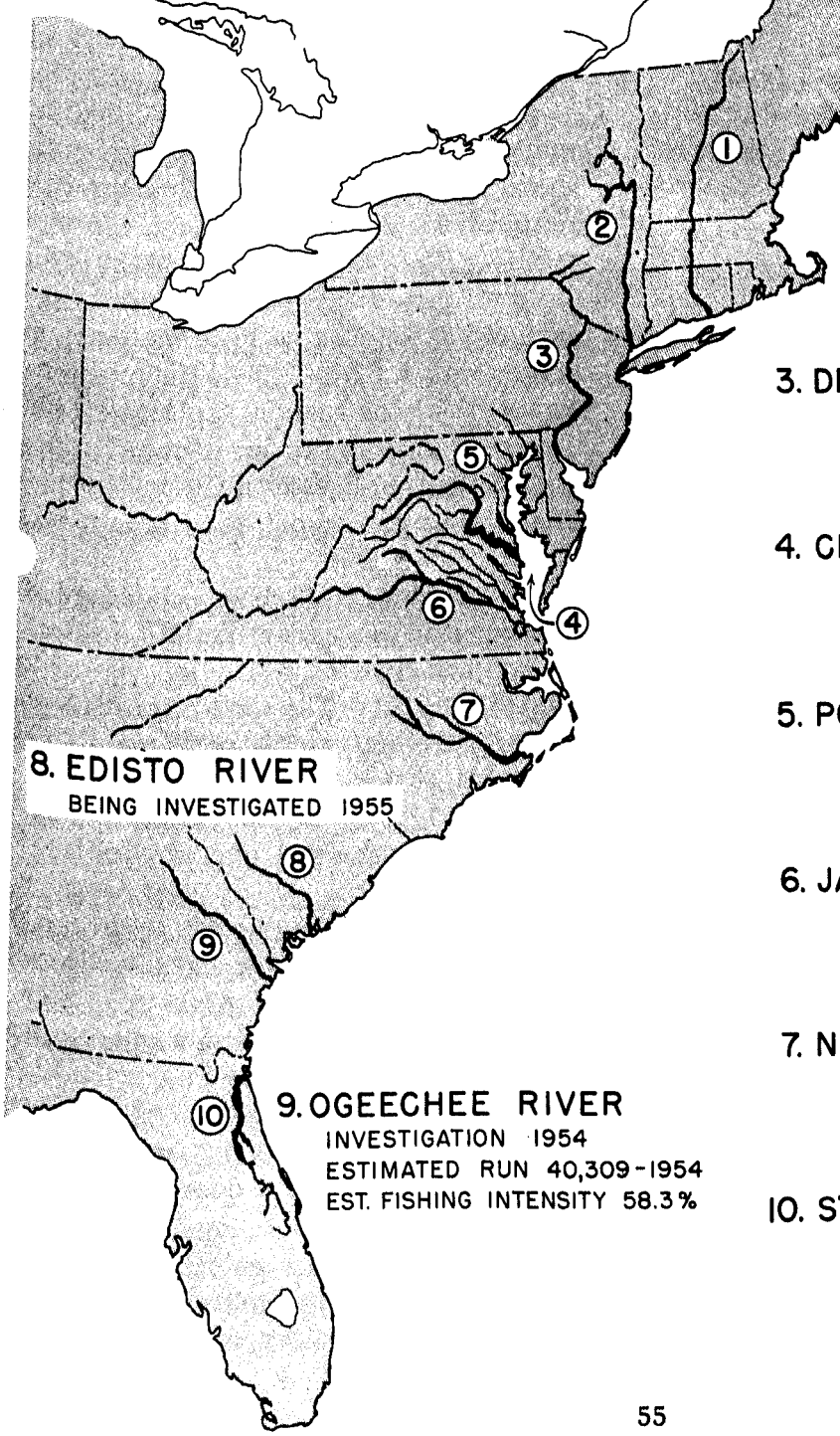
South Carolina has completed a paper, "A migration study of the Cooper River population of striped bass, Roccus saxatilis Walbaum," by George D. Scruggs, Jr., which presents findings to date.

This laboratory again participated in a cooperative study of the Roanoke River in relation to water releases at Kerr Dam as they affect striped bass. High water during the 1955 striped bass season bettered the river pollution situation. All cooperating agencies believe the Roanoke River striped bass situation deserves more attention than the "panic projects" instituted each March for the past 3 years. A comprehensive program involving several agencies, including the Fish and Wildlife Service, is being organized and is expected to get under way this fall.

Vessel FWS 1227 was operated on the Hudson River during May and June in a cooperative study of spawning areas with New York State.

SHAD INVESTIGATION





1. CONNECTICUT RIVER
INVESTIGATION 1951
ESTIMATED RUN 191,478-1954
EST. FISHING INTENSITY 41.0%

2. HUDSON RIVER
INVESTIGATION 1950-1951
ESTIMATED RUN 775,875-1954
EST. FISHING INTENSITY 43.2%

3. DELAWARE RIVER
INVESTIGATION 1950
HEAVY POLLUTED
MINOR RUN ONLY

4. CHESAPEAKE BAY
INVESTIGATION 1952
ESTIMATED RUN, Md. only 835,484-1954
EST. FISHING INTENSITY, Md. only 51.0%

5. POTOMAC RIVER
INVESTIGATION 1952
ESTIMATED RUN 490,345-1954
EST. FISHING INTENSITY 58.0%

6. JAMES RIVER, VIRGINIA
INVESTIGATION 1952
ESTIMATED RUN 454,487-1954
EST. FISHING INTENSITY 72.9%

7. NEUSE RIVER
INVESTIGATION 1953
ESTIMATED RUN 146,287-1954
EST. FISHING INTENSITY 67.1%

8. EDISTO RIVER
BEING INVESTIGATED 1955

9. OGEECHEE RIVER
INVESTIGATION 1954
ESTIMATED RUN 40,309-1954
EST. FISHING INTENSITY 58.3%

10. ST. JOHNS RIVER
INVESTIGATION 1952, 1953
ESTIMATED RUN 326,724-1954
EST. FISHING INTENSITY 38.0%

PACIFIC SALMON INVESTIGATIONS

Clinton E. Atkinson, Seattle, Washington

Pink salmon in Southeastern Alaska.--Fishing effort curtailment in Southeastern Alaska during the 1954 season resulted in increased escapements, exceeded in recent years only by those of 1951 and 1949. Early closure afforded excellent protection to "late" runs; as a result, "late" run escapements were fair to good in all districts. "Early" run escapements were good in the central districts, poor in Tenakee and the Southern district. No major changes in regulations were proposed for the 1955 season.

Twenty-one strays were accounted for at Sashin Creek, now held as a barren stream in even years to measure the extent of pink salmon straying. While the number of strays was negligible in 1954, as in 1952 (45), this small nucleus may prove sufficient to re-establish a normal run in a few successful generations.

Cold, wet spring weather resulted in a delayed downstream migration of pink salmon fry in Southeastern Alaska. Freshwater survival rates were fair--better in early streams than in late ones. Fry migration estimates were obtained at 5 counting stations by releasing marked fry above the traps and relating proportions of marked to unmarked fry recovered. Snake Creek traps take approximately 0.5% of the total migration while Hood Bay traps take about 3.0%. Studies of vertical distribution of migrating fry showed a slight and variable tendency to concentrate 6 to 12 inches above the stream bottom in deep and shallow areas.

Fishing in the Icy Strait, Western and Eastern districts opened June 24. The vessels Heron and Sablefish visited all commercial fish traps to inaugurate the annual census of pink salmon fingerlings. This program will expand to other districts as traps are installed until all 115 traps are contributing to the program. Schools numbering up to 2,000 pink salmon fingerlings ranging up to 2-1/2" in length were in several traps. Few specimens of other salmon species were noted and no identification problems have developed.

Red salmon--Cook Inlet.--Preliminary analysis of 1954 red salmon tagging in offshore waters of Cook Inlet indicated 28% commercial recovery of the 1,473 individuals tagged. The drift gill net took 30.4% of the total recovery, set net 43.4; trap 23.3, unknown 2.9. The ratio of males to females tagged was 1.02 to 1.00. Recovery ratio was 1.07 males to 1.00 females. Principal recovery areas in order of their importance were Salamato Beach, Kalifonski Beach, East Kalgin Island drift and Kalgin Island.

Red salmon--Kodiak.--In early May, 4 migrant traps were installed in Karluk weir. The first migration of seaward reds was on May 22. The next migration occurred during the evening of May 26 and thereafter heavy migrations took place every few days up to late June. The migration was later and much larger than that of last year.

Several batches of tattoo-marked fish were released at Karluk Lake outlet to determine the percentage of migration taken in 4 migrant traps. Preliminary results indicate approximately 15% of the migration is being sampled. By installing and operating traps in the same manner each year, a reliable index of the size of the downstream migration will be obtained.

The red salmon spring escapement to Karluk, Red River and Alitak is considerably below the average for the past 5 years in these areas.

Bare Lake was fertilized on June 10 and as in the past, this fertilization has had a profound effect. Downstream migration of reds totaled 14, 735 as of June 28, the largest migration recorded. Again this year, migrants are longer and heavier than those of past years.

A considerable number of dolly varden were tagged or marked, depending upon size of the fish, to measure changes in the population level and to study their growth and movement. Stickleback eggs are being fertilized artificially and incubated to learn more of their life history in this environment.

A jug experiment is being conducted to assess the effect of adding Haas and Reed's original "A-Z" trace element solution on the rate of photosynthesis and phytoplankton production. Preliminary results indicate a dilution of 1 part "A-Z" solution to 1, 000 parts H_2O makes a noteworthy increase in the rate of photosynthesis over control.

Red salmon-International North Pacific.--The field program for racial sampling of North Pacific salmons in 1955 was organized, men were recruited, equipment was obtained and instructions were written. Crews were active at Bristol Bay, Kodiak Island, Alaska Peninsula, Northern Bering Sea, Cook Inlet, Southeastern Alaska and British Columbia. Additional work is commencing along the Aleutian Island chain and at Columbia River.

Racial data are being obtained from 3 Japanese fleets in the North Pacific high seas fishery and from 1 fleet in the Okhotsk sea fishery. The vessel John N. Cobb is collecting racial samples from Gulf of Alaska waters.

While American biologists were in Japan, they made arrangements to obtain detailed salmon catch statistics from all fishing companies operating motherships in the North Pacific Ocean. Arrangements were made to obtain racial data on salmon indigenous to Hokkaido through use of sampling methods similar to those used in the United States.

King crab--Alaska.--Over 100 experimental king crab pots, complete with floats and cobweb-like radar reflectors and spaced in a grid pattern, are being fished in the Bering Sea to determine their abundance and migration. Some crabs tagged last season have been recovered.

Herring--Alaska.--Aerial surveys of herring spawning activities made in the spring of 1955 recorded 63 miles of spawning beaches. The most significant change was recorded in the Sitka area--15.6 miles of spawning beach this year as compared to 7.5 miles in 1954.

Salmon trollers from Sitka have again requested closure of the herring reduction fishery and a meeting was held in Sitka on June 24, 1955 to hear complaints. No closure or additional restriction was imposed. The catch per unit of effort exceeds that of the 1954 season. Three plants and 6 boats are operating in Southeastern Alaska. Several boats of the fleet contemplate fishing beyond the 3-mile limit during the period of July 2 to July 20. Age composition comparison of the 1954 and 1955 season follows:

Year class	1954 (complete)	Age	1955 (to July 3)	Age
1953	0%	2	26%	3
1952	1%	3	6%	4
1951	43%	4	34%	5
1950	19%	5	15%	6
1949	6%	6	3%	7
1948	18%	7	10%	8
1947	9%	8	4%	9
1946	1%	9	1%	10
1945	2%	10	1%	11
1944	1%	11	0%	12

Two plants are operating in Prince William Sound, 8 boats are fishing and have caught approximately 40,000 barrels of herring.

Age analysis--all species.--Feeding experiments are under way to check scale growth and retention of trace elements in young salmonids. In fish fed bismuth compounds, bismuth was detected in scales and body when tested some time after suspension of the bismuth food. Manganese and strontium, also tested, proved unsatisfactory since all fish checked showed the presence of these elements. Cobalt failed to deposit in scales or bones in identifiable quantities. Scale growth has been followed for over 2 years and photographed in chinooks growing in the University of Washington salt water tanks.

Electrical fish guiding (laboratory).--The most effective guiding combination of pulse frequency and pulse duration with the sequentially energized single-row array was found in the duty cycle range between 0.06 to 0.10. Mortalities occur when the duty cycle is greater than 0.10. Experiments have demonstrated that polarity of field is not important to the guiding effectiveness of the single-row array. Electrical guiding experiments are in progress with silver salmon fry and fingerlings outlining the relationship between fish size, water velocity and guiding effectiveness.

Laboratory studies using infra-red radiation reveal that salmon fingerlings do not react to it. Present studies of fish behavior in the dark are being conducted, using infra-red viewing equipment borrowed from the Navy.

Electrical fish guiding (field).--Experimental electrical guiding studies were carried out at Jenkins Creek and Icicle Creek using single, bizonal and sequentially fired single row arrays created by vertically suspended aluminum tubing electrodes. A horizontal array, made of horizontal ribbons of aluminum, as well as a "Burkey type" of installation, was tried. The Jenkins Creek arrays operated in about 2-1/2 feet of water and were about 65 feet long. Icicle Creek arrays were 6 feet deep and about 220 feet long. Ninety experimental procedures and 10 controls involving a total of about 167,000 sockeye, coho and chinook salmon fingerlings were carried out, using square wave pulses of direct current, continuous direct current, and 60 cycle alternating current.

The most successful installations guided from 85% to 94% of the fingerlings. None of the installations was effective for fry.

Electrical fields killed 4,082 salmon fingerlings and fry or about 2.4% of the fish counted.

Squawfish predator control.--Two field sites on the lower Columbia River have been searched for locations of an experimental array for electrical control of squawfish predation.

Effect of electricity on fish reproductive ability.--Results of a 2-year examination of rainbow trout exposed to electric shock as yearlings indicate no harmful effect on either their reproductive ability or growth.

Fish tracking.--Two types of electronic gear are used to track or follow fish as they approach dams and proceed through water-use projects. The automatic system uses a tiny transistorized signal transmitting device attached to the adult salmon. A receiver in a boat picks up the signals. The other type is a sea scanar emitting underwater sound waves converted into radarscope visual signals. These units may be installed in a boat or ashore.

The automatic tracker operates successfully in both turbulent and quiet water. Sea scanars are successful only in quiet water which is free of occluded air. However, at Bonneville Dam, during the spring chinook migration, sea scanars were used to follow adult fish. During the day, fish believed to be salmon were observed at depths of 6 to 15 feet below the surface. At night, all fish were located in a sharply marked zone within 10 feet of the surface.

The Washington State Department of Fisheries, International Pacific Salmon Fisheries Commission and the Service observed distribution of fingerling schools with short-range sea scanar in the forebay of Baker Dam. Schools were observed to a depth of 60 feet but the majority were within 50 feet of the surface. Individual schools under constant observation did not appear to pass through an experimental electrical guiding array when electrodes were energized.

Development of electronic tools.--A single pulse generator for field electrical guiding and a generator control unit and overload relay assembly were completed. An automatic overload and reset was installed on field gear and overload protection was put on laboratory electrical guiding gear. A high power sequential pulse unit was constructed for field use and will be in operation soon.

Development of infra-red viewers and infra-red television and direct-reading current meters is in progress.

Telemetering of Columbia River data radar-beam tracking of drift bottles, location of buoys or set lines and electronic tag detectors are planned.

Fish counter (electronic).--Development of new sizes and types of electrodes and new tunnels is progressing. Transistorization of the small counter is also making headway.

A device for detecting fish passage through a weir has been devised for testing at Bonneville.

Columbia River 1954 catch summary.--An estimated 15,083,895 pounds of salmon and steelhead trout caught on the Pacific coast originated in the Columbia River; 7,702,895 pounds of which were caught inside the Columbia River.

King salmon, Mill Creek Station, California.--An effort is being made to determine by various stream measurements what causes the survival pattern of salmon eggs planted in a stream section. It is concluded that position on the riffle and stream flow velocity were the two chief factors influencing survival differences.

The use of the "Vibert" hatching box as a research tool has been investigated.

This device attempts to reduce mortality of spawn by eliminating the grinding effect, if any, of stream gravel. Nevertheless, survival is similar for eggs in the boxes to that in plastic sacks, until the last stages of development before hatching when plastic sacks prove superior.

A summary of the first year's results from king salmon spawning pens at Mill Creek has been submitted. A total of 8,382 fry were counted out of the 3 pens, representing survival rates of 14.5%, 4.9% and 6.9% of estimated eggs in spawners, and 16.0%, 6.0% and 15.6% of estimated eggs spawned.

The survival of salmon eggs has been measured in three situations: (1) buried in natural streambed, (2) buried in controlled flow section, and (3) in hatchery troughs. Analysis of the results indicates that freshets and sedimentation caused by freshets remain the major sources of egg mortality.

Salmon seaward migration - Bonneville.--Inclined plane fingerling traps took about twice as many chinook yearlings as in previous years of trapping; this may have been due to greater percentage of flow strained by the traps.

Fingerlings are now anaesthetized before measurements and scales are taken and are later returned to the river.

More than 1,000 tatooed fingerlings from Washington State Department of Fisheries-McNary Dam fingerling mortality tests were recovered in Bonneville traps and data essential to tests were obtained.

Effect of Bonneville turbine and draft tubes on salmon fingerlings.-- 18,324 chinook fingerlings, tattooed for positive identification, were divided into 4 lots and passed through turbine No. 2. Two lots (controls) were anaesthetized to simulate dead fish. Recoveries of non-anaesthetized fish were more than 2-1/2 times as great as those of anaesthetized fish, indicating probability of selective fishing.

Rock Island Dam, efficiency of fishways.--Intensive fishing by Indians and commercial fishermen below McNary Dam reduced Rock Island spring chinook escapement to about 4,000 during June. The few chinook and steelhead tagged were taken in a trap floating in the forebay ahead of the left bank fishway.

Effects of sound on young salmon.--Contractual work with sound has terminated and the manuscript is nearing completion. No positive response of fingerling salmon to sound was demonstrated.

Estimating mortality of adult salmon, Bonneville Dam, FWS Contract #14-19-008-2234.--Low water and lack of spill at Bonneville Dam during spring chinook run prevented occurrence of an observable mortality. A new contract was requested for continuation of work by Oregon Fish Commission.

Columbia River water quality and effect on fisheries, FWS Contract #14-19-008-2220-University of Washington.--Collection and processing of water quality data from 25 stations on the Columbia River system was resumed.

Experiments to develop serological methods for detecting specific strains of Chonodrococcus columnaris are continuing. Four new antisera are being employed. A new contract is anticipated.

Literature research.--A special bibliography, including photostats and abstracts of references, was prepared for the Administrator, Alaska Commercial Fisheries, on

effects of logging and silt on salmon and salmon streams. Services to staff biologists included furnishing specialized bibliographies and publications needed for reference.

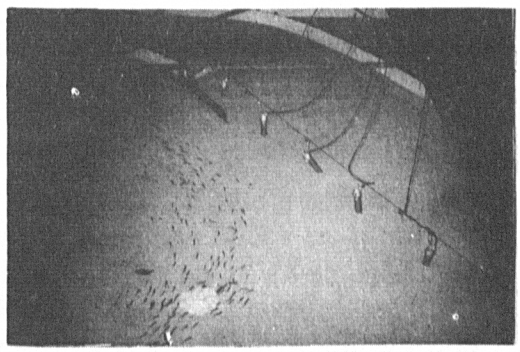
Bibliographic card files were kept current by adding new references. The librarian brought the task of reorganizing and cataloging the library to 40% completion.

Problem: In Pacific Coast salmon streams huge power dams are being built, blocking the migrations of salmon and trout. Fishways can be constructed for the ascent of adult fish, but their progeny must also be protected in returning to the sea. This can be accomplished by guiding the young fish into safe passageways provided for them.

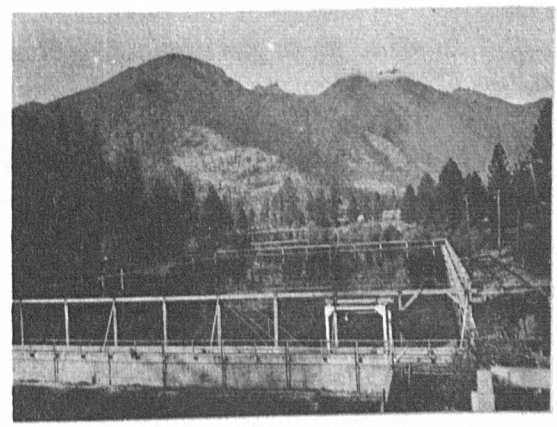
Procedures: Since it was known that fish will respond to an electrical current passing through the water, laboratory experiments were carried out to determine the basic data on reactions of young salmon to electricity. Many different combinations of voltages, pulse-rates, pulse-durations, electrode arrays, electrode spacings, etc. were tried. Using the resulting data, "pilot-model" fish guiding devices were constructed.

Results: Laboratory experiments showed that young salmon could be successfully guided, under the proper conditions. Devices incorporating these conditions were applied at field installations on salmon streams. Two of these installations have been constructed to date; at one of these from 55 to 91 percent of the migrating salmon were guided to the desired side, at the other from 52 to 94 percent. These devices are currently being improved for actual application at power dams.

ELECTRICAL FISH GUIDING



GUIDING YOUNG SALMON IN LABORATORY TANK



A FIELD-SCALE TEST INSTALLATION IN A SALMON STREAM

SHELLFISH LABORATORIES

I. WOODS HOLE SHELLFISH LABORATORY

Paul S. Galtsoff, Woods Hole, Massachusetts

Information regarding the life history, ecology and cultivation of oysters in the United States is scattered in thousands of papers, a great amount of which is found in obscure and not easily available publications. In addition, many observations on oysters and oyster bottoms made during the last 25 years by the Fish and Wildlife Service and various state organizations remain unpublished or have not been analyzed. Old and new data are being carefully evaluated, classified and brought together in the form of a comprehensive manual which may serve as a guide and reference book for research investigators, state officials responsible for management of oyster resources in their respective states, and private oyster growers.

During April, May and June 1955, the work consisted primarily of histological studies of oyster tissues and organs which disclosed these new facts:

1. Detailed structure of the periostracum gland of the mantle, an organ secreting conchiolin--the organic matrix of shell.

2. Structure of subligamental ridge--an organ secreting the ligament.

3. Distribution of alkaline phosphatase--an enzyme involved in shell calcification. This study was made by applying modified Gomori's technique for localizing the enzyme in the mantle. Results were highly satisfactory.

Attention was paid also to localization of fat in connective tissues and various organs of the oyster. By developing a simplified technique for making frozen sections of fresh tissues, large amounts of fat globules in connective tissue cells and ovocytes could be demonstrated. Illustrations made of sections of dehydrated and paraffin embedded material are misleading; they usually show connective tissue cells as vacuolized, empty structures while under natural conditions these cells are overfilled with oil globules and glycogen particles. Undoubtedly, cell lipids play an important role in growth of ovocytes for oil globules are found in the latter during their development and growth. Further exploration of fat distribution in other organs is being continued.

Histological studies were completed on distribution of peripheral nerves and especially innervation of tentacles which are the principal sensory organs of the oyster.

An interesting relationship has been discovered between pallial muscles and nerves; in many instances the latter were found completely surrounded by muscle fibers.

The ligament of the oyster, a non-living elastic band which connects the valves at the hinge, was found to be a complex structure resembling a system of arches and coils which expand and push the valves apart when the adductor muscle is relaxed. The ligament consists of a scleroprotein secreted by the epithelium of the subligamental ridge. Arches probably correspond to growth rings of the ligament and at the same time represent lines of stresses in the elastic material. The "coils" oriented

at about a 45° angle to the arches have distinct fibrillar structures. The complexity of the microscopic structure of the ligament justified an exploration by means of the electron microscope. Despite difficulties in sectioning hard and brittle material of the ligament, sections not exceeding 0.2 micron in thickness were obtained. Ultra microscopic structure of the material treated with osnium tetraoxide shows the presence of tightly packed fibrillae varying from 400 to 500 Ang. in diameter. So far only transverse sections have been made and ligament investigations are being continued. Understanding structure and function of the ligament is important for correct interpretation of experimental observations dealing with oyster behavior under normal and altered conditions since such observations are based on recording time and degree of opening of valves.

Experimental work, interrupted in the fall of 1954 because of damages to the salt-water system by two September hurricanes, was resumed in December. Data show shell growth does not cease with age, but continues even in large specimens probably more than 20 years old. Irritation caused by foreign material inserted between the mantle and the shell may stimulate shell deposition even at temperatures ranging from -0.5° to 3° C. Rate of shell deposition increases with temperature rise.

Experiments on drills consisted primarily of studying their orientation and movement in the presence of seed and adult oysters. Preference of adult drills for seed oysters can be demonstrated only in case there is a water current running from the oysters toward the drills. Drills rarely move directly toward the food source. In the majority of cases the movement is irregular, suggesting a scanning or searching by the snail. There is no evidence that crawling is a "forced movement" in a sense of Jock Loeb's theory of tropisms. Tentacles and eyes are not involved in ability of drills to locate food. Drills with tentacles cut off behaved in the same manner as control specimens. A study is being made to determine effects of external metabolites of oysters on drills' movements.

II. MILFORD LABORATORY

Victor L. Loosanoff, Milford, Connecticut

Long Island Sound oyster spawning and setting.--During the summer of 1954 observations on oyster spawning and setting were conducted. Bulletins informed the industry and interested biologists of setting progress. In general, the 1954 setting was a failure.

In cooperation with several oyster companies, the laboratory made daily observations on intensity of setting to determine when to plant shells. Since the setting never reached sufficient intensity to be of commercial magnitude, the companies planted no shells.

Studies were continued on the existence of physiologically different races of oysters, proving definitely that oysters far removed from Milford, Connecticut, differ, at least

in some respects, from the oysters in that area. Since the former are usually unable to spawn under local conditions, planting them in Long Island Sound will not contribute to increased production of set and the practice, in general, is unwise. Extensive statistical analysis of influences of different environmental factors upon spawning and setting of oysters in Long Island Sound is almost completed; the material is being prepared for publication.

Studies of several aspects of spawning and egg production of oysters and clams, Venus mercenaria, were undertaken. The number of eggs released by individual female oysters ranged from 10,000 to 66.4 million. The highest number released by any female at a single spawning was 48.8 million. This single heavy release exceeded the seasonal total egg discharge of all but 7 of the 43 females in the experiment. There was no significant difference in the average number of eggs released whether the females were spawned at 3-, 5- or 7-day intervals. The average number of spawnings per female did, however, decrease progressively as the length of time between spawnings increased.

The total number of eggs produced showed a correlation of .54 (significant at .01 level) with the size of the female, as indicated by shell cavity volume. There was also a correlation of .51 (significant at .01 level) between the number of eggs released and the number of spawnings, i.e., females with a great number of eggs to release spawned more frequently than those with fewer eggs.

The total number of eggs released by individual female clams ranged from 8 million to 39.5 million. The highest number released by any female at a single spawning was 24.3 million. The correlation between number of eggs and shell cavity volume was .38 (significant at .05 level).

Requirements of oyster larvae and cultivation of lamellibranchs other than Crassostrea virginica.--Development of methods of cultivation of lamellibranch larvae and studies of their physiological and ecological requirements were continued. Larvae of Teredo navalis, Pecten irradians and Arca transversa were grown through metamorphosis and their length-width relationship ascertained. In studying the physiological requirements of larvae, addition to sea water of vitamins, such as riboflavin alone or in combination with calcium pantothenate, pyridoxine hydrochloride and thiamine hydrochloride, usually increased the growth rate of larvae of Crassostrea virginica and Ostrea lurida, but not larvae of the clam, Venus mercenaria.

Streptomycin and aureomycin slightly increased rate of growth and survival of clam larvae when given in certain concentrations. Both antibiotics reduced the growth rate of clam larvae if used in too high a concentration; aureomycin caused complete mortality of these larvae when given at the rate of 320 p.p.m. Commercial terramycin and an unpurified fungicidal antibiotic, malucidin, showed only growth-reducing and lethal effects. Sulfamerazine, sulfathiazole and sulfanilamide, at the concentrations tested, similarly reduced the rate of growth and survival of clam larvae.

Groups of young clams and oysters were grown for selection of the fastest and slowest growing individuals. These will be crossed to isolate fast-growing and slow-growing races of clams and oysters. Several crosses of clams, such as Venus mercenaria x V. notata, V. notata x V. campechiensis, were developed. Similar experiments confined to genetics and aimed at developing fast-growing and fatter races of commercial mollusks are in progress. Effects of various salinities on growth and mortality of young

clams were studied to determine optimum growth conditions for clams.

Enemies and diseases.--Screening of chemical compounds to find attractors, repellants or poisons for oyster enemies, especially drills, was resumed. Extensive studies were started on the physiology of two species of common drills populating Long Island Sound to find the weak link in their natural history and physiology through which they can be controlled. Field studies were conducted on occurrence in Long Island Sound of adult drills of Urosalpinx cinerea and Eupleura caudata, and of their egg deposition.

III. BEAUFORT LABORATORY (SPECIAL SHELLFISH INVESTIGATIONS)

Walter A. Chipman, Beaufort, North Carolina

Shellfish foods and feeding.--Further observations on filtering activities of oysters and hard shell clams confirmed previous findings that changes in filtration rate were related to changes in efficiency of the gills as filtering organs as well as to changes in amount of water passed through the gills. In general, retention by the gills was better for plankton species of large size than for those of small size. Feeding experiments in which oysters were placed in suspensions containing 2 different species of phytoplankton labeled with different radioisotopes showed, in some instances, a species of large size would be accepted and that of a smaller size rejected. Selectivity was observed also when 2 species in the suspension were nearly identical in size and in other characteristics.

Metabolism of fission products in marine plankton.--Accumulation of strontium$^{89-90}$ and yttrium^{90} in marine plankton was investigated further. A species of Carteria was the only one of 9 species of algae studied which took up appreciable amounts of strontium. Concentrations reached depended on conditions of growth and cell multiplication. All species readily took up yttrium. Loss of contained radioactivity from these radioisotopes was demonstrated as being slight when the cells were washed with non-radioactive sea water medium. Exchange of strontium between the cells and medium was observed when strontium of the medium was chelated.

No great accumulation of cesium by phytoplankton occurred when this element was added to the culture medium in which cells were grown, the ratio of cesium^{137} in the cells to that in the water at equilibrium being only slightly greater than 1. Cesium^{137} within Nannochloris cells was not removed in measurable amounts by washing the cells or resuspending them in a new medium. When killed by various agents, however, they lost their radioactivity.

Unlike strontium and cesium, ruthenium may be present in sea water environments following an atomic bomb detonation almost entirely as particles. These may vary in size and many are likely to be extremely small. Ruthenium trichloride, with ruthenium^{106} was coprecipitated from acid solution with calcium carbonate and suspensions of this material used to measure the uptake of ruthenium^{106} by marine organisms. Phytoplankton present in water containing

particulate ruthenium^{106} may become coated with this material and thus carry the isotope to filter feeding forms. However, filter feeding animals efficiently remove non-living particles from sea water.

As filter-feeding forms which may represent the many food organisms for higher animals, Artemia nauplii larvae and Arbacia plutei larvae were used to investigate the uptake of ruthenium^{106} from sea water suspension. These larvae rapidly filtered particles from sea water and became radioactive from the uptake of ruthenium^{106}, but soon lost their radioactivity when placed in normal sea water.

Metabolism of fission products in shellfish.--Previous work has shown the uptake of radioactivity by oysters in sea water containing radioactive strontium. Increased dosage would result if plankton serving as food for the oyster concentrated radioactive strontium. A series of observations comparing the uptake of radioactivity by oysters when immersed in sea water containing strontium^{89} and fed Carteria cells containing this isotope were made. The increased radioactivity thus attained was striking and emphasizes the importance of radioactive particulate matter in the sea in the uptake of radioactivity through food chain relationships.

Oysters, clams and scallops took up cesium^{137} when it was added to the sea water in which they were immersed. The uptake of cesium by oysters depended on external sea water concentrations of this element. A small continued uptake followed the rapid initial uptake. In scallops, cesium^{137} soon reached an apparent steady state condition in organs and tissues. In the adductor muscle, however, the uptake was less rapid but long continued. In time the muscle tissue exceeded the other tissues in radioactivity. Blue crabs showed the same pattern of uptake as the scallops when the radioactive cesium was taken up from the digestive tract. Measurement of the biological half life of cesium^{137} in the blue crab, the oyster and hard shell clam emphasized the fact that loss of cesium^{137} is not semilogarithmic with time. A large portion of the original activity remains for long periods of time in the bodies of these marine animals, the isotope being concentrated chiefly in muscle tissue.

Filter-feeding oysters and scallops rapidly removed ruthenium^{106} in sea water suspensions containing this isotope. High radioactivity appeared in the digestive tract but little uptake took place from the fed material.

Larvae of Palaemonetes failed to accumulate ruthenium^{106} in their tissues when this isotope was ingested as particles or taken into the digestive tract from feeding on Artemia larvae containing the isotope. Blue crabs were given the isotope in pieces of gelatin placed in the stomach. Only the digestive tract and organs directly connected with the tract became radioactive from the administered ruthenium^{106}.

Accumulation of fission products by marine fishes.--Measurements of the passage of strontium^{89}, cesium^{137} and ruthenium^{106} through the skin of little tuna show penetration and diffusion of these isotopes with rapid passage of cesium^{137} into the muscles and slow movement of ruthenium^{106} into the fish body.

The uptake of ruthenium^{106} by menhaden through filtration of particles showed an accumulation of radioactivity in the digestive tract only. The amounts taken into the tissues were extremely small. Similar results were obtained by feeding this isotope to croakers and bluefish. The small amount of ruthenium taken from the digestive tract was accumulated in the liver.

Gelatin pieces containing cesium^{137} were rapidly broken down in the stomachs of croakers, king whiting and bluefish with rapid uptake of the isotope by various internal organs. Highest concentrations reached in the first six hours were in the liver, kidney and heart; radioactivity was rapidly lost from these organs. The spleen increased in radioactivity following the peak of radioactivity of the liver, kidney and heart and then slowly decreased in radioactivity. Muscle tissue initially was low in cesium^{137} but slowly accumulated the isotope and finally exceeded concentrations of the internal organs. This tissue accounts for 80% of the total weight of fish.

The biological half life of cesium 137 in tissues of croakers was followed over many days with the fish held in normal sea water. Radioactivity loss did not proceed semilogarithmically with time. Radioactivity decrease gradually slowed with substantial amounts remaining for long periods of time.

IV. PENSACOLA LABORATORY (GULF OYSTER INVESTIGATIONS)

Philip A. Butler, Pensacola, Florida

OYSTERS

In seven years' observations of the reproductive cycle of the oyster at Pensacola, each season has shown some distinctive feature. Spat were found in March 1955 which was six weeks earlier than in any previous year; however, in the midsummer of 1955 setting had virtually stopped. Oysters are filled with gonad material, and a second peak of spawning is expected when water temperatures decline from mid-season highs.

Although average salinities are not above normal, spat of non-commercial oysters continue to increase in number from year to year. They seriously compete for space with the commercial oyster.

A comprehensive report is in progress on the setting behavior of oysters in the Pensacola area during the past five years.

Repeated measurements on the growth of hard clams, Venus, transplanted from the Milford, Connecticut laboratory to Pensacola in 1954, showed surprisingly low rates. One cause of this condition was the plastic window screen cloth which covered the trays; apparently the holes of this screen clogged and acted as a filter, keeping food away from the clams. In a 30-day test, 100 clams transferred to a larger mesh tray gained an average of 3 mm. in diameter more than a control group retained in a plastic tray.

SALTONSTALL PROGRAM

Local environment as it affects oysters.--In May, the Oceanographic Department of the Texas A. & M. College completed, under contract, a comprehensive survey of water currents around the laboratory island. Analysis of these data has not been submitted to

the Pensacola laboratory, but it is expected to show the degree of tidal flushing, the magnitude and direction of local water currents. With this information, sampling stations can be established and investigations continued to determine whether water-borne factors are responsible for the quality of oysters grown on the east side of the island being better than those of the oysters grown on the west side of the island. Quantitative differences in the several plant pigments which can be isolated from the plankton at the 2 locations will be determined first. Such differences, if they exist, should indicate the amount of food available to oysters.

The laboratory's working hypothesis is that water currents are responsible for local concentrations of oyster food and that by duplicating conditions that cause such food concentrations more suitable conditions for oyster culture can be created.

Investigation of oyster drill, Thais.--Investigations of the biology of this predator have been continued. A survey of its economic importance along the Gulf Coast will be conducted.

Ecological relationships of the oyster community.--The laboratory phase of this program will cover the biology of the parasites of the boring clam and the drill to determine their possible use as biological controls. The field investigations will consist of a 2-year study of the biota on 2 commercial oyster reefs, one in a high salinity area and the other in a low one. This study will evaluate the role of different members of the oyster community as it affects oyster production.

CHESAPEAKE BAY SHELLFISH INVESTIGATIONS

James B. Engle, Annapolis, Maryland

Chesapeake Bay oyster spawning and setting.--Oyster setting in the summer of 1954 was commercially successful in Eastern Bay but again a failure on the bars of upper Chesapeake Bay proper. The following table illustrates and compares for several years the Eastern Bay condition:

Station	Spat catch per bushel of test shells		
Eastern Bay	1954	1953	1952
Millhill	10,750	675	377,350
Bodkin Rock	49,350	1,350	74,775
Long Point	79,850	1,525	22,800

These figures represent the optimum setting on clean test shells. If there had been no loss, the 1952 and 1954 sets would be excessive and the 1953 set would produce one of commercial magnitude. However, the set surviving on planted shells until the following setting is a better criterion for determining setting success for commercial use as seed.

The following table shows this: All counts are low but 1954 setting in the

Station Eastern Bay	Set on planted cultch surviving to October 1954	1953	1952
Millhill	510	60	1,300
Bodkin Rock	725	50	___

Setting extremes shown in the above 2 tables demonstrate the great difference between the optimum or setting potential established on clean test shells and what set is actually available from cultch broadcast in spring and early summer. Cultch planted by the State of Maryland is not always planted at the best time to present clean shell to maturing oyster larvae. Some indication of the importance of clean cultch planted at the right time can be seen in results of the following observations: (1) clean cultch was put in shell bags and planted when larval counts of oysters in the plankton showed a large number about to metamorphose; (2) at the same time cultch taken from old shells on the bottom was put in another shell bag. Both bags were placed close together and left on the bottom throughout the setting season. The following table shows setting differences:

Year	Millhill set per bushel	
	Clean shells	Old shells
1954	1,175	710
1953	170	--
1952	3,370	1,095

Oyster setting in upper Chesapeake Bay proper was extremely low. The following table indicates the magnitude of this set on test shells:

Station		Spat per bushel of test shells 1954	1953	1952
Swan Pt. S.	) east side	50	3,225	325
Swan Pt. Mid.	) Chesapeake Bay	25	1,425	238
Swan Pt. N.	)	100	1,025	150
Tollys	) west side	50	400	75
Hacketts	) Chesapeake Bay	0	750	100
Gibson Is.	)	0	---	---

upper Bay was the lowest in the past 3 years. Recruitment from this season's setting added practically nothing to the population.

Distribution and survival of oyster larvae determine, in general, set magnitude. The table at the top of the following page shows how larvae were dispersed in Eastern Bay and upper Chesapeake Bay proper.

Oyster larvae abundance in plankton indicated 3 surges in spawning in Eastern Bay, one about the third week in June, one the second week in July, and one the first week in August. Setting followed each spawning surge but each was progressively smaller as the season advanced. Spawning, however, continued throughout the summer, varying only in intensities mentioned in the table at the top of the next page.

Glycogen dropped to 4% in Eastern Bay oysters in August and rose to 10% by October and 23% by December. A dip of 3% in March was followed in early May by an increase to 28%. This cycle shows the normal sequence of changes, but the quantity of change indicates a year of slightly below normal oysters as glycogen usually

exceeds 30% at the normal peak condition of oysters.

out 1954 salinities remained about 2 °/°° higher than in 1953 and about 3 °/°° higher

Station	Larval Counts 1954 Total	1954 Late stage	1953 Total	1953 Late stage	1952 Total	1952 Late stage
Millhill E. B.	6, 400	180	13, 280	40	28, 630	470
Bodkin E. B.	31, 610	50	9, 270	50	8, 660	140
Long Pt. E. B.	17, 650	230	6, 420	50	10, 410	190
Tollys C. B.	850	0	1, 550	10	1, 580	0
Hacketts C. B.	500	0	4, 080	50	1, 680	0
Swan Pt. C. B.						
South	2, 500	20	2, 600	40	3, 320	0
Middle	1, 000	0	4, 760	120	2, 040	0
North	350	0	4, 600	60	2, 750	0

Productivity studies.--Chlorophyll "a" and inorganic P04 cycles were observed at 6 stations in upper Chesapeake Bay area during 1954-1955. Both elements in the productivity picture show some interesting coincidences. In the open portions of upper Chesapeake Bay, chlorophyll "a" and available inorganic P04 are found in double the amounts recovered in Eastern Bay, a large tributary. Chlorophyll in Chesapeake Bay samples was about 3.08 to 1.46 µgA/liter in Eastern Bay and P04 was 3.62 to 1.75 µgA/liter, the average per sample per season (summer).

These same productivity factors, related to rainfall departure from normal, show some significant trends. The driest summer in the past 14 years was 1954, as reported by the United States Weather Bureau. This affected water chemistry in the Chesapeake Bay area. A comparison of available P04 for the past 3 years with rainfall departure illustrates this trend. (See table at the top of next page).

Dryness and consequent loss of land drainage affect ecology of the area. In addition to conditions shown in preceding tables, salinities also reflect lack of rainfall, i.e., through- than in 1952. These relations are part of a puzzle which have not been fitted together so the productivity picture may be seen.

Methods of determining oyster population changes.--A summary of analysis of data collected over the past few years follows:

1. A small dredge conveniently handled by one person will make catches according to oyster abundance. Catch reliability might be expected to increase with dredge size, but would require more power of boat and men, and increase time of sorting and counting catch.

2. The derived index of oyster abundance, as between geographic areas of bottom and between years, apparently reflects abundance as shown by commercial removals.

3. Efficiency of the small dredge in taking bottom material from the actual path of hauling is low. Populations calculated from dredge sampling must be adjusted by a multiple of 10 or more before the calculated population change approaches the change as recorded in commercial removals.

Year	Hacketts	Tollys	Rainfall departure	
1952	.245	.249	wet	+1.33
1953	.291	.289	mod. dry	-0.86
1954	.362	.314	very dry	-4.29

A similar comparison on production of phytoplankton (chlorophyll "a") shows a trend which is opposite to that on P04.

Year	Hacketts	Tollys	Millhill	Rainfall departure	
1952	6.38	6.05	4.59	wet	+1.33
1953	4.10	4.25	3.81	mod. dry	-0.86
1954	2.67	3.08	1.46	dry (very)	-4.29

4. The order of magnitude of the adjustment factor is not applicable to all oyster sizes. This adjustment difference obtains regardless of the mesh in the dredge.

5. Over a period of several consecutive years population estimates derived from dredging may be expected to reveal trends and areas of abundance as distinguished from areas of scarcity. Numerous inconsistencies may be expected from one year to another, but with scanty indications as to how they may be resolved. With all possible precautions many factors remain that can affect variability; these factors are people and their equipment control in wind and water.

Inventory of oyster resources in Chesapeake Bay.--The Fish and Wildlife Service, Maryland Department of Tidewater Fisheries and Maryland Department of Research and Education conduct a cooperative survey annually to assay the Chesapeake Bay oyster population of Maryland waters. The 1954 survey included examination of 130 oyster bars. Samples were to determine the number available for harvest during the present season; number of small oysters available for future crops, and the current natural recruitment as indicated by 1954 spatfall survival. Survey results are shown on the following page.

The figures obtained as a result of the survey show roughly the expected distribution and production of oysters for the next few years. Market size oysters are about as abundant this season as in 1953-1954; small oyster are considerably fewer than last year; yearlings are also fewer but spatfall average for all Maryland stations is slightly more than double that of last year. With these figures as a basis for rough calculations, a qualified guess is possible as follows for the near future: the 1954-1955 harvest should be about equal or possibly slightly greater than that of last year; for the succeeding two seasons the harvest should fall off materially, but increased setting, mostly in Eastern Shore tributaries, should return production to the level of this current year's harvest in 3 seasons.

The inventory survey disclosed some interesting conditions on the several seed areas being developed in Maryland. Not one of the four seed areas had a high setting. Several natural bars given maintenance shell plantings received higher spat counts. Millhill in Eastern Bay received the highest spatfall of the 4 state seed beds. The rest received too low a spatfall in 1954 to be worked profitably on the basis of this

Areas	No. of stations	Oysters per bushel bottom material			
		Market	Small	Yearling	Spat
Chesapeake Bay proper	52	73.5	27.0	11.6	17.0
Choptank River	13	63.2	33.7	5.2	32.5
Potomac River	16	79.6	35.4	3.3	39.1
Eastern Shore Trib.	42	59.1	28.5	10.1	136.6
Average 123 stations 1/		68.3	29.4	9.3	63.3

1/ Seed-producing bars in St. Marys River and Eastern Bay were not included in the averages.

year's recruitment. However, St. Mary's River, only lightly tapped for seed removal during the last 3 years, has a sizable accumulation of small oysters suitable at this time for transplanting. The other 2 seed areas, Punch Island Creek and Holland Straits, have produced little seed for several years because of low setting rates and limited amounts of cultch.

The seed areas, able to receive 1,000,000 bushels of clean shell per year, had only 300,000 bushels planted in 1954. Seed from Millhill, St. Mary's River and Holland Straits may have to be moved to make way for clean and more efficient cultch in 1955.

Clams.--Three-month-old clams, Venus mercenaria and V. mortoni and their hybrids, from Milford, Connecticut, were planted in cages in York River, Virginia, in May 1954. Growth and survival records made at 6-month intervals showed rapid growth among hybrid clams of V. mortoni female-V. mercenaria male and V. mortoni male-female, but slow growth among clams of V. mercenaria female-male and V. mercenaria female-V. mortoni male. Mortality was high among all groups, some of which was caused by disturbance of the bottom by Hurricane "Hazel". Oyster drills also accounted for some clam mortality in each cage.

Effectiveness of drill trapping on survival of oyster spat in Chesapeake and Chincoteague Bay areas.--Members of the Chesapeake Bay Shellfish Investigations and of the Maryland and Virginia State fishery research staffs put this program into operation in the field in April 1955.

Lower Chesapeake Bay drill project.--In lower Chesapeake Bay in York River, 2 plots of 3 acres each, close to each other, with a barren area of about 3 acres separating them, were laid out. The State of Virginia planted 2 experimental plots with 2,000 bushels of clean shells each. After shells were planted, 280 traps, baited with young oyster clusters, were systematically dispersed over 1 plot and the other was left untrapped. Trap lines placed at right angles to tide flow contained 35 traps per line; traps were 10 feet apart and lines 50 feet apart.

Results in 1955 observations on these plots after 4 weeks of trapping follow:

Date	Urosalpinx	Eupleura	Total
6/16/55	32	831	863
6/22/55	36	932	968
6/29/55	23	577	600
7/6/55	24	719	743

These figures show a decrease in catch which appears significant. The unit of effort remained the same for each week.

The trapping method of removing drills from oyster beds is not applicable in exposed areas as a means of control. A network of traps in an area where boat traffic is heavy also creates a navigation hazard. At a conference, state officials, industry representatives, and the Chesapeake Bay Shellfish Investigations concurred that a drill dredge device would be more suitable than traps for deep water in exposed areas such as exist in lower Chesapeake Bay and other large estuaries where drills abound and are pests. The major objection to this device is the ease with which it clogs and loses its effectiveness. A redesign of this gear with incorporation of a suction-cleaning element seemed, in the opinion of the conferees, desirable. Such a program of gear development is under way and a pilot dredge with a suction cleaner will be tried on deep water beds in the fall.

Chincoteague Bay drill project.--A program in many respects similar to the one being conducted in lower Chesapeake Bay is operating in Chincoteague Bay to trap oyster drills. The objective is the same--to test the possibility that trapping drills may be efficient enough to permit oyster spat to survive. Part of the program is designed to check the value of control methods practiced by industry in these waters. Some methods applied by industry coincide with methods which the Chesapeake Bay Shellfish Investigations proposes to use and which will make integration of theory and practice in these experiments feasible.

In April 1955, 4 plots of 4 acres each, with a 4-acre space separating each plot, were marked by stakes. Each plot was tested for drill population density with a string of 40 traps baited with young oysters. Drills were in about the same distribution in each plot. Plots were treated as follows:

1. In April, 1 plot was trapped with 160 baited traps, arranged in 4 lines across the tide with 40 traps to the line. Traps were tended weekly until the first week in June. The area was then covered with clean shells, at the rate of 800 bushels to the acre, as cultch to collect spat. Trapping will continue until cold weather.

2. A plot was cleaned with fine-mesh dredge prior to shelling. This plot will be trapped until cold weather.

3. Another plot was trapped immediately after shelling in June and trapping will continue until cold weather.

4. Another plot was shelled in June and not trapped.

The plot trapped from April (item 1 above) until June 30, 1955 shows the following catch record:

Date	Urosalpinx	Eupleura	Total
4/26/55	165	536	701
5/11/55	203	558	761
5/23/55	105	337	442
6/10/55	65	188	253

The same number of traps and the same time interval between tending make these figures comparable and indicate the possibility of reducing an oyster drill population by trapping in this manner.

At both projects a copper sulphate bath was used to immerse traps that had egg capsules of drills attached. The best method for killing drill embryos is exposure to dilute copper sulphate. In the past, the return of drill egg capsules has been a major source of recontamination and extended distribution of this animal.

CLAM INVESTIGATIONS

John B. Glude, Boothbay Harbor, Maine

Clam census.--Analysis of data shows a decrease in the number of clams over 25 mm. from 11.5 millions in 1954 to 8.3 millions in 1955. The following population estimates indicate this decrease is a continuation of the trend toward a decreasing population in Sagadahoc Bay.

Year	Population
1949	40.3 million
1950	34.1 "
1951	29.7 "
1952	18.5 "
1953	16.4 "
1954	11.5 "
1955	8.3 "

Reproduction.--Plankton and set sampling during the summer and fall of 1954 indicated a good set in August in Loves Cove and Sagadahoc Bay. Sampling during the winter of 1954-1955 indicated a good 1954 set, but numbers had been reduced by that time to sizes below 5 mm. which green crabs do not readily attack. Spring set samples in Loves Cove showed a reduction in the numbers of 1954 set from 300 per square foot to about 100 per square foot, from March to May. Survivors are largely below 6 mm. in length.

Clam population surveys.--A resurvey in the summer of 1954 of several areas in eastern Maine, of a survey made by the Maine Department of Sea and Shore Fisheries in 1949 and 1950, showed (1) a serious reduction in clam stocks, (2) an absence or scarcity of recent year classes except 1953 and 1954, (3) an apparent sufficiency of 1953 and 1954 sets which were too small to become green crab prey, and (4) a tremendous increase in green crab numbers.

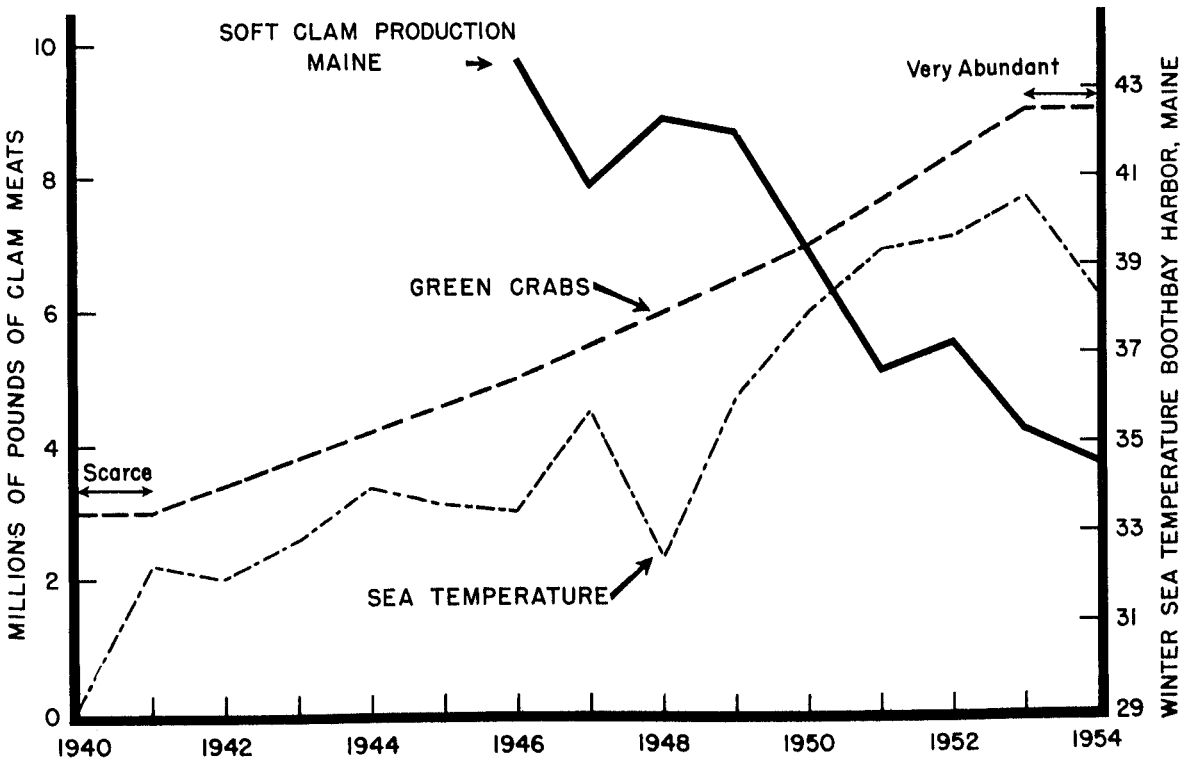
These surveys further confirmed the hypothesis that clam scarcity in Maine is the result of an increase in predatory green crabs. Additional population surveys are planned for the summer of 1955.

Green crab control.--Three fences, each enclosing 100 square feet, were installed in Sagadahoc Bay during the spring of 1954. A hurricane destroyed one fence. The other 2 fences have remained in good condition but have not protected natural set clams. While they have prevented most crabs from entering the areas, small clams are sufficiently active to move into and out of the small fenced areas and are eventually destroyed on the open flats. These results indicate that natural set cannot be protected in small areas of a large flat while the clams are in the active stage. Either the whole area must be enclosed or the clams to be protected by a small fence must be beyond the active stage; that is, over one-half inch in length.

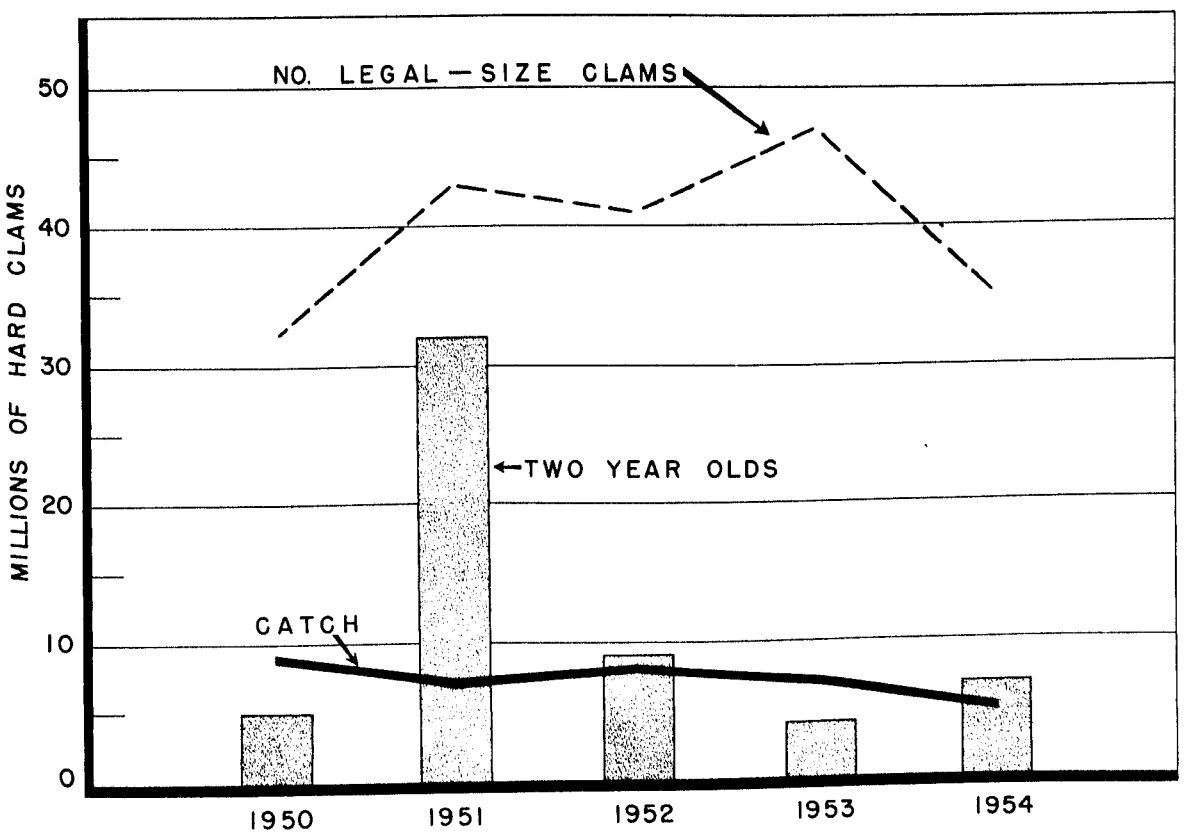
About 5 acres of clam flats in Sams Cove, near Waldoboro, Maine, were enclosed by a 500-foot fence of one-half inch mesh hardware cloth 18-inches high with a 4-inch flange across the cove mouth. Trapping inside and outside this fence indicates that crabs are entering the enclosed area; they crawl around and over the flange. Wider flanges of smooth wood and/or metal will be tried.

In Cameron Point Cove, Southport, Maine, 3 fences, each enclosing 100 square feet, were erected in May 1955 and planted heavily with seed clams. Clams were also planted in adjacent unprotected areas in the same concentration. Unprotected clams were consumed in 6 days, while concentrations within the fence remained high. Within a month, however, clams inside the 18-inch fence which had no flange had been consumed.

SOFT CLAM STUDIES



HARD CLAM STUDIES



Clams within the 18-inch fence with a 4-inch flange, and within the 12-inch fence with a 4-inch flange, had been reduced to less than one-half the planted number within a month. Wide flanges of wood and zinc are being tried.

Littoral green crabs (Maine).-- Surveys in the intertidal zone during November and December in 3 localities indicated greatly reduced numbers of small (20 to 30 mm.) crabs where counts had been extremely high during the summer. This result supports the idea of fencing areas early in the spring before the crabs become active and move in. It also indicates that the best time for applying control methods to vast numbers of young crabs is the summer when they heavily infest the intertidal zone.

Green crab abundance.--Catches of green crabs indicate no change in intensity of crabs, which might be attributed to effects of cold winters. Spring trap catches, though normally smaller than fall catches, indicate crabs are no less plentiful in 1955 than they were in the previous 2 years. Samples dug from the banks in the winter showed no mortality from the cold spell during January.

Green crab feeding experiments.--Green crabs readily eat Mya from 5 to 25 mm. and will also eat larger Mya if they are available. Mya, Macoma, Gemma, and Venus are eaten in that order of preference. Small Venus (6 to 10 mm.) are eaten before the larger sizes (20 to 25 mm.) but with Mya and Macoma the size preference is not as readily noticeable.

Green crab food.--Crabs were collected from thatch bank caves and subtidal channels close to the thatch banks. The frequency of occurrence of various foods differs markedly in the 2 groups. Dredged crabs utilize mollusks (74%), arthropods (31%) and plants (23%). Thatch bank crabs utilize mollusks (59%), arthropods (18%) and plants (51%). Dredged crabs had animal food in 86% of the stomachs, while bank crabs had animal food in 67%.

Analysis of stomachs of all crabs showed Mya, mussels, gastropods and Gemma the important foods in the order mentioned. This order of importance was true by both frequency of occurrence and the number of individuals containing countable food.

Greenwich Bay studies.--Population census in late 1954 revealed the lowest density in 5 years' sampling. Average density for all hard clams over 15 mm. was 0.502 per square foot. The major decrease took place in the "neck" size (47-66 mm.), with slight decreases in other small sizes over previous years. The catch per unit effort remained nearly the same, but the catch of "necks" fell and the catch of "large" increased. A rather heavy concentration of hard clams just below legal size appeared in the intertidal zone along Buttonwoods Beach. With this exception, the areas of concentration appeared nearly the same as in previous years. There was a further drop in the average number of boats fishing per day to a new low of 29.

Larval studies.--Analysis of seasonal larval abundance data for Wickford Harbor and Greenwich Bay for 1950 to 1954 inclusive, indicates a similarity in Venus spawning pattern. To intensify work on the basic problem of relationship between larval abundance and subsequent set larval abundance, observations are being discontinued in Greenwich Bay but increased in Wickford Harbor.

Set studies.--Annual census of set-of-the-year Venus was made in Wickford

Harbor. The distribution of young Venus with reference to water depth was reversed from that of 1953. In 1953 the intertidal set was noticeably more dense than the subtidal; in 1954 the opposite was true. It had been concluded that the intertidal set was usually more numerous than the subtidal. The effect of hurricane "Carol" in late August 1954 may have caused the apparent contradiction in 1954. Setting would have been largely completed and areas suffering most from the scouring action of wind-driven water would have been the intertidal bars and flats.

Tidal spat trap studies.--Final cumulative density of 1954 Venus set in the spat trap of 2.7 per square foot is above the average for all of Wickford Harbor but well below that for many selected areas. Observations on abundance of 1955 larvae of all ages in the spat trap to June 30, 1955, indicate that the trap is taking the same larval composition, as regards numbers and size, as nearby plankton pump samples.

Predator studies.--Laboratory studies on Venus predators, particularly the mud crab Neopanope texana, showed mud crab activity ceases below temperatures between 8-10° C. Crabs buried into the substrate and became dormant at or below these temperatures.

Parasites and diseases of soft and hard clams and green crabs.--Studies on metazoan and protozoan parasites were completed during the period July 1, 1953 through June 30, 1954 and showed none of the observed members of these groups are responsible for extensive mortalities of clam stocks in nature.

Cooperative studies with Yale University directed toward defining the clinical significance of the clam-borne trematode Himasthla quissetensis (H. muehlensi) have been completed and demonstrate no significant risk is involved from consuming uncooked clams harboring this parasite of avian hosts. A report on the Himasthla subject as it relates to shellfish, vertebrates and snail hosts is in process.

An unidentified gram-negative bacillus, previously reported from Mya, has been found to be relatively common in stocks of Mya from the region of Boothbay Harbor, Maine. Recent experiments have failed to demonstrate the high degree of pathogenicity previously reported.

Clam farm and predator research.--Green crab fences built in June 1954 with the help of Hampton, N. H., and Ipswich, Mass., to protect clams from green crabs and horseshoe crabs, were partially successful. The Ipswich fence, enclosing a natural set, could not be maintained because of excessive clogging and erosion. The Hampton fence stood up well, but the natural set did not materialize. Clams were planted inside the fence, but unlike the 1953 experiments, many small crabs went through the 1-inch mesh wire and devoured the clams. A smaller mesh wire will be used in future experiments.

Despite conflicting results, Ipswich, Mass., built two fences in the spring of 1955 and Essex, Mass., is planning to build a large fence.

One-eighth-inch mesh Saran, placed on the flats with edges buried to keep out detritus, has proven successful in collecting and saving natural clam sets in some areas. The Saran, which was down from April 1954 to February 1955, collected 215 clams per square foot, 19 of which were over 19 mm. long, and, therefore, of the 1953 year class. Surrounding flats had 39 clams per square foot, none of which was from the 1953 year class.

Horseshoe crab population and migration studies.--Since 1952, 1,799 horseshoe crabs have been tagged in or near Plum Island Sound. Mature crabs tagged in 1952 totaled 984; in 1953, 281; in 1954, 389. Results indicate a migration in and out of the Sound of a more or less localized group limited to Ipswich Bay if not to Plum Island Sound proper, which may return 1, 2 or 3 years later.

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Marvin, Kenneth T.	Chemist	Gulf	Galveston, Texas
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Snieszko, Stanislas F.	Bacteriologist	Micro. Lab.	Leetown, W. Va.
Soderstrom, Clifford E.	Fish. Aid	Pacific Salmon	Seattle, Wash.
Squires, Delpha M.	Fish. Aid	South Pacific	La Jolla, Calif.
Stewart, Dorothy D.	Fish. Aid	POFI	Honolulu, T. H.

Name	Title	Investigations	Location
Stickney, Alden P.	Fish. Biol.	Atlantic Salmon	Boothbay Harbor, Me.
Stringer, Louis D.	Fish. Biol.	Clams	Kingston, R. I.
Stroup, Edward D.	Fish. Aid	POFI	Honolulu, T. H.
Stunkard, Horace W.	Collaborator	Clams	New York, New York
Sykes, James E.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Taft, Bruce A.	Fish. Aid	South Pacific	La Jolla, Calif.
Tait, Howard D.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Talbot, Gerald B.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Tanonaka, George K.	Fish. Aid	Pacific Salmon	Seattle, Wash.
Taylor, Clyde C.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Tetzloff, Clifford L.	Fish. Biol.	Great Lakes	Marquette, Mich.
Thompson, Paul E.	Fish. Biol.	Asst. Branch Chief	Washington, D. C.
Thompson, Richard B.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Thorne, Donald L.	Lab. Elec.	Pacific Salmon	Seattle, Wash.
Thrailkill, James R.	Fish. Biol.	South Pacific	La Jolla, Calif.
Trefethen, Parker S.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Uchida, Richard N.	Fish. Biol.	POFI	Honolulu, T. H.
Uzmann, Joseph R.	Parasitologist	West. Fish. Disease	Seattle, Wash.
Van Campen, Wilvan G.	Translator	POFI	Honolulu, T. H.
Van Landingham, John W.	Phy.Sci.Aid	POFI	Honolulu, T. H.
Van Oosten, John	Fish. Biol.	Great Lakes	Ann Arbor, Mich.
Vieira, Manuel	Stat. Assist.	North Atlantic	Woods Hole, Mass.
Volz, Charles D.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Vorobiov, Alexander V.	Fish. Aid	South Pacific	La Jolla, Calif.
Vrooman, Andrew M.	Fish. Biol.	South Pacific	La Jolla, Calif.
Wahle, Roy J.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Walberg, Charles H.	Fish. Biol.	Middle Atlantic	Beaufort, N. C.
Waldron, Kenneth D.	Fish. Biol.	POFI	Honolulu, T. H.
Walford, Lionel A.	Fish. Biol.	Branch Chief	Washington, D. C.
Watson, Frank H.	Fish. Aid	South Pacific	La Jolla, Calif.
Weber, Kingsley G.	Fish. Biol.	Pacific Salmon	Seattle, Wash.
Webster, John R.	Fish. Biol.	Chesapeake	Annapolis, Md.
Welch, Walter R.	Fish. Biol.	Clams	Boothbay Harbor, Me.
Wells, LaRue	Fish. Biol.	Great Lakes	Marquette, Mich.
Wheeler, Ray S.	Fish. Aid	Gulf	Galveston, Texas
White, Effie L.	Fish. Aid	Sal. Nutr. Lab.	Willard, Wash.
Widrig, Theodore M.	Statistician	South Pacific	La Jolla, Calif.
Wieberg, Nels R.	Fish. Aid	Great Lakes	Marquette, Mich.
Wigley, Roland L.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Willis, Charles F.	Fish. Aid	Beaufort Lab.	Beaufort, N. C.
Wilson, William B.	Fish. Biol.	Gulf	Galveston, Texas
Wise, John P.	Fish. Biol.	North Atlantic	Woods Hole, Mass.
Wolf, Kenneth E.	Bacteriologist	Micro. Lab.	Leetown, W. Va.
Wolf, Robert S.	Fish. Biol.	South Pacific	La Jolla, Calif.
Wong, Stanley H.S.	Mech. Engr.	POFI	Honolulu, T. H.
Wood, Edward M.	Fish. Biol.	Sal. Nutr. Lab.	Willard, Wash.
Wood, Luella B.	Lab. Helper	Sal. Nutr. Lab.	Willard, Wash.

Name	Title	Investigations	Location
Woodall, Arthur N.	Chemist	Sal. Nutr. Lab.	Williard, Wash.
Woolley, Grant A.	Fish. Aid	Pacific Salmon	No. Bonneville, Wash.
Worlund, Donald D.	Statistician	Pacific Salmon	Seattle, Wash.
Yamashita, Daniel T.	Fish. Biol.	POFI	Honolulu, T. H.
Yasutake, William T.	Histo. Tech.	Sal. Nutr. Lab.	Willard, Wash.
Yoshida, Howard O.	Fish. Aid	POFI	Honolulu, T. H.
Young, Robert S.	Phy.Sci.Aid	POFI	Honolulu, T. H.
Yuen, Heeny S. H.	Fish. Biol.	POFI	Honolulu, T. H.
Zein-Eldin, Zoula P.	Chemist	Gulf	Galveston, Texas