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ANNUAL REPORT FOR 1967

COOPERATIVE FISHERY UNITS

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

BUREAU OF SPORT FISHERIES AND WILDLIFE

DIVISION OF FISHERY SERVICES

RESOURCE PUBLICATION 62

The Department of the Interior, created in 1849, is concerned with management, conservation, and development of water, wildlife, fish, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As America's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States, now and in the future.

Cover drawing by Craig P. Phillips, National Fisheries Center and Aquarium, Washington, D.C.

UNITED STATES DEPARTMENT OF THE INTERIOR
STEWART L. UDALL, *SECRETARY*
Stanley A. Cain, *Assistant Secretary for Fish and Wildlife and Parks*
Fish and Wildlife Service, Clarence F. Pautzke, *Commissioner*
Bureau of Sport Fisheries and Wildlife, John S. Gottschalk, *Director*

ANNUAL REPORT FOR 1967

COOPERATIVE FISHERY UNITS

A Nation-wide Cooperative Program of Training, Investigation and Application by the Bureau of Sport Fisheries and Wildlife, State Game and Fish Departments, and Colleges and Universities

DIVISION OF FISHERY SERVICES

Willis King, Chief

Prepared by Donald Chapman, Leader,
Idaho Cooperative Fishery Unit

RESOURCE PUBLICATION 62

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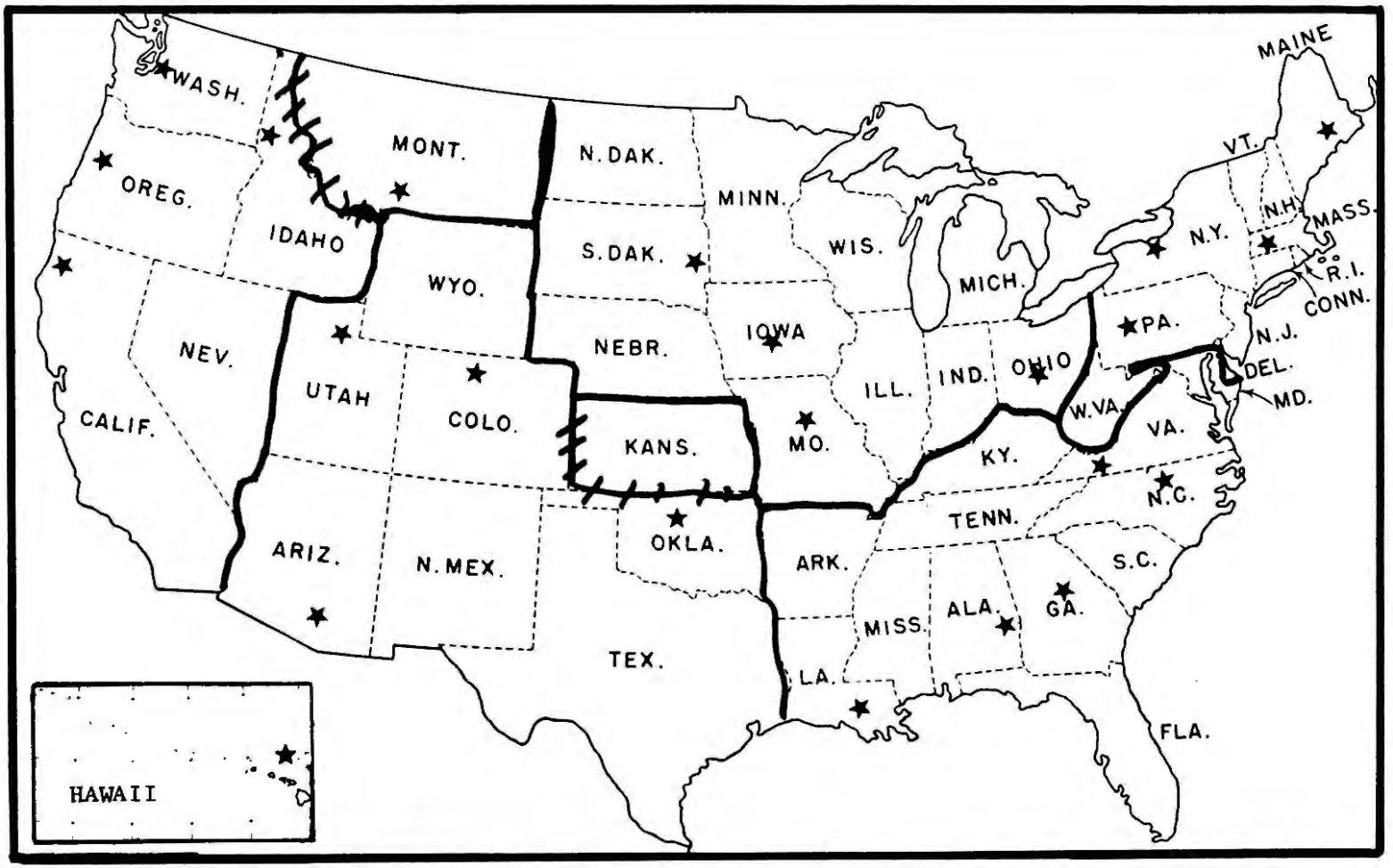
TABLE OF CONTENTS



DISTRIBUTION OF COOPERATIVE FISHERY UNITS

ANNUAL REPORT 1967

COOPERATIVE FISHERY UNITS

INTRODUCTION

The need for biologists trained in many aspects of fishery science has continued to grow in the past two decades. Cooperative fishery units are helping meet this need at 23 universities throughout the United States, from Maine to Hawaii. These units, each authorized by Congress, bring together the capabilities of the Bureau of Sport Fisheries and Wildlife, the universities and state conservation agencies. The fields of study are diverse, and in the training process unit leaders and graduate students carry on research designed to help solve problems related to the aquatic resources of the Nation. In this work, new tools must be found to help fishery managers solve the problems created by people in a complex technological society. Benefits of the program are passed on to the sport fisherman who is seeking a satisfying recreational experience.

ADMINISTRATION

Authority for the establishment of the cooperative fishery units is in Public Law 86-686 (74 Stat. 733) approved September 2, 1960. The purpose as stated in the Act (Appendix A) is "To facilitate cooperation between the Federal Government, colleges and universities, the states, and private organizations for cooperative unit programs of research and education relating to fish and wildlife and for other purposes."

Each of the 23 Cooperative Fishery Units is supported jointly by the Bureau of Sport Fisheries and Wildlife, a college or university, and usually a state department of fisheries or fish and game. In 3 units there are two cooperating state agencies. In accord with a formal agreement among cooperators, general guidance is provided by a coordinating committee made up of representatives from the participating agencies. Graduate study proposals and annual budgets are reviewed by the committee.

The Bureau of Sport Fisheries and Wildlife provides two highly-trained fishery biologists who serve as Unit Leader and Assistant Unit Leader. On occasion the Bureau contributes limited funds to support graduate student research projects.

Any Bureau facilities in proximity to a unit, such as a fish hatchery or research laboratory, are generally available to unit leaders or students for research.

TABLE 1

Locations and dates of establishment of cooperative fishery units

Alabama	Auburn University, Auburn	11/8/66
Arizona	University of Arizona, Tucson	10/16/64
California	Humboldt State College, Arcata	8/1/66
Colorado	Colorado State University, Fort Collins	11/1/62
Georgia	University of Georgia, Athens	10/11/62
Hawaii	University of Hawaii, Honolulu	2/18/66
Idaho	University of Idaho, Moscow	9/1/63
Iowa	Iowa State University, Ames	1/18/66
Louisiana	Louisiana State University, Baton Rouge	6/26/63
Maine	University of Maine, Orono	11/6/62
Massachusetts	University of Massachusetts, Amherst	1/23/64
Missouri	University of Missouri, Columbia	10/1/62
Montana	Montana State University, Bozeman	9/1/63
New York	Cornell University, Ithaca	9/27/63
North Carolina	North Carolina State University, Raleigh	10/1/62
Ohio	Ohio State University, Columbus	10/10/65
Oklahoma	Oklahoma State University, Stillwater	7/27/65
Oregon	Oregon State University, Corvallis	7/20/66
Pennsylvania	Pennsylvania State University, University Park	2/20/64
South Dakota	South Dakota State University, Brookings	7/1/65
Utah	Utah State University, Logan	12/1/61
Virginia	Virginia Polytechnic Institute, Blacksburg	10/29/65
Washington	University of Washington, Seattle	12/21/66

The cooperating state conservation departments provide funds and often facilities for research by graduate students. Quite often state personnel are assigned temporarily or part-time to support a unit project.

The college or university furnishes office and laboratory space, secretarial help, various facilities, and may provide some funds for operations or student help.

The fishery units function within the Bureau's regional organization so that unit personnel receive general supervision and administrative services from the office of the Regional Director of the region in which the unit is located. This places the fishery units in a pattern common to most Bureau programs and helps assure a close working relationship among the universities, the states, and federal agencies.

PROGRAM OBJECTIVES

Training fishery biologists is the most important function of the units, which contribute well-trained biologists to help meet federal, state, and private employment needs, and also educate individuals who move into academic pursuits. The latter contribution directly accelerates the rate of professional training.

Research by unit personnel and graduate students is also a major output of the program. This involves individual research projects chosen with respect to the interests and capabilities of the personnel, facilities available, other research programs of cooperators, and in response to state, regional and national needs. These projects are primarily directed toward the solution of ecological and environmental problems and the development and evaluation of techniques.

The units contribute to public knowledge of fishery management through lectures, seminars, releases to the press and popular literature, and by cooperation in demonstrations of management methods. They often serve a continuing education function by providing short courses to professional biologists, making new techniques and concepts available.

Special assignments are occasionally made to unit personnel, such as participation in national surveys, design of research projects or programs, or other fishery work requiring professional competence. In some cases, field studies on large federal land and water areas are carried on, particularly where students can be used to advantage in training and to further project objectives.

TRAINING OPPORTUNITIES

Students interested in advanced training in fishery biology can find a diversity of courses and research topics at the 23 colleges and universities which house cooperative fishery units. Dispersion of units throughout the United States provides training and research opportunities in many ecological and environmental conditions. In addition, emphasis is given to different fields of biology, depending on the interests and needs of cooperating agencies. This provides students the opportunity to specialize in such broad areas as fishery management and ecology, population dynamics, taxonomy, fish culture, pathology, nutrition, and the related fields of limnology, oceanography, statistics and biometrics.

In addition to regular student training, seminars, workshops, and refresher courses for state and federal biologists are scheduled at several of the units. These activities are designed to bring biologists up-to-date on such subjects as aquatic weed control, use of specialized gear for fish population studies, methods of pollution abatement, pesticides surveillance and monitoring, radiation biology, and biometrics.

SUMMARY OF ACCOMPLISHMENTS

In 1967 there were 49 courses taught by unit leaders and assistants, with an enrollment of 553 students. A few of these courses were team-taught, but most were the equivalent of 2 or 3 semester-hour credits. Supervision was given to 256 graduate students in thesis work or special problems.

Advanced degrees were awarded to 38 unit-supported graduate students; 36 Masters of Science and 2 Doctors of Philosophy. Many unit personnel advised undergraduate fisheries students on educational or vocational matters, but the extent of this contribution is unreported here. The number of advanced degrees awarded should increase sharply in 1968-1970 because of the time lag between unit formation and completion of degree requirements by an initial crop of graduate students. Of the 38 students who received advanced degrees, 11 took permanent positions with state conservation agencies, 5 were employed by universities, 4 by federal agencies, 4 by other employers, and 14 chose to pursue the Ph.D. degree, usually at universities other than that at which they received the M.S. degree. There were 46 papers by unit personnel published in 1967 (Appendix B). In addition, unit leaders and students presented many talks and seminars to professional groups and interested laymen.

In addition to formal teaching responsibilities and the guidance of student research, unit leaders and assistant leaders participated in dozens of seminars in academic circles, in special lectures to groups ranging from grade-school children to chambers of commerce, and in many radio and television educational programs. Many unit personnel were active in local and national professional societies, often serving as committee members, officers, and program organizers. Most unit leaders and assistants were frequently involved as consultants to state conservation agencies or to various federal agencies including their own.

As scientists, most unit leaders acted as manuscript referees or editors, either at the formal request of journal editors or to serve colleagues who requested critical reviews of manuscripts. Nearly all unit leaders served on several faculty committees at their universities, being expected to perform as academicians as well as fishery biologists.

The source of support for research activities shown below is from state and federal funds allocated for unit programs unless special awards, contracts or other outside source are mentioned. The listing of research work in each unit is very brief, and readers are urged to contact unit personnel directly for more extensive information. Only completed theses are reported here in any detail as abstracts. All abstracts are as written by the thesis author except for minor editorial changes.

Alabama Cooperative Fishery Unit

The cooperative agreement establishing the Alabama Cooperative Fishery Unit was signed on November 8, 1966, by representatives of the Bureau of Sport Fisheries and Wildlife, Auburn University, and the Alabama Department of Conservation. The Unit Leader, Dr. John Ramsey, joined the Bureau early in 1967. The Assistant Leader position was vacant during the entire year. The Coordinating Committee was made up by Mr. Charles Kelley, Game and Fish Division, Alabama Department of Conservation; Dr. E. V. Smith, School of Agriculture, Auburn University; and R. T. Webb, Bureau of Sport Fisheries and Wildlife.

Dr. Ramsey supervised several students in special problems or thesis research. He also conducted studies of systematics of two species of Notropis in eastern North America; the status of Fundulus albolineatus in springs of the Cumberland and Tennessee river drainages; distribution of fishes in the Apalachicola River; status of the percid fish genera Etheostoma and Percina; and the fin regenerate squash technique for determining chromosome numbers in fishes.

Fishery studies by students:

R. J. Gilbert, candidate for the M.S. degree, began a study of the distribution of fishes in the central Chattahoochee River drainage in Alabama and Georgia. He should finish his work in 1969.

313-165 O-68—2

Arizona Cooperative Fishery Unit

The Arizona Cooperative Fishery Unit became operational in November 1964 with the appointment of Dr. William J. McConnell as Unit Leader. The Assistant Unit Leader, Mr. Charles D. Ziebell, joined the unit in February 1966.

The Coordinating Committee consists of the Assistant Regional Director for Cooperative Services, Bureau of Sport Fisheries and Wildlife and a representative from each of the Arizona Game and Fish Department and the University of Arizona. The Unit Leader serves as secretary and advisor to the Coordinating Committee at its annual meetings.

The entire fishery program at the University of Arizona is conducted through the Cooperative Fishery Unit by unit personnel. This includes graduate and undergraduate studies as well as research and extension.

The Unit Leader and Assistant Unit Leader each conducted a seminar in fishery related topics in 1967. Thirteen students participated.

The Assistant Unit Leader continued his investigation of the ecology of channel catfish in small impoundments. During the past year this consisted of population sampling. Closely related to the channel catfish project was the field testing of a sonic remote recovery device for recovery of unmarked fish traps and other gear. Also related to the study of the ecology of channel catfish was the development of a compact, sonic internal fish tag having a service life of at least 100 days. This was done in cooperation with a local non-profit electronic research laboratory (Sensory Systems, Inc.).

The Assistant Unit Leader also assumed responsibility for the unit program in exotic fish weed control and sport fishery extension. This consisted chiefly of field trials of weed control by Chinese grass carp and the development of pond fisheries for Tilapia.

The Unit Leader continued with his investigation of the effects of natural plant tannins and related phenolic compounds on growth of aquatic organisms. The chief effort during the first part of the year was an attempt to identify these compounds, if necessary by characterization by molecular size and hydroxyl group activity. During the latter part of the year bioassays were conducted on a variety of typical natural phenolics contributed to water by watershed litter. These included mixed tannins, flavanoids, phenolic acids, hydroxy-cinnamic acids and others. This work was supported by the Arizona Water Resources Research Center and Federal Water Pollution Control Administration.

Assistant Leader Charles Ziebell, Arizona Unit, sutures channel catfish after implanting experimental ultrasonic teaching tag. Carlson, Limnology professor assists.

Richard Biggins, Arizona Unit, inspects assembled hoop net used to collect centrarchids for food interaction study.

Fishery studies by students:

P. A. Stewart, M.S. candidate, completed his work on factors influencing trout production in 4 mountain impoundments in central eastern Arizona. He found that plankton photosynthesis was closely related to PO_4 and alkalinity content of inflow. Measurements of plankton chlorophyll did not agree with measured mean rates of plankton photosynthesis. Mean zooplankton biomass was closely related to plankton photosynthesis plus a NO_3 correction; or to an index based on inflow PO_4, NO_3 and alkalinity. Zooplankton biomass was not related to benthic photosynthesis.

W. M. Seawell, M.S. candidate, finished his thesis on the limnological effects of yellow pine litter in small impoundments. Reduction of alkalinity, increased color, and high oxygen demands by leachates were the main negative effects observed. Positive effects of pine needle leachates were addition of biogenic salts (high concentrations of phosphate and nitrate) and addition of organic matter. Main factors affecting import of litter into lakes were dryness of watershed, run-off rate, and buoyancy of litter. From the data collected during this study, it appears that the inhibitory effects of pine needle leachates outweigh the relatively low trophic value contributed. Slow leaching of litter by water on the watershed is probably more beneficial to the fishery than import of whole litter into lakes.

G. F. Adams, M. S. candidate, completed his work on soluble carbohydrates as an energy source for fish-forage organisms. From November 1965 to April 1967, three experiments were performed in twelve 0.006-acre tanks to evaluate the effects crude beet molasses and crystalline corn-dextrose additions might have on the presumed food chain of experimental fish populations. Carbohydrate additions did not augment the food chain enough to significantly increase growth rates of rainbow trout (Salmo gairdneri), the Malacca Tilapia hybrid, and largemouth bass (Micropterus salmoides). Significantly greater phytoplankton biomass, corresponding to carbohydrate additions in one experiment, may indicate utilization of carbohydrate as a source of energy by algae. Increased CO_2 concentrations incident to bacterial metabolism of sugars may also have been responsible. Evidence of increases in bacterial numbers following carbohydrate additions was found from plate counts, increase in maximum hydrogen-ion concentration, reduction of minimum oxygen concentration, and possibly from significantly greater turbidity found in tanks receiving the heavier concentration of carbohydrates. Additions of carbohydrates on a schedule corresponding to the planktonic bacterial pulses may have some importance in the management of lakes toward greater production of fish food organisms.

R. G. Biggins, M.S. candidate, studied food interactions of centrarchids in a small warm-water impoundment. The project should be completed in June 1968.

E. P. Bergersen, M.S. candidate, investigated the factors affecting zooplankton production in 4 Arizona lakes. This study is planned for completion in 1969.

S. Lewis, M.S. candidate, worked on effects of floating mechanical evaporation barriers on limnology and fish growth in small ponds. The study, funded by the Arizona Water Resources Research Center, should be completed in 1968.

R. J. Hallock, M.S. candidate, studied production of sport fish in reclaimed wastewater with support from the Federal Water Pollution Control Administration (through the City of Tucson). Tentatively, the work is to be completed in 1969.

D. J. Hopson, M.S. candidate, began work on the effects of a numerically abundant small non-game fish on growth of young game fish. The project is scheduled to be completed by mid 1969.

California Cooperative Fishery Unit

The California Cooperative Fishery Unit was established at Humboldt State College with the signing of a cooperative agreement on August 1, 1966 by representatives of the Bureau of Sport Fisheries and Wildlife, California Department of Fish and Game, and Humboldt State College.

Dr. Roger A. Barnhart transferred from the Georgia Cooperative Fishery Unit to the Unit Leader position of the California Unit on December 18, 1966, and began his duties as Unit Leader on January 2, 1967. The Assistant Unit Leader position was filled by Dr. Charles F. Bryan on October 16, 1967.

Members of the Coordinating Committee are Dr. Richard Ridenhour, representing Humboldt State College; Dr. Alex Calhoun, California Department of Fish and Game; Mr. Jack Hemphill, Bureau of Sport Fisheries and Wildlife; and the Unit Leader.

The Unit Leader was occupied with preparing and planning student research, developing special sampling equipment, and assisting students in field work. He taught two fisheries seminars in 1967, with total enrollment of 16 students. The Assistant Unit Leader assisted students and began analyzing stomachs of largemouth bass fry, zooplankton and bottom samples collected at Marion National Fish Hatchery.

Fishery studies by students:

W. D. Kesner, M.S. candidate, initiated a study of the characteristics of the half-pounder steelhead of the Klamath River drainage. The work should be completed by mid 1969.

T. Sopher, M.S. candidate, began investigating distribution and relative abundance of fishes of Arcata Bay, California, and should finish by 1969.

D. J. DeMont, M.S. candidate, studied the physical parameters involved in electrofishing in fresh, brackish and marine environments. He plans to complete his research by 1969.

Colorado Cooperative Fishery Unit

The Colorado Cooperative Fishery Unit was formed by agreement among the Bureau of Sport Fisheries and Wildlife, the Colorado Game, Fish and Parks Department, and Colorado State University. The Unit was activated in March 1963 with the appointment of Dr. Robert E. Vincent as Unit Leader. Dr. Robert J. Behnke joined the Unit as Assistant Leader in August 1966.

The Coordinating Committee, which meets annually, consists of: Dr. Gustav A. Swanson, Colorado State University; Mr. Laurence E. Riordan, Colorado Game, Fish and Parks Department; Mr. Lewis R. Garlick, Bureau of Sport Fisheries and Wildlife; and the Unit Leader.

The Unit Leader spent most research effort on planning and directing graduate student projects. His study on movements of fishes in a small stream is continuing.

The Assistant Unit Leader continued work on an inventory of Rocky Mountain fishes and studies of western North American Salmo. Cytological investigations of two undescribed forms of trout revealed the Apache trout of Arizona (2N=58) has the identical chromosome number as the California golden trout (S. aguabonita) and the fine spotted Snake River cutthroat (2N=64) is similar to other subspecies of interior cutthroat trout. A summary of information on rare and endangered fishes was distributed. Summaries on the fishes of the Colorado River and of the state of Colorado were prepared. Comparative studies on various genera of Salmonidae on a world-wide basis are underway including the description of a new species of trout from Turkey.

Fishery studies by students:

R. J. Baldes, M.S. candidate, completed requirements for a Master of Science degree. His salary was provided by the Sport Fishery Research Foundation. In his work on microhabitats occupied by trout, he concluded that physical parameters of habitat govern the characteristics of microhabitats. The constantly moving medium of lotic environments imposes unique problems on stream-dwelling animals. A resting microhabitat for fishes in streams becomes the focus for movement to other segments of the habitat. Brown trout were observed in a simulated stream environment (flume) at three water volumes (1.2, 3.6, and 6.8 cfs). Resting microhabitats occupied by study fish were within a velocity range of 0.4 to 0.7 ft/sec. Other factors such as turbulence, light, water depth, spatial limits, direction of flow, and cover also influenced the locations selected by fish.

L. H. Heaton completed requirements for a Master of Science degree, studying oral effects of Furazolidone on trout. Furazolidone, N(5-nitro-2-furfurylidene)-3-amino-2-oxazolidone, was tested for its tissue residue buildup and its safety for use with brown trout, rainbow trout, cutthroat trout, and brook trout. This drug has been shown to be effective in the treatment of salmonid furunculosis (Aeromonas salmonicida). Dosage of Furazolidone used in the tissue residue experiments was 35 mg/kg of fish per day for 20 days. The highest average amount of Furazolidone was 0.482 ppm found in brown trout on the 10th day of treatment. All species of trout used averaged less than 0.075 ppm by the 10th day post-treatment. Dosage of Furazolidone used in the oral safety experiments was 50 mg/kg of fish per day for 40 days. Mortalities were examined histopathologically for the cause of death or illness. Two fish out of 43 mortalities were undetermined as to the cause of death. No mortalities were attributed to Furazolidone. Furazolidone palatability was tested in the four species of trout by starting with 70 g of Furazolidone/100 lbs of food, and increasing up to 210 g/100 lbs of food. The highest acceptable dose for brown trout was found to be 90 g/100 lbs of food. Highest acceptable dose for rainbow trout was 190 g/100 lbs of food. Brook trout and cutthroat trout fingerlings would accept 170 g/100 lbs of food. Catchable size cutthroat trout accepted 190 g/100 lbs of food.

B. S. Kinnear completed requirements for a Master of Science degree, investigating fishes and fish habitats in Black Canyon of the Gunnison National Monument. The National Park Service furnished funds for his salary and expenses. Seven species of fishes were captured in Black Canyon of the Gunnison National Monument: rainbow trout, brown trout, white sucker, bluehead sucker, flannelmouth sucker, speckled dace, and bonytail chub. Suckers dominated the fish fauna. Two water temperature patterns existed within the Monument canyon. A diel temperature inversion developed from April to May. Temperature at 3:00 AM averaged 2^{o} F warmer than temperatures at 3:00 PM. Highest water temperature recorded in 1964, 1965, and 1966 was 68, 64, 61^{o} F respectively and lowest temperature recorded each year was 32 F. Maximum water volumes through the Monument canyon occurred in June and minimum volumes in September. Average volume during the 1965 water year was the 14th highest recorded and average volume in the 1966 water year was the second lowest recorded. Five habitat types were described: cataract, rapid, run, pool, and riffle. Percentage of pool and riffle increased and the others decreased as water volume and velocity decreased. Black Canyon is an ecological threshold between the upper and lower reaches of the Gunnison River.

C. J. Walters completed requirements for a Master of Science degree, with support as a National Science Foundation Fellow. He studied distribution and production of midges (Tendipedidae) in an alpine lake, reporting as follows: Larval populations and emergence of midges were sampled during the summer of 1966 in Emmaline Lake, Colorado. The fish population was removed from this alpine lake in 1964. Emergence was sampled using surface cone traps. Midge emergence was extremely variable in time and space, greatest numbers emerging in early summer over broken rock and sandy shoreline areas. Weight of emerging midges was often greatest over the mud lake bottom where it bordered rocky slopes. Taxonomic diversity was high; at least 10 species of midges occurred in emergence samples. Statistically, emergence counts followed the negative binomial distribution with "k" usually in the range 0.1 to 0.2, suggesting contagion. Larval populations in mud bottoms were not clearly correlated with emergence over mud areas. Survival of pre-emergent larvae to adulthood was low, but 20 to 50 adults emerging per m^2 in late July were apparently enough to yield larval populations of over $5000/m^2$ by late September. Larval growth and net biomass production were greatest in early summer and fall. Detectable larval mortality occurred only in late fall.

Two types of traps are being tested to measure the emergence of midges. Square traps float on the surface and circular cone traps float just beneath the surface. Midges are an important food of trouts in high lakes and sampling of emergence is an index of availability to fish food. (Colorado)

Eleven 1/10th acre ponds were constructed for bait fish rearing studies. Each pond has a separate inlet and outlet. Funds for the construction were provided by the Bureau of Commercial Fisheries under PL 88-309 and by the Colorado Department of Game, Fish and Parks. (Colorado)

313-165 O-68—3

M. G. Wickham completed requirements for a Master of Science degree, studying the physical microhabitat of stream trout. He noted the following: The physical microhabitat of stream-dwelling fishes is relatively unknown. Research with albino brook trout suggests a previously-unreported scheme of fish habitation, the focal point concept. This concept is expressed in focal point residency and in movements away from the focal point. Each focal point is a relatively small area representing less than 3% of the area over which the fish ranged. During a 50-day study period, an average of 15% of each study section was utilized 95% of the time. Most focal points had a slow water area (0.33 ft/sec average) overlain by a swift water mass (0.86 ft/sec average). Study fish occupied the slow water area almost exclusively with the exception of occasional short (time) trips into the swifter layer. All focal points had a high spatial correlation with cover and a high percentage of time (94%) was spent in shaded areas. Movements took place in small amounts of time (6% of all observational time) and over relatively large areas of the stream (up to 25% of the available stream area). In a large percentage of the movements (66%) fish left and returned to a focal point.

R. W. Gregory, Ph.D. candidate and employee of the Colorado Game, Fish and Parks Department, investigated protein metabolism in fish sperm. His study should be completed by late 1968.

D. J. Horak, Ph.D. candidate and another employee of the State of Colorado, worked on survival and creel return of hatchery-reared rainbow trout in relation to stamina. He plans to complete his work in 1969.

S. Flickinger, Ph.D. candidate with salary provided by the Bureau of Commercial Fisheries, investigated production of fathead minnows under intensive management in the Rocky Mountain region. His work should end late in 1969.

R. A. DeLong, Ph.D. candiate, studied protein polymorphisms in some salmonid fishes. He tentatively plans to complete his work in 1969.

C. J. Walters, a Ph.D. candidate on NSF fellowship, worked on effects of fish introduction on the invertebrate fauna of an alpine lake. He should complete his work in 1969.

P. A. Stewart, a Ph.D. candidate, worked on trout cover, water velocity, and water depth as they influence trout populations in a small stream. He should finish late in 1970.

A. K. Andrews, M.S. candidate supported by the Bureau of Commercial Fisheries, investigated life history of the fathead minnow in Colorado, and is scheduled to complete his work in 1968.

H. W. Li, M.S. candidate, surveyed fishes of the South Platte River basin, and hopes to complete his work in 1968.

C. B. Schreck, M.S. candidate supported by the National Park Service, surveyed the trouts of the upper Kern River basin in California. He should complete his thesis in 1969.

S. E. Turner, M.S. candidate supported partly by a Jack Falcon fellowship, worked on water velocity and coexistence of hatchery-reared rainbow trout and wild brown trout. He is tentatively scheduled to complete his study in 1969.

Georgia Cooperative Fishery Unit

The Georgia Cooperative Fishery Unit was established on October 11, 1962. Mr. Melvin Huish served as Acting Leader of the Georgia Unit in 1967.

The activities of the Unit were supervised by a Coordinating Committee which met semi-annually. Members of the committee were Dr. Leon A. Hargreaves, University of Georgia, Mr. Howard D. Zeller, Georgia Game and Fish Commission (Replaced by Mr. Leon Kirkland), Mr. James R. Fielding, Bureau of Sport Fisheries and Wildlife (Replaced by Mr. Robert Webb), and the Acting Unit Leader.

Mr. Huish continued independent research during 1966 on cardiac and opercular rate responses to several chemicals. The results will form a doctoral dissertation. Other activities were largely associated with student research. He also taught 2 fisheries courses for 35 students.

Fishery studies by students:

W. Lorio, Ph.D. candidate on Hatch funds, studied the relationships of insecticide residues in an aquatic environment.

M. A. Callaham, Ph.D. candidate, studied effects of antimycin in southeastern waters. The work will be completed about 1969.

R. L. Busbee, Ph.D. candidate, studied the physical, chemical and biological differences exhibited in impounded waters under 2 methods of water discharge. A final report will be completed in 1968.

R. R. VanKirk, Ph.D. candidate funded by the U.S. Forest Service, is investigating trout habitat in selected streams on Georgia national forests lands. The work will terminate in mid 1968.

D. R. Holder, M.S. candidate funded through the Georgia Water Resources Research Center (Water Resources Act), studied water quality gradients in Lake Sidney Lanier and completed his thesis.

S. E. Wright, an M.S. candidate specially funded in part by the Georgia Game and Fish Commission, worked on the life history and taxonomy of the Flint River redeye bass (Micropterus coosae). Thesis results were as follows: The study of the life history and taxonomy of the Flint River redeye bass was completed on June 30, 1967. One hundred and thirty-seven bass were examined from the study area. Greatest growth was in the first three years of life and was probably influenced by water level and turbidity. Fecundity ranged from 5,396 to 21,779 eggs per female, and was directly related to size of the female. Maturation occurred in the third and fourth year of life. The more important foods in the diet were insects, crayfish and fish. Smaller fish consumed more insects and larger fish more crayfish and fish. In both years of the study, spawning occurred in late May after a rise in water level. Water levels may be more important than is realized in initiating spawning. The Flint River form of Micropterus coosae exhibits most variation from the upland form in scale counts, pyloric caeca number and body proportions. Despite these differences in taxonomic characters, the Flint River form was identifiable as Micropterus coosae, Hubbs and Bailey.

S. E. Wright, Ph.D. candidate funded by the Sport Fisheries Research Foundation, studied the influence of 2 levels of water discharge on the limnology, biology and sport fishery of Lake Russell. The work should be completed by 1970.

R. Rees, M.S. candidate financed by the Anadromous Fish Program, investigated the ecology of striped bass in 3 diverse habitats in Georgia. The study should be done by 1970.

Hawaii Cooperative Fishery Unit

The Hawaii Cooperative Fishery Unit was initiated February 18, 1966. Dr. J. A. Maciolek became Unit Leader on the same date. An Assistant has not been employed. The Coordinating Committee is made up by Mr. Jack Hemphill, Bureau of Sport Fisheries and Wildlife, Mr. Michio Takata, Hawaii Division of Fish and Game, Mr. V. E. Brock, Hawaii Institute of Marine Biology, and the Unit Leader.

Two long-term studies have been undertaken by the Unit Leader on Hawaiian streams. One of these concerns the life history and trophic ecology of the atyid shrimp or opae that occurs in virtually all permanent streams at elevations up to 4,000 feet. Once a prominent food item of the Hawaiians, this small (2-inch) crustacean is fished only to a limited extent today. It is, however, the most abundant animal in many streams and would be the basic food of fishes established in such locations.

Generally, streams support less than a dozen species of macroscopic invertebrates because of Hawaii's isolation and geologic youth. This isolation in some instances has led to the development of peculiar endemic forms. Some of the major discoveries of the current survey are: an aquatic hymenopteran, probably a new genus, that parasitizes diptera larvae; a yet-unidentified aquatic moth larva that appears to occupy a "caddisfly" niche; two or more sub-aquatic case-making insects that have characters of both Trichoptera and Lepidoptera--authorities feel that these may represent a new major taxon of insects. Adults of one form have been successfully reared in the laboratory from the larval stage.

Hawaii has few natural freshwater lakes because of high permeability of the soil and rock. A survey of such environments has indicated, as with streams, a species-impoverished fauna. The two most notable lakes surveyed thusfar are: Waiau, at 13,020 feet elevation on Mauna Kea, possibly the highest lake in the United States; Wai Ele'ele, "discovered" by Unit personnel in the dense rain forest at 6,700 feet on Haleakala.

Fishery studies by students:

S. Malecha completed requirements for a Master of Science degree with a thesis titled "Studies on the serum protein polymorphisms in some populations of introduced freshwater fishes." It concerned different species of Tilapia from different locations on the island of Oahu. He found that of the 7 enzyme systems studied, esterases and transferrins were good indices of phenotypic differences. Six phenotypes governed by 3 alleles, and 3 phenotypes governed by 2 alleles, were described for the transferrin and esterase systems, respectively. Another highlight of Malecha's study was the development of a simple coefficient which describes the degree to which a population is inbred.

R. Wass received a Master's degree, with research concerning the fish population on an isolated 1/3-acre reef--its species composition, standing crop biomass and repopulation. By removing and retrieving the entire population with rotenone, nearly 5,000 fish representing 77 species were recovered. Actual standing crop was 1,117 lbs/acre. Repopulation has been slow, and although the project has terminated formally, observations have been continued. The study reef has been compared with a nearby control reef using Simpson's index of diversity.

D. Kawate, M.S. candidate, undertook a comparative ecological study of two Oahu streams. His anticipated completion date is January 1969.

J. McVey, Ph.D. candidate, began a study of the general ecology of an artificial reef. The study should be completed in 1969.

E. Murchison, a Ph.D. candidate, investigated the recreational fishery and sport fish ecology of Hanauma Bay. He should finish in 1969.

S. Swerdloff, Ph.D. candidate, studied the comparative ecology of selected Chromis species. He plans to complete his work in 1969.

A. Timbol, M.S. candidate, studied growth rates of milk fish (Awa) fed different commercial diets. He hopes to complete his degree in 1968.

Idaho Cooperative Fishery Unit

The Idaho Cooperative Fishery Unit was established September 1, 1963 by cooperative agreement. The first Assistant Unit Leader reported April 15, 1964, and the Unit Leader reported June 15, 1964.

The Coordinating Committee is made up by the Regional Director, Bureau of Sport Fisheries and Wildlife or his representative; Dean Ernest Wohletz, College of Forestry; Mr. John R. Woodworth, Idaho Department of Fish and Game; and the Unit Leader.

Most research of Unit Leader Dr. D. W. Chapman is conducted as part of graduate student programs. An exception is a study of behavior of juvenile chinook salmon and steelhead at low water temperatures. This work has suggested that most over-wintering steelhead and salmon in Idaho generally remain in the stream substrate as long as temperatures remain below about 41° F. Laboratory work to date confirms field observations. Dr. Chapman taught 2 courses to 25 students.

In addition to graduate student supervision, the Assistant Leader, Dr. T. C. Bjornn, conducted studies of the yield of smolt steelhead and chinook salmon from the Lemhi River, survival and emergence of chinook salmon and steelhead fry from substrata with varied proportions of gravel and granitic sand, and methods of estimating the sport catch of salmon and steelhead from Idaho waters. Considerable support was provided the Unit by Dingell-Johnson funds from the Idaho Department of Fish and Game.

Fishery studies by students:

E. H. Edmundson, M.S. candidate, completed a thesis on diurnal and diel movements of juvenile steelhead trout and chinook salmon. Diel and diurnal movements of juvenile steelhead trout (Salmo gairdneri) and spring and summer run chinook salmon (Oncorhynchus tshawytscha) were measured with snorkel gear in segments of two Idaho streams. For steelhead trout, the observed daily movements were less than 3 meters in 60% of the observations and less than 6 meters in 85% of the cases. Sixty-seven percent of the observed daily movements for juvenile chinook salmon in a stream aquarium 10 meters long were less than 0.6 meters. Fish frequently remained at one point or station for periods of at least several days, and in the same area for periods of several weeks during the summer. Steelhead trout were inactive at night, occupying bottom areas of low velocity, usually inshore. During the day they were in areas of moderate current. Chinook salmon were observed at night both on the bottom and near the water surface in quiet water, and on the bottom in flowing water. Chinook salmon were found at all depths in quiet water during the day. In winter, some steelhead trout were found in the substrate in the same area they occupied the previous summer.

G. L. Munther, M.S. candidate, completed his work on movement and distribution of smallmouth bass. Movements and distribution of smallmouth bass (Micropterus dolomieu) were studied in the Snake River. Seventy-six percent of tagged bass recovered after being free at least seven days were recovered in the same pool in which they were tagged. Of those that had moved, 71% had moved less than 1200m. Movement that occurred interseasonally was, in part, due to changes in habitat preference at different seasons. In spring smallmouth occupied warm shallow pools as well as the main river channel and in summer they occupied pools, eddies and slow runs having a broken rock substrate. During late fall and winter smallmouth occupied still pools at least 3 m deep and under laboratory conditions went beneath the substrate when temperatures were below 6.7° - 7.8° C. During summer smallmouth moved throughout an entire pool, associating with the edge of the current during early morning. During midday some moved into quiet surface waters, and in late afternoon were similarly located, but those that were not associated with the edge of the current were in deeper water than at midday. At night they were on or beneath a broken rock substrate in quiet water.

F. Everest, Ph.D. candidate, studied the factors affecting distribution and relative abundance of juvenile steelhead trout and chinook salmon. He will complete his work in 1968.

J. Keating, M.S. candidate employed by the Idaho Fish and Game Department, continued his work on life history and food habits of smallmouth bass in the Clearwater and Salmon rivers. He hopes to finish in 1968.

W. Miller, Ph.D. candidate funded on a Dingell-Johnson contract, studied the factors causing emigration of chinook salmon fry in the upper Salmon River. His thesis should be completed in 1969.

H. Gibson, M.S. candidate funded by the U.S. Forest Service, investigated the effects of Zectran insecticide on aquatic organisms. His thesis will be completed in 1968.

C. Armour, Ph.D. candidate, studied identification of races in adult chinook salmon in the Snake River. He plans to terminate in mid 1969.

R. Raleigh, Ph.D. candidate employed and funded partly by the Bureau of Commercial Fisheries, worked on innate migrational behavior of emerging sockeye salmon fry. He will complete his thesis late in 1968.

J. Edgington, M.S. candidate, worked with effects of logging on small trout streams of northern Idaho. His thesis should be completed in 1968.

C. M. Falter, Ph.D. candidate salaried and partly funded by the National Defense Education Act (NDEA), studied feeding responses and food assimilation in northern squawfish. He plans to terminate in 1969.

J. Griffith, Ph.D. candidate salaried and partly funded by National Defense Education Act, began a study of interspecific interactions. He tentatively is scheduled to finish his degree in 1970.

D. Gordon, Ph.D. candidate salaried by special contract with the Bureau and funded in part by the Idaho State Applied Research program and partly by special grant from Idaho Department of Fish and Game, began a 2-year research problem on socio-economics of Idaho sport fisheries, planning a completion date in 1970.

H. Pollard, M.S. candidate, began study of interaction of hatchery-planted catchable trout and juvenile anadromous fish. He hopes to complete his work in 1969.

Iowa Cooperative Fishery Unit

The Iowa Cooperative Fishery Unit was established December 20, 1965. Dr. Robert Muncy became Unit Leader April 1, 1966 and Mr. Ross Bulkley became Assistant Unit Leader September 19, 1966. The Coordinating Committee is composed of Dr. K. D. Carlander, Iowa State University, Mr. E. B. Speaker, Iowa State Conservation Commission, Mr. R. W. Burwell, Bureau of Sport Fisheries and Wildlife, and the Unit Leader.

The Unit Leader studied walleye in the Des Moines River to evaluate year-class strength. The Assistant Unit Leader continued a project on factors associated with maturation and reproduction success of Clear Lake yellow bass. Unit Leader with the Assistant Unit Leader directed the graduate program for one Doctoral student and three Master of Science candidates. Dr. Muncy taught Ichthyology and assisted in a course in Fishery Management.

Fishery studies by students:

J. Shireman, Ph.D. candidate, completed his thesis, investigating protein fractions in bluegill sunfish. Total serum protein levels of bluegill sunfish in experimental tanks were reduced 30% after 36 days of starvation. Cellulose-acetate electrophoresis identified four major serum protein fractions. Serum protein patterns of bluegill from study ponds indicated differences in percentage protein fraction within ponds, sexes and collection dates as well as statistical interactions. Electrophoretic analysis of serum proteins must consider environmental and physiological factors causing variation.

G. Atchison, M.S. candidate, studied the life history of yellow bass, completing his thesis. Since yellow bass show little sexual dimorphism, gonadal examination was necessary to determine sex except during spawning. Most male yellow bass matured at age III and females at age IV. Eggs hatched within 2 to 3 days depending upon temperature. Mass mortalities in 1965 and 1966 did not increase growth rates of residual yellow bass.

F. Bulow, Ph.D. candidate, examined possible biochemical indicators of growth in shiners, and should complete his work in 1969.

W. Gale, Ph.D. candidate, studied seasonal changes in the bottom fauna and fishes in a pool of the Mississippi River. He plans to terminate late in fall of 1968.

D. Jude and R. Ranthum, M.S. candidates, studied seasonal changes in fish distribution in the Mississippi River and certain environmental effects. Both students hope to complete theses in 1968.

313-165 O-68—4

F. Jernejcic, M.S. candidate, studied food preferences of walleyes in Clear Lake, and plans to complete his work in 1969.

T. Jacobsen, M.S. candidate, investigated water temperature dynamics of Clear Lake. His thesis should be done by mid 1968.

D. Huggins, M.S. candidate, studied the limnology of DeSota Bend Lake and is scheduled to complete his thesis in 1968.

Louisiana Cooperative Fishery Unit

The Louisiana Cooperative Fishery Unit was established on June 26, 1963, with the signing of an agreement by Louisiana State University, Louisiana Wild Life and Fisheries Commission, and the Bureau of Sport Fisheries and Wildlife.

Mr. William Herke was Acting Leader from June 26, 1963 to February 27, 1964, when Dr. R. Oneal Smitherman became Unit Leader. Dr. Smitherman resigned as Unit Leader, effective July 1, 1967. Mr. Herke was again Acting Leader from July 1, 1967 until November 4, 1967, when Dr. Jerry C. Tash became Unit Leader.

Activities of the Unit are supervised by a Coordinating Committee which meets semi-annually. Members of the committee are: Dr. J. Norman Efferson, Louisiana State University; Mr. Ernest C. Martin, Bureau of Sport Fisheries and Wildlife; Mr. Joe L. Herring, Louisiana Wild Life and Fisheries Commission, and the Unit Leader.

The Assistant Unit Leader continued the study of the comparative value of semi-impounded and natural marshes as nursery areas for fishes, shrimps and crabs. This project will be placed under the supervision of two graduate students in early 1968 at which time the Assistant Leader will begin work on his 1966-1967 data for a doctoral thesis.

The Unit Leader taught Fishery Pathology to 7 graduate students.

Fishery studies by students:

H. A. Loyacano, Jr., completed the M. S. degree with a thesis on acute and chronic effects of salinity on two populations of red swamp crawfish (Procambarus clarki). Salinity tolerance was compared between an inland population of red swamp crawfish (Procambarus clarki) from Baton Rouge, Louisiana, and a coastal marsh population from Grand Chenier, Louisiana. Newly hatched red swamp crawfish were killed in less than one week in salinities of 15, 20, and 30 ppt. Crawfish

40 to 120 mm showed no significant mortality after one week in salinities up to 30 ppt. Thirty-millimeter crawfish exposed to salinities of 0, 10, 20 and 30 ppt for four weeks grew very little when fed fresh fish flesh, tropical fish food pellets and Oedogonium sp. All 30 mm crawfish in 30 ppt died. Growth varied inversely with salinity. Crawfish 40 to 50 mm total length held in 0, 10, and 20 ppt salinity for four weeks had average increases in weight of 4.4, 13.5 and 4.9 percent, respectively, when fed mixed green algae, although they ate the algae continually. Those in 10 ppt grew faster than those in 0 and 20 ppt. Differences in growth were insignificant in 0 and 20 ppt. Molting occurred in 20 percent of those crawfish in 0 and 10 ppt, 12.5 percent of those in 20 ppt and 2.5 percent of those in 30 ppt.

W. H. Walker completed his M.S. thesis on crawfish waste as a supplemental diet for channel catfish (Ictalurus punctatus) in Louisiana. The study compared raw and pelleted crawfish processing waste with a commercial feed in ponds. The feasibility of feeding such foods in shallow ponds was explored at Ben Hur Farm, East Baton Rouge Parish, Louisiana. Raw crawfish processing waste was passed through a meat grinder, weighed and fed. Dried crawfish waste was ground into a meal and compressed into 1/8- x 1/4-inch pelleted form. The control was a complex commercial fish ration containing a number of ingredients with vitamin and mineral fortification. Nine experimental ponds of approximately 0.1 to .25 acres each were stocked with channel catfish at a rate of 1,455 per acre. The ponds were blocked into three groups according to size and the three rations were randomly assigned to the ponds in each block. The fish were fed their respective rations daily at a rate of 3 percent of their body weight for 105 days. The commercial ration and the pelleted crawfish waste were fed on a dry weight basis while the raw waste was fed on the basis of its wet weight. A sample of fish was seined every two weeks to adjust feeding rates. Experimental ponds had mean depths of approximately 2 feet. Surface temperatures reached 103°F and maximum bottom temperatures were 88°F. Channel catfish cleaned up all of each of the rations at even the highest temperature during the experimental period. Crawfish waste, which is about 35 percent crude protein on a dry matter basis, appeared to be a potential feed for catfish when in pelleted form but not when fed raw. The raw waste rapidly dispersed in water and most was unavailable for feed. Mean weight gains were .232, .345, and .447 pounds for raw crawfish waste, pelleted crawfish waste, and the pelleted commercial ration, respectively. Crawfish waste, when fed to channel catfish in pelleted form, produced reasonably good growth, but the commercial ration gave the best growth.

G. Stacy III completed his M.S. thesis on the food habits of bowfin. Food habits were studied through stomach analysis for 248 adult bowfin from Lacassine National Wildlife Refuge and other locations in southern Louisiana. Stomach contents of adult bowfin, 22.0 to 71.6 centimeters in total length, were analyzed as to frequency of occurrence, weight, and volume. Major food items for adult bowfin were grass shrimp, crawfish, fish, and insects. No obvious differences in food habits of adult bowfin with relation to locations, size, sex, or season were detected. Only one gamefish, a bluegill, was found in a bowfin stomach. Stomach analyses were also made for 10 fingerling bowfin from Lacassine National Wildlife Refuge. Stomach contents of fingerling bowfin, 3.5 to 5.3 centimeters in total length, were analyzed as to frequency of occurrence and volume. Major food items for fingerlings were planktonic crustaceans, and small insect larvae and naiads. Adult bowfin apparently feed mainly on crustaceans and small non-gamefish in the freshwater marsh environment of southern Louisiana.

K. C. Price investigated the effects of silvex (PGBEE) on animals and plants in farm ponds and determined the silvex residues in the animals, completing his M.S. thesis. Three farm ponds were selected for the study and sampled on a regular monthly basis by seining, shocking, netting and direct observation. Quantitative benthic samples were taken on a monthly basis. Quantitative plankton samples were taken monthly before treatment and at shorter intervals after treatment. Bluegill and carnivorous fish were collected at regular intervals for gass chromatograph analysis of the silvex residues. The ponds were treated with silvex at the rate of eight pounds acid equivalent per surface acre. Fish kills were observed after 50 percent of the ten silvex applications. Gizzard shad (Dorosoma cepedianum), bluegill (Lepomis macrochirus), and largemouth bass (Micropterus salmoides) were the principal species affected. In general, residue values followed the same course. Maximum levels were reached at 24 hours after treatment. This decreased to negligible amounts by one to three weeks after treatment. The highest residue value recorded was 78 ppm for bluegill. Benthic organisms showed an overall pattern of significant increase in numbers. Application of silvex destroyed the normal phytoplankton population which consisted of numerous species. Euglena sp. and dinoflagellates replaced these species. The phytoplankton did not regain its normal structure during the three months that it was observed. Rotifers and crustaceans decreased following silvex application, but they regained their normal population size within one to three weeks.

K. O. Allen, Ph.D. candidate, studied salinity and temperature tolerances of channel catfish and pompano (Trachinotus carolinus), and hopes to terminate in 1969.

J. W. Bellinger, M.S. candidate funded by Louisiana legislative appropriation, studied food habits of pompano, and should finish in 1969.

C. L. Birdsong, M.S. candidate funded by the Louisiana Land and Exploration Company, worked on assessing safe concentrations of chemicals for use in pond culture with pompano. He hopes to complete work in 1969.

R. Boothby, M.S. candidate, studied food habits of redfish (Sciaenops ocellata) and plans to finish work in 1969.

L. de la Bretonne, Jr., M.S. candidate, investigated mineral requirements of red swamp crawfish, and should complete his thesis in 1968.

E. Jaspers, M.S. candidate funded by Louisiana legislative appropriation, studied the ecology of burrows of the red swamp crawfish and tentatively plans to finish his thesis in 1969.

P. W. Ryan, M.S. candidate, investigated food habits, spawning and growth of spotted bass (Micropterus punctulatus) in the Tchefuncte River. He should terminate in 1968.

R. Tomlinson, M.S. candidate, studied food habits of the dolphin (Coryphaena hippurus) off South Pass, Louisiana, and should finish his degree in 1968.

C. G. LaCaze, M.S. candidate working in absentia while employed with the Louisiana Wild Life and Fisheries Commission, is expected to complete his degree in 1968 with a thesis on food and feeding habits of crawfish.

Maine Cooperative Fishery Unit

The Maine Cooperative Fishery Unit was established on November 6, 1962. The Unit Leader was selected immediately and reported for duty in November 1962. The Assistant Unit Leader joined the Unit in August 1963.

The Coordinating Committee was composed of Dr. Kenneth Allen, University of Maine, Dr. W. H. Everhart, Maine Department of Inland Fisheries and Game, Mr. R. E. Griffith, Bureau of Sport Fisheries and Wildlife, and the Unit Leader.

The two Unit Leaders taught Ichthyology to 27 students. Dr. Hatch also taught Limnology to 6 students, and Dr. Haefner taught 2 additional courses to 21 students. Both leaders spent most of their research time assisting graduate students.

Fishery studies by students:

T. R. Embich, candidate for the M.S. degree, studied the ecology of the sand shrimp (Crangan septemspinosa) in the Penobscot River estuary. He should complete his work in 1969.

J. S. Krouse, M.S. candidate, investigated the effects of salinity, temperature and dissolved oxygen on survival of young striped bass (Roccus saxatilis). He plans to terminate in 1968.

J. D. McNeish, M.S. candidate, studied effects of chronic sublethal dosages of DDT on swimming performance of Atlantic salmon parr. The degree should be completed in 1969.

K. Nelson, M.S. candidate, worked on the effects of varied photoperiod lengths and temperature gradients on parr-smolt transformation in hatchery-reared Atlantic salmon. She hopes to complete her degree early in 1969.

P. W. Schneider, Jr., M.S. candidate on an NSF traineeship, studied the role of photoperiod and diet in determining the rate of smolt transformation in hatchery-reared Atlantic salmon. He should receive his degree in 1968.

W. K. Shorey, M.S. candidate, investigated a benthic community of the Penobscot River estuary, and should terminate in 1969. He received partial support from an NSF grant and a Zoology Department teaching assistantship.

Massachusetts Cooperative Fishery Unit

The Massachusetts Unit was officially established in January 1964. Dr. R. J. Reed became Assistant Unit Leader in March 1964, and Dr. J. A. McCann became Unit Leader in September 1963. The Coordinating Committee is composed of Profs. A. D. Rhodes and C. F. Cole of the University of Massachusetts, Mr. C. S. Bridges of the Massachusetts Division of Fish and Game, Mr. I. W. Alperin of the Massachusetts Division of Marine Fisheries, and Mr. R. E. Griffith of the Bureau of Sport Fisheries and Wildlife.

The Unit Leader served as advisor to several graduate students and conducted research in biostatistics. He also taught biometrics to 8 students and team-taught in 2 other courses with 58 students. Dr. Reed assisted with team-teaching in the latter 2 courses and acted as SCUBA certification officer for a number of Bureau personnel. He also is project leader for a grant from the Water Resources Research Center.

Undergraduates punching data on cards to carry out calculations on the University's CDC 3600 computer. (Massachusetts)

Fishery studies by students:

E. F. Zanella, M.S. candidate funded by the Water Resources Research Center, completed his thesis on limnological investigations of selected farm ponds in Hampshire County, Massachusetts. The limnological study of 12 representative small artificial ponds was conducted to determine the quality and productivity of the resource as well as to determine those management procedures necessary to provide a satisfactory fish crop. Information obtained on the physical, chemical and biological characteristics of the 12 ponds for a twelve-month period indicates most of these small ponds are acidic and of relatively low productivity. The ponds are marginal for the survival of both cold water and warm water species. Few ponds are managed for fish at the present time and little interest exists in improving fish crops for pleasure or profit on the part of pond owners. Low interest in small pond resources by fishermen in the area makes extensive management unwarranted. Present criteria for managing these ponds in Massachusetts were evaluated.

C. M. Frisbie, M.S. candidate, wrote his thesis on the age and growth of the striped bass (Roccus saxatilis) in Massachusetts coastal waters. Scale samples from 1056 striped bass caught by fishermen were aged and prior growth back-calculated. Random samples from 1956-1959 were studied to establish recent growth rates and to compare these with better known populations. Generally, growth rates for Massachusetts fish were comparable to those of more southern Atlantic and Pacific coast populations. Greatest annual growth occurred within the second year of life as opposed to the third year maximum found in an earlier study of Connecticut fish. There were no significant differences in length-weight relationships for the four years studied. A greater weight and length at any given age was found for Massachusetts striped bass when compared to recent California and Maryland studies. Large fish exhibited considerable variation in both length and weight. No management changes seem necessary based on the results of this study.

B. L. Freeman, M.S. candidate, evaluated methods of collecting sport fishery statistics in Massachusetts. He should finish his work in 1968.

J. R. Leonard, M.S. candidate, investigated the distribution and composition of fish found in a 32-mile segment of the Connecticut River. His degree should be completed in 1968.

L. C. Belusz, M.S. candidate, studied the relationship of bottom organisms to the food chain of fish species in the Connecticut River above Holyoke Dam. This thesis should be completed in 1968.

Graduate student Charles Keene spreading rotenone in the reclamation of the University's research area at Cranberry Pond, Leverett, Massachusetts.

313-165 O-68—5

C. I. Keene, III, M.S. candidate, studied certain ecological parameters of Cranberry Pond at Leverett. His degree should be completed in 1968.

W. P. Elliot, M.S. candidate, studied ecological parameters in Bassett Pond, near New Salem, and plans to complete his work in 1968.

J. G. Holsapple, M.S. candidate, worked on ecological parameters in Lower Spectacle Pond near New Salem. He should finish his work by mid 1968.

D. W. Frame, M.S. candidate, studied the succession of attached fauna and flora on test panels in the Cape Cod Canal, and plans to complete his thesis in 1968.

A. B. Howe, M.S. candidate, investigated the biology of the Atlantic tomcod (Microgadus tomcod) in Weweantic estuary. His thesis should be done in 1968.

J. A. Stolgitis, M.S. candidate, examined the fecundity and early life history of the tautog (Tautoga onitis) in the Weweantic River estuary. This student took a permanent position with the Rhode Island Fish and Game Department and a completion date for his thesis is uncertain.

R. C. Lebida, M.S. candidate funded by the Water Resources Research Center, worked on the seasonal abundance and distribution of eggs, larvae, and juvenile fishes in the Weweantic River estuary. Lebida left the Unit to work with the Wyoming Game and Fish Commission and, later, the Alaska Department of Fish and Game. His completion date is uncertain.

J. F. Watson, M. S. candidate, worked on the early life history of the American shad (Alosa sapidissima) above Holyoke Dam. He should complete his thesis in 1968.

R. M. Smith, M.S. candidate funded by the Water Resources Research Center and Federal Water Pollution Control Administration, studied the influence of pesticides on the ichthyofauna of the Weweantic estuary. He should complete his thesis in 1968.

D. S. Crestin, M.S. candidate, investigated the ecology of the American smelt (Osmerus mordax) in the Weweantic River estuary, and plans to terminate in 1969.

G. R. Piehler, Ph.D. candidate, worked on developing efficient marine sport fishery statistics in Massachusetts, particularly angler characteristics, preferences and economic impact. His thesis should be completed in 1970.

Graduate student David Frame identifying organisms from test panels used in the Cape Cod Canal study. (Massachusetts)

Missouri Cooperative Fishery Unit

The Missouri Cooperative Fishery Unit was established October 1, 1962. The Unit Leader reported for duty in June 1963. The present Assistant Leader reported for duty in September 1967.

The Coordinating Committee is made up by Dr. R. S. Campbell of the University of Missouri, Mr. P. G. Barnickol of the Missouri Conservation Commission, Mr. R. W. Sharp of the Bureau of Sport Fisheries and Wildlife, and the Unit Leader.

The Unit Leader, Dr. Richard Anderson, supervised the research of several graduate students, concentrating his interests in warm-water fish production and population dynamics. The Assistant Unit Leader, Dr. Daniel Coble, worked in several areas of fishery ecology. The Unit Leader taught trophic ecology to 14 students and worked with several students on special problems.

Fishery studies by students:

L. Stadnyk completed a thesis (M.A.) on the effect of selected pesticides upon carbon uptake and growth in phytoplankton. The study demonstrated that some of the commonly used herbicides and insecticides caused alterations in the rate of growth and production of algal biomass and the rate of carbon assimilation. Addition of small quantities of chemicals to the aquatic ecosystem resulted in lowered primary production by planktonic algae, especially when the toxic chemical was added continuously. The herbicide diuron was completely phytotoxic to Scenedesmus quadricauda. The herbicide 2, 4-D and the chlorinated hydrocarbons caused a reduced rate of growth and a lower rate of caron-14 uptake. Sevin was found to stimulate growth and carbon uptake at all concentrations tested. The organic phosphate insecticide diazinon did not affect growth or carbon uptake at 0.1 ppm and 1.0 ppm although a toxic effect upon carbon-14 assimilation was noted at 10.0 ppm. One of the major limitations of this study was the use of only one species of algae (the green alga Scenedesmus quadricauda). Unquestionably, the effects of the tested chemicals may vary with different groups of algae (i.e., bluegreen algae, diatoms, etc.). A second limitation may be the effect of physical conditions upon the toxic effect of a pesticide. Under different conditions of light, temperature and mineral nutrition, a pesticide may show different effects. Bacteria may play an important part in the detoxification of certain chemicals. Since bacteria were present in the algae cultures, this effect may be important when considering the effect of a compound upon phytoplankton. In conclusion, it can be stated that certain pesticides have an effect upon primary production. The productivity of a body of water may be altered by the

addition of trace amounts of these organic chemicals. From this study it appears that the toxic effect of many chemicals (insecticides in particular) may be more apparent through concentration within the food chain or through direct toxicity to benthos than through their effects on algal metabolism.

G. Divine wrote a thesis (M.A.) on a study of smallmouth bass in ponds with special consideration of minnows and decapods as forage. In an attempt to evaluate the smallmouth bass as a pond inhabitant, two strains of smallmouth bass were stocked with a variety of forage organisms in five warm-water ponds. Ponds were stocked in July 1965 with Minnesota and Missouri strains of young-of-the-year smallmouth bass ranging from 50 to 120 mm total length. Crayfish, freshwater shrimp and four species of minnows were stocked as possible forage organisms in various combinations in the five ponds in May and June 1965. The golden shiner, fathead minnow, red shiner and redfin shiner were found to have different survival rates in the different pond environments. Golden shiner survival was good in all ponds, fathead survival was best in ponds of low to intermediate turbidity and survival of red shiners was best in the turbid ponds. The redfin shiner failed to survive. Crayfish and freshwater shrimp multiplied rapidly in two ponds of intermediate turbidity where they were stocked. Golden shiners fed on a variety of plant and animal materials. The largest of them had the most varied diet and also consumed much higher plant material and filamentous algae. Fathead minnows appeared to feed primarily on detritus throughout life. Red shiners were primarily carnivorous with the larger individuals feeding almost exclusively on insects. Growth of the Minnesota smallmouth bass was greater than that of the Missouri strain in all ponds. The Minnesota strain grew an average of 21 mm from the turbid pond and an average of 79 mm from a less turbid pond during 1966. Crayfish were present only in two ponds of intermediate turbidity and were the most important item in the diet of the bass there. Bass from two turbid ponds consumed primarily insects and tadpoles. In a clear pond tadpoles and minnows were dominant in the bass diet. Because of greater survival and more rapid growth, the standing crop of Minnesota bass was greater than that of the Missouri bass in all ponds in March 1967. Standing crops of bass at the end of the experiment ranged from 10.8 to 58.5 pounds per acre.

T. McComish, Ph.D. candidate, studied growth and bioenergetics of bluegill under controlled conditions. He should complete his work in 1969.

S. Michaelson, M.A. candidate, has worked on age structure and other population characteristics of balanced and unbalanced bass-bluegill populations. His thesis should be finished in 1968.

J. Selgeby, M.A. candidate supported in part by the Bureau of Commercial Fisheries (North Central Reservoir Investigations), investigated the composition, distribution and dynamics of zooplankton in Lake Francis Case. He plans to complete his thesis in 1968.

Montana Cooperative Fishery Unit

The Montana Cooperative Fishery Unit was established at Montana State University, Bozeman, on September 1, 1963. The Unit Leader Dr. Richard Graham began duties September 1, 1963 and the Assistant Leader, Dr. William R. Gould, began duties December 22, 1963. The Coordinating Committee members were: Dr. C. J. D. Brown, Montana State University, Mr. Arthur N. Whitney, Montana Fish and Game Department, Mr. Jack E. Hemphill, Bureau of Sport Fisheries and Wildlife, and the Unit Leader.

Most of the activities of the Unit Leader and Assistant Leader have been in planning and directing graduate student projects. The Unit Leader spent most of the summer in Washington, D. C. where he served on a Bureau of Sport Fisheries and Wildlife committee reviewing state water quality standards. A long-term population study of a trout stream to be initiated by the Unit Leader was temporarily postponed by the above assignment. The Assistant Leader continued to assist Dr. C. J. D. Brown on certain aspects of the taxonomy and distribution of Montana fishes. Dr. Graham taught courses in fisheries management and water pollution to 3 students and Dr. Gould taught Ichthyology to 19 students.

Fishery studies by students:

A. A. Elser, M.S. candidate, studied fish populations of a trout stream in relation to major habitat zones and channel alterations. The project was completed in April 1967. The relationship of fish populations to major habitat zones and channel alterations was studied in Little Prickley Pear Creek, Montana, during the summers of 1965 and 1966. Five major zones were defined as follows: headwater, meadow, mountain, lower meadow, and Wolf Creek Canyon, with at least one representative study section in each. Approximately 23 percent (6 of 30 miles) of the stream has been altered. Field measurements showed no pool-riffle periodicity in the altered mountain sections, while successive riffles were spaced at intervals of 5.7 widths in the unaltered areas. By areas, the altered sections of the mountain zone consisted of 87 percent shallow-fast water with no deep-slow, compared to 49 and 14 percent, respectively, for the unaltered sections.

The amount of cover per acre of stream was about 80 percent greater in the unaltered mountain sections than in the altered. Rock deflectors in the altered section of Wolf Creek Canyon rendered the physical characters of the stream nearly comparable to the unaltered sections.

Fish populations were estimated by means of a simple mark-and-recapture census. Non-trout species were absent from the altered sections, but made up 30 to 58 percent of the total number and weight, respectively, in the unaltered mountain sections. Trout were 78 percent more abundant in the unaltered mountain sections than in the altered. Standing crops of trout ranged from 40 to 226 pounds per acre, and the total stream supported an estimated 20,400 trout greater than 4.0 inches long and a total trout biomass of 9,500 pounds. Channel alterations resulted in a total loss of 4,700 trout with a total weight of 2,200 pounds.

S. Lewis, M.S. candidate, investigated fish populations in pools of various sizes and types. The project was completed in April 1967. The relationship between physical parameters and fish populations of 19 pools of Little Prickley Pear Creek, Montana, was studied during the summers of 1965 and 1966. The pools were mapped and their fish populations sampled. Differences in surface area, volume, average depth, average current velocity, total cover and percent cover accounted for 75, 77 and 70 percent of the variation in numbers of total trout, brown trout and rainbow trout respectively. Current velocity and total cover were the most important factors, and together they accounted for most of the explained variation. Each of these two factors contributed significantly to total trout numbers. Cover was the most important factor for brown trout, and current velocity was most important for rainbow trout. The number of trout per unit of cover (cover quality) and the number per unit of pool surface area (pool quality) increased significantly as current velocity became greater. Deep-slow pools with a large amount of cover had the most stable populations with brown trout being more stable than rainbow trout. Suckers were most common in large, deep-slow pools with extensive cover. The importance of cover to trout is discussed in terms of security and photonegative response, and current velocity in terms of space-food relationships.

M. Kraft, M.S. candidate, worked on the effect of controlled dewatering on trout populations. He should finish in 1968.

W. McClay, M.S. candidate, examined the effect of controlled dewatering on the aquatic insects of a trout stream. The thesis will be completed by April 1968.

F. L. Bandow, M.S. candidate, did a study of the yellow perch in Canyon Ferry Reservoir. He should complete his work in 1968.

E. Avery, M.S. candidate, examined the effects of a sewage effluent on the aquatic invertebrates and fish of the East Gallatin River. He plans to complete his thesis in 1969.

R. G. Marcoux, M.S. candidate, studied the fish populations of Spring Creek, Montana, and should have his thesis written by 1969.

Rock jetties in altered stream channels were evaluated as habitat improvement structures by Montana Unit students.

Part of a radioisotope laboratory at the New York Cooperative Fishery Unit.

New York Cooperative Fishery Unit

The New York Cooperative Fishery Unit was established on September 27, 1963. Dr. A. W. Eipper began duties as Unit Leader December 2, 1963. The Assistant Leader is Dr. C. A. Carlson. The Coordinating Committee for the New York Unit is composed of Dr. D. A. Webster representing Cornell, Mr. W. G. Bentley representing the State Conservation Department, the Unit Leader and Mr. Richard Griffith from the Bureau.

In addition to supervision of graduate students, Dr. Eipper continued investigation of the effectiveness of various methods of marking young fish and collecting large samples of fishes from ponds. He taught one course in fishery resource management. Dr. Carlson continued work on evaluation of predation as a cause of early mortality, and has begun studies of radioisotopes as marks or tracers. He taught one course in fish ecology.

Fishery studies by students:

T. H. Eckert, M.S. candidate, studied predation on largemouth bass in their first year of life, and expects to complete his work by 1969.

D. Mathur, M.S. candidate, worked on food habits of largemouth bass larvae. His thesis should be submitted in 1968.

G. C. Laurence, Ph.D. candidate, investigated the role of food in the mortality of largemouth bass larvae. He should complete his work in 1970.

T. R. Badenhuizen, M.S. candidate, assessed the effects of incubation temperature on survival of largemouth bass embryos. He should finish work in 1969.

R. G. Dudley, M.S. candidate, investigated effects of dissolved oxygen concentration on survival of largemouth bass embryos. He plans to terminate in 1969.

North Carolina Cooperative Fishery Unit

This Unit was established October 1, 1962. Dr. F. Eugene Hester entered duty as Unit Leader on April 15, 1963, and Mr. R. E. Stevens became Assistant Leader on January 24, 1966. The Coordinating Committee members are: Dr. J. L. Apple, North Carolina State University, Dr. D. E. Davis, North Carolina State University, Mr. E. C. Martin, Bureau of Sport Fisheries and Wildlife, and the Unit Leader.

The Unit Leader participated in research with graduate students, and taught a formal course in growth and reproduction in fishes to 5 graduate students. He also assisted in a course in fishery science taught to 45 students. Mr. Stevens worked with graduate students and continued pursuit of the Ph.D. degree by conducting thesis research on hormonal relationships effecting egg maturation and ovulation in centrarchidae. He is also active in striped bass research.

Fishery studies by students:

E. J. Carpenter completed his M.S. degree with a thesis on movements of redbreast sunfish in the Little River, Wake and Johnston Counties, North Carolina. Between August 26, 1965 and July 20, 1966, a total of 116 redbreast sunfish (Lepomis auritus) were trapped, tagged and released within a 16.2 mile length of the Little River in Wake and Johnston Counties, North Carolina. In the autumn between August 26 and October 30, six individual fish were retrapped one or more times each, for a total of eight recaptures, all at the site of their tagging. In 1966 between February 12 and July 20, twenty-nine individual fish gave 33 returns (reported by fishermen) and recaptures (in traps). No movement was noted until May 28 when warm weather and heavy rains raised the river temperature to 65-68°F and increased the water depth 75 cm. On and after May 28, six fish were captured 1.5 to 8.9 miles upstream from the site of tagging. Only one fish was recaptured which had moved downstream (1.9 miles). It appeared that the redbreast sunfish population in Little River was sedentary in the autumn, winter and early spring. An upstream movement in late spring was indicated by the six fish which were captured 1.5 to 8.9 miles upstream from the original site of tagging.

J. V. Merriner, concluded work on the M.S. degree. His thesis was on artificial intergeneric hybridization among four centrarchid genera with an evaluation of egg size as a factor in determining hybridization success. Hybridization experiments were conducted using artificial stripping, fertilization, and incubation techniques. Fertilization and hatching percentages were obtained for each cross. Four categories of hybrid success were found to exist. These were:

A. High success reciprocally: Micropterus X Chaenobryttus

B. Marginal success reciprocally: Pomoxis X Lepomis and Chaenobryttus X Pomoxis

C. High success one-way: Micropterus female X Lepomis male and Chaenobryttus female X Lepomis male

D. Unsuccessful reciprocally: Micropterus X Pomoxis

Early development and emergence were found to be critical developmental periods. Photomicrographs of the various crosses are included. Results are discussed in the context of phylogenetic relationship. Data concerning the time of first hatched and time between first and last hatched are presented. Egg size studies showed that Micropterus eggs were significantly larger than those of the other species. Likewise a highly significant size difference was found between eggs of Lepomis and Pomoxis. It was concluded that egg size should not be considered as a factor determining hybridization success. Data from two experiments conducted to determine the effect of egg size upon hatching time are presented in the thesis.

R. L. Wilbur completed his M.S. thesis on some effects of a herbicide, Kuron, on midge larvae (Tendipedidae), and on the eggs, fry, and young individuals of selected species of fishes. Kuron treatments did not significantly affect the tendipedid populations in three experiments conducted in plastic swimming pools during the summers of 1965 and 1966. In aquarium experiments the effect of Kuron on small chain pickerel (Esox niger), redfin pickerel (Esox americanus), bluegill sunfish (Lepomis macrochirus) and largemouth bass (Micropterus salmoides) was tested. It was found that treatments of 1.0 ppm acid equivalents or more resulted in complete mortality of the pickerels. Hatching of redfin pickerel eggs did not occur at 10.0 ppm acid equivalents and was reduced at 5.0 ppm. The only experiment on hatching and fry survival of chain pickerel was destroyed by fungus. Hatching of bluegill eggs was not influenced by concentrations of Kuron up to 10.0 ppm acid equivalents, but complete mortality of the fry occurred at 5.0 and 10.0 ppm. The differences revealed through residue analyses between laboratory concentrations and the concentrations in natural waters treated the same poses an unresolved problem.

J. L. West, Ph.D. candidate, studied growth and reproductive characteristics of force intergeneric sunfish hybrids. His completion date is not known.

C. R. Stroud, Jr., M.S. candidate, completed his research on the relative values of several techniques for individually marking fishes for later identification. He hopes to receive a degree in 1968.

B. C. Toney, M.S. candidate, is in final stages of preparing a thesis on a comparative study of the growth rate of chain and redfin pickerel and largemouth bass. Toney received some support by the National Science Foundation.

R. G. Hudson, M.S. candidate salaried by the Sport Fishery Research Foundation, studied movements and population dynamics of redbreast sunfish (Lepomis auritus) in Little River, near Raleigh. He should finish his degree in 1968.

B. E. Daughtridge worked toward the M.S. degree, studying survival, growth and food habits of striped bass and striped bass x white bass hybrids stocked into farm ponds containing bluegills and minnows.

W. R. Bonner, M.S. candidate supported in part by funds from the Bureau's Division of River Basin Studies, studied the effect of reservoir design on downstream water quality.. He should terminate in 1968.

H. M. Tyus, a National Science Foundation Fellow working on the M.S. degree, is studying intergeneric hybridization success as a measure of phylogenetic relationships in sunfishes. Tyus plans to complete his work in 1968.

J. C. Meshaw, Jr., M.S. candidate, was funded in part by the Bureau's Division of Fish Hatcheries. His study planned to be completed in 1969, is on availability of zooplankton and their selection by fingerling striped bass.

J. M. Kapetsky, M.S. candidate, is making an electrophoretic comparison of blood properties of 5 sunfishes and their hybrids. He should be done in 1969.

W. D. B. Davies, Ph.D. candidate, began investigating the tolerance limits of temperature, pH and water hardness for fingerling striped bass. He hopes to finish in 1970.

R. C. Hujik, M.S. candidate funded in part by the National Science Foundation, planned a study of the success of fertilization, hatching and survival of all possible crosses within the genus Roccus. He should finish his work in 1969.

Ohio Cooperative Fishery Unit

The Ohio Cooperative Fishery Unit was established on October 10, 1965 by the signing of a cooperative agreement between the Ohio Division of Wildlife, the Ohio State University and the U.S. Bureau of Sport Fisheries and Wildlife.

Dr. Gerald J. Lauer assumed the duties of Unit Leader on April 4, 1966. Stephen H. Taub reported as Assistant Leader on June 20, 1966. Dr. Lauer resigned on May 2, 1967 to accept a position with the Philadelphia Academy of Natural Sciences. Dr. Richard A. Tubb became Unit Leader on June 6, 1967. The Coordinating Committee consisted of Mr. Samuel Jorgenson, U.S. Bureau of Sport Fisheries and Wildlife, Mr. Clarence F. Clark, Ohio Division of Wildlife, Dr. T. J. Peterle of Ohio State University, and the Unit Leader.

The 2 Unit Leaders have worked on an evaluation of strip-mine reclamation for fish and wildlife restoration supported by the Bureau's Appalachia program. The specific objectives of the unit staff were to (1) document the water chemistry of all ponds, (2) compare the biological, chemical and physical properties of large, intermediate, and small ponds of different acidities, (3) to locate ponds capable of supporting fish life and determine the species and age composition of the fishes. Dr. Lauer designed the sampling program. Mr. Taub and Robert E. Deis, an undergraduate research assistant, did much of the field work. Dr. Tubb identified the zooplankton and benthic fauna and analyzed the chemical and physical data collected in the study. Only 12 ponds of the 170 impoundments examined were capable of supporting fishes. Only one pond had a substantial population of fish (bluegills). The bluegill population showed a slower growth rate than the State average for bluegills. Zooplankton consisted almost entirely of rotifers in the ponds having a low pH value.

An analysis of the rainfall and chemical fluctuations of cations in the strip-mine ponds indicated that most of the dissolved salts had been leached from the spoil banks. Much of the surface is still without a ground cover and new surfaces are exposed to erosion. The oxidation of pyrite in the spoil banks continues to decrease the pH of the runoff water. The final report is in manuscript.

The Assistant Leader also worked on an evaluation of largemouth bass use of crayfish as a food supply, and on biology of a chub (Parexoglossum laurae hubbsi).

Unit personnel also taught 2 courses to 6 students and supervised 7 graduate students.

Fishery studies by students:

R. O. Parker, Jr., completed his M.S. thesis on rotenone and fish population estimates. Practically 100% of the fish used in thirteen laboratory tests came to the surface after death by rotenone poisoning. The most common species used were bluegill (Lepomis macrochirus) (540), green sunfish (Lepomis cyanellus) (264), golden shiner (Notemigenus crysoleucas) (143), goldfish (Carassius auratus) (50), and brown bullhead (Ictalurus nebulosus) (42). Environmental factors such as oxygen, total alkalinity, pH, and turbidity seemed to have no influence on this behavior. Water temperature and depth (down to and including ten feet) only influenced the rate at which these fish came to the surface. The rate of surfacing was slower in colder and/or deeper water. Field studies on four impoundments indicate that under certain conditions practically all the dead fish in non-vegetative, shallow

(less than ten feet) impoundments come to the surface and are available for recovery. Species observed in the field were bluegill, green sunfish, orange-spotted sunfish (Lepomis humilis), largemouth bass (Micropterus salmoides), white crappies (Pomoxis annularis), quillback (Carpiodes cyprinus), and black bullheads (Ictalurus melas).

C. B. Stein, Ph.D. candidate, investigated the life history of the three-ridge mussel (Amblema plicata). She should finish her degree in 1969.

E. Thompson, Ph.D. candidate, studied effects of pesticides on hatchability of eggs and survival of fry of several fish species. She hopes to complete her thesis in 1969.

T. R. Tucker, M.S. candidate, studied aspects of the fish population in Hoover Reservoir. The thesis should be completed in 1968.

E. A. Wydallis, a Ph.D. candidate, is assessing the production of corticosteroids by fish under crowded conditions. Her thesis should be completed in 1968.

W. Dudrow, a Ph.D. candidate salaried by the Bureau of Commercial Fisheries, investigated colonization rates of benthic invertebrates in Hoover Reservoir. The thesis is planned for completion in 1970.

Oklahoma Cooperative Fishery Unit

The Oklahoma Unit was established July 27, 1965. Mr. Bradford E. Brown entered duty as Assistant Unit Leader in December 1965, and Dr. R. C. Summerfelt became Unit Leader in September 1966. The Coordinating Committee includes Mr. Lewis Garlick, U.S. Bureau of Sport Fisheries and Wildlife, Dr. M. T. Edmison of Oklahoma State University, Mr. Buford Tatum of the Oklahoma Department of Wildlife Conservation, and the Unit Leader.

The research of the Unit Leader has centered on the ecology of fish distribution, aging flathead catfish, food habits of fishes in reservoirs, and evaluation of stocking flathead catfish in a reservoir where fish populations are already established. The Assistant Unit Leader worked with schooling and shelter-seeking in channel catfish, creel census methods, assessment of commercial fishing in reservoirs, and sampling methods in Lake Raymond Gary.

Unit research work received substantial support from the Bureau of Commercial Fisheries (PL 389), and from Dingell-Johnson funds channeled through the State of Oklahoma.

Unit personnel taught 3 courses to 33 graduate students.

Fishery studies by students:

R. L. Boyer, M.S. candidate, studied aspects of the behavior, fecundity and food habits of the longear sunfish (Lepomis megalotis) in two Arkansas reservoirs. He should terminate in 1969.

R. Hover, M.S. candidate, investigated the influence of aeration and artificial destratification on distribution of fishes in Eufaula Reservoir, Oklahoma, and should finish his thesis in 1969.

I. Inman, M.S. candidate, evaluated shelter preferences of fingerling channel catfish, and hopes to finish a thesis in 1969.

A. Jearld, M.S. candidate, worked on food habits, fecundity and growth of the channel catfish in a 3,000-acre Oklahoma reservoir. His work should be completed in 1969.

P. Mauck, M.S. candidate, studied growth, feeding and reproductive habits of the carp (Cyprinus carpio), from several Oklahoma reservoirs. His thesis should be done by 1969.

J. Norton, M.S. candidate, worked on abundance, distribution and character of sediment in a 3,000-acre 30-year-old reservoir in Payne County, Oklahoma. He plans to finish the thesis in 1968.

M. Parrack, M.S. candidate, evaluated commercial fishing on four Oklahoma reservoirs. His work should be completed by 1969.

R. Spall, M.S. candidate, surveyed the occurrence and distribution of helminth parasites of fishes of Lake Carl Blackwell, Oklahoma. His thesis should be available in 1968.

L. Stavick, M.S. candidate, did a literature review of channel catfish farming.

P. Turner, M.S. candidate, undertook study of the food habits, fecundity and movements of the flathead catfish in a 3,000-acre Oklahoma reservoir. His thesis should be done in 1968.

Oregon Cooperative Fishery Unit

The Oregon Cooperative Fishery Unit was established on July 20, 1966 at Oregon State University, Corvallis. Dr. Raymond C. Simon was appointed Unit Leader on April 10, 1966, and Dr. Richard S. Wydoski became Assistant Unit Leader on September 25, 1966. Dr. Simon is assigned to the main campus at Corvallis, and Dr. Wydoski is headquartered at the University Marine Science Center at Newport.

Experimental apparatus for coho salmon genetics study. Each trough contains offspring from a single cross enabling back-reference of offspring traits to parental traits. (Oregon)

Samples of blood are withdrawn from steelhead trout by sterile cardiac puncture. Blood is later used as source of leukocytes for chromosome study, and for genetic studies of serum enzymes. (Oregon)

The Unit is associated with the Department of Fisheries and Wildlife in the School of Agriculture. Activities of the Unit are administered through a Coordinating Committee composed of Dr. Thomas E. Kruse, Oregon Fish Commission; Dr. Thomas G. Scott, Oregon State University; Dr. John Rayner, Oregon Game Commission; and Mr. Jack Hemphill of the Bureau of Sport Fisheries and Wildlife. Dr. Simon serves as Executive Secretary of the Committee.

The research program of the Unit Leader is concentrated on fish genetics. Objectives of these studies are: (1) to define levels of genetic heritability for desired characters to enable improved artificial selection practices, and (2) to investigate evolutionary history of fishes by chromosome studies and (3) to study patterns of inheritance of several serum enzymes. The research of the Assistant Unit Leader is concerned with biological studies on marine and estuarine fishes and with the life history of cutthroat trout in coastal streams.

Dr. Simon worked with thesis supervision for 5 students and in addition supervised 3 students in Fisheries 505, Reading and Conference.

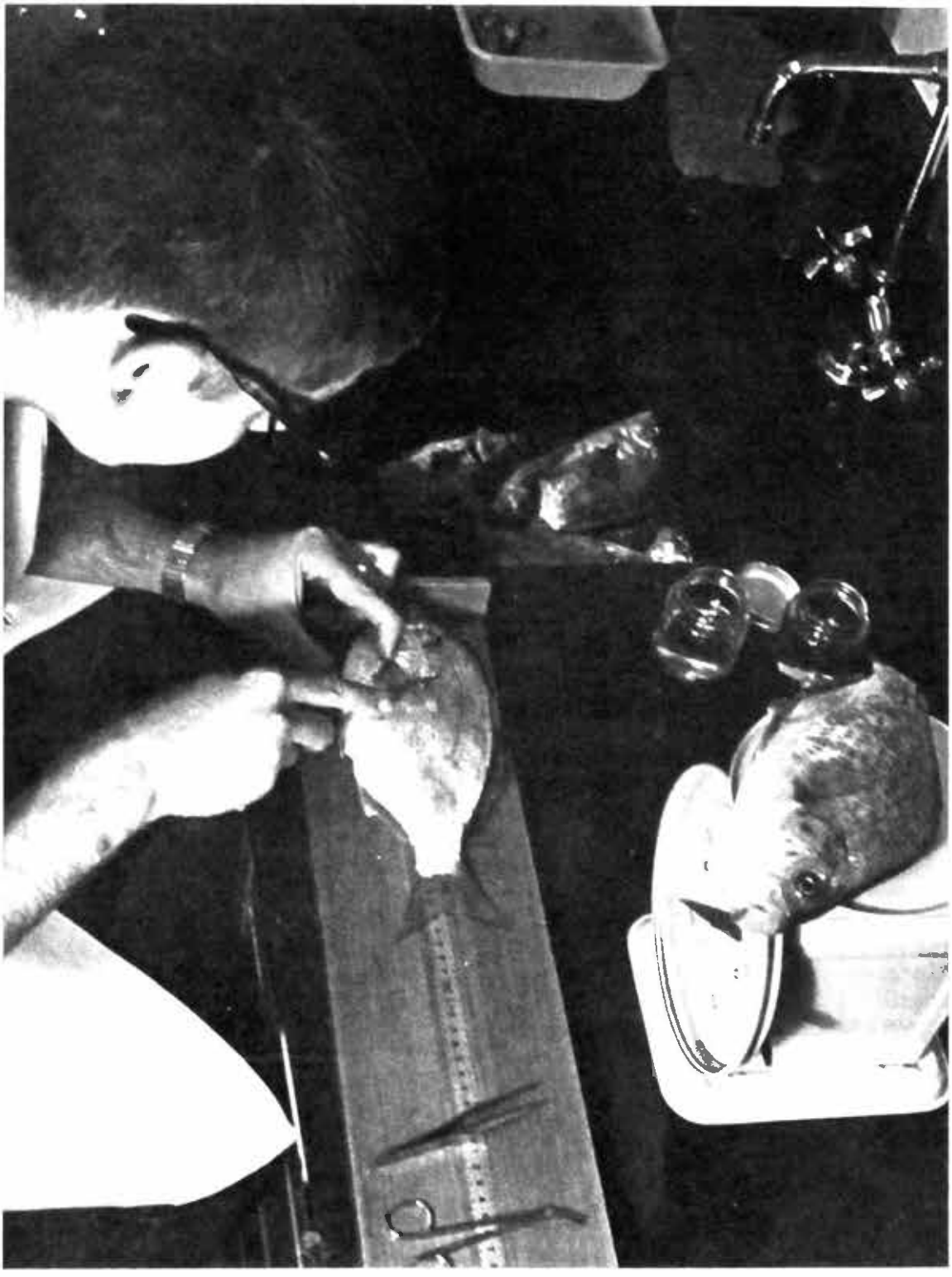
Fishery studies by students:

D. E. Bennett, M.S. candidate, is studying populations of red-tailed surf perch along the Oregon coast. This study involves age and growth determinations and fecundity estimations. Project completion date is anticipated in May 1969.

A. J. Gharrett, a candidate for the M.S. degree is studying the similarity of nucleic acids between and within species of salmonid fish. Project completion date is scheduled for June of 1969.

J. R. Graybill, Ph.D. candidate, is studying population genetics in coho salmon to estimate the relative contributions of additive genetic effects, environmental effects, and dominance to the expression of growth rate, size, number of eggs, age at maturity, survival, and efficiency of food conversion. Facilities, new construction and assistance in this study are provided by the Oregon Fish Commission through co-sponsorship of the Anadromous Fish Program. Project completion is scheduled for June 1970.

R. L. Wilmot, M.S. candidate, is studying chromosomes in salmon and trout to improve leukocyte culture techniques and other methods for chromosome demonstration before approaching questions of chromosome mechanics as they relate to vertebrate evolution. He hopes to complete the project in September 1970.



Red-tailed surf perch provide size and age data in study by Unit student Donald Bennett. (Oregon)

Pennsylvania Cooperative Fishery Unit

The Pennsylvania Cooperative Fishery Unit was established February 29, 1964. Dr. Robert L. Butler reported at the University in November 1963. Dr. Anthony Bodola came to the Unit in September 1964. Upon transfer of Dr. Bodola, Dr. Donald Hales came to the Unit September 1967.

The Unit Coordinating Committee is made up as follows: Dr. Alex Black, Pennsylvania State University, Mr. Robert Bielo, Pennsylvania Fish Commission, Mr. Richard Griffith, Bureau of Sport Fisheries and Wildlife, and the Unit Leader.

The research of the Unit Leader and Assistant Leader is interwoven with the work of graduate assistants. They have concentrated on the behavior of smallmouth bass as related to overhead cover under conditions of acid mine pollution, effectiveness of the bowfin as a predator on bluegill, the effects of fluctuating stream flows on invertebrate populations, and the effects of an insecticide (Sevin) on macro-invertebrates. The Federal Water Pollution Control Administration has also supported work by unit personnel on the distribution of fish in Pennsylvania as related to acid mine drainage.

Unit personnel assisted with some teaching in animal behavior, ichthyology, and limnology.

Fishery studies by students:

L. Helfrich, a candidate for the M.Ed. degree, completed a thesis on the effects of rotenone on macro-invertebrates in Sinking Creek, Centre County. The four orders of macro-invertebrates studied (Trichoptera, Ephemeroptera, Plecoptera, and Diptera) exhibited a reduction in number after rotenone was introduced into their environment. The other orders of macro-invertebrates found in the bottom and drift samples were represented by too few organisms to be useful in detecting population changes. An examination of the bottom samples from all stations except one shows an overall decrease of 52% for the Trichoptera (225 organisms to 107), 44% for the Ephemeroptera (410 organisms to 228, 97% for the Plecoptera (103 organisms to 3), and 96% for the Diptera (818 organisms to 41). A comparison of the normal drift rate with the post-treatment drift at one station showed a marked increase in the latter of every organism studied. The decrease of macro-invertebrates in the bottom and the increase in the drift indicate that most organisms were affected, in varying degrees, by rotenone.

T. Haines completed the M.S. degree. His thesis concerned the behavior of smallmouth bass as related to artificial cover. It was demonstrated that yearling smallmouth bass utilize shelter in flowing water. When artificial shelter in the form of plexiglass coverts was presented to the fish, utilization of the coverts was related to the features they offered and water velocity. An area of darkness, quiet water and visual reference was shown to be important in covert use. Thigmotropism could not be demonstrated. Use of coverts was increased when water velocity was approximately doubled. The extremely high use of the most complex cover indicates that this response is a characteristic of the species. Out of 7,200 seconds for each test replicated 16 times use of the most complex covert was 7,190 seconds with a standard error of six seconds. The probability of this occurring by chance compared to the same area of the stream aquarium without cover was less than .001.

D. Berliner, M.Ed. candidate, studied criteria of stunting in centrarchid populations. His thesis should be completed in 1968.

J. Francis, M.Ed. candidate, investigated the response of acclimatized amphipods, Gammarus, to lower dissolved oxygen concentrations. His thesis is tentatively planned for completion in 1969.

N. Silverstrim, M.S. candidate, worked on an ecological study of an alkaline stream with heavy iron deposits originating from treatment of mine acid water in Beaver Run, Clearfield County. The thesis should be done in 1969.

B. Randall, M.S. candidate, studied immature stages and growth of three mayflies: Stenonema canadense, S. ithaca, and Paraleptophlebia mollis. His thesis should be completed in 1968.

L. J. Fritchman, M.S. candidate, assessed effects of cover on the agonistic behavior of smallmouth bass, and plans to finish in 1968.

R. Ellis, Ph.D. candidate, studied population dynamics of the isopod Lirceus lineata as related to fish production in Lower Spring Creek, Centre County. The thesis should be completed by 1970.

R. J. Klauda, M.S. candidate, studied behavior of smallmouth bass as a response to cover under soft water conditions, and plans to complete the thesis in 1968.

T. H. Wohnsiedler, Ph.D. candidate, worked on the effects of organic pollution on hatchability and survival of brook trout, as well as production and growth of brown trout in Spring Creek. The thesis should be written in 1969.

South Dakota Cooperative Fishery Unit

The South Dakota Cooperative Fishery Unit was established in July 1965, and activated in September 1965 when Dr. Alfred C. Fox reported for duty as Unit Leader. The Assistant Leader position was filled by Dr. Richard A. Tubb in June 1966. Dr. Tubb left in June 1967 to fill the Unit Leader position at Ohio State University. The Assistant Leader position remained vacant until late August when Mr. Richard L. Applegate transferred to the unit from South Central Reservoir Investigations.

The Coordinating Committee meets annually with the Unit Leader serving as Chairman. Members of the Committee are: Dr. Duane Acker, South Dakota State University; Mr. Robert Hodgins, South Dakota Department of Game, Fish and Parks; and Mr. Robert Burwell, Bureau of Sport Fisheries and Wildlife.

The Unit research effort is aimed at a number of problems which the South Dakota Department of Game, Fish and Parks consider important to their program. Most of these problems concern the sporadic fishery produced by shallow eutrophic lakes which are highly productive but subject to periodic fish-kills and stunted overpopulations. The role of agricultural land practices including feedlot operations, chemical fertilization, biocide applications, and erosion will be investigated.

It is anticipated that some of the Unit students will participate in project work of other Federal programs such as North Central Reservoir Investigations, Bureau of Commercial Fisheries, and the Division of Fish Hatcheries.

Dr. Fox taught fisheries science and Mr. Applegate taught aquatic ecology to 12 students.

Fishery studies by students:

T. Felix, M.S. candidate, studied movements of forage fish in a South Dakota stream, completing his thesis. Movement patterns of Semotilus atromaculatus, Rhinichthys atratulus, Campostoma anomalum and Catostomus commersoni were investigated in an eastern South Dakota stream for a period of one year. Electrofishing, fin clipping and a multiple census method were employed. Population structures were estimated for each species. Populations were considered unstable due to the occurrence of appreciable emigration and immigration between sampling periods. Differential size class mobility was established for all species. All species exhibited upstream movement tendencies during the summer and more random movement tendencies during the fall. Size classes of S. atromaculatus, R. atratulus and C. anomalum showed

differential upstream movement affinities. Considerable growth recruitment occurred in the smaller size classes. Greater mobility of larger size classes of all species was found.

Marking mortality was considered negligible for S. atromaculatus, C. anomalum and C. commersoni but highly significant for R. atratulus. Upstream summer migrations and downstream winter migrations were the general movement trends of all species. All species were classified as semimobile because of mobile and sedentary qualities.

L. Kallemeyn, M.S. candidate, studied the ecological impact of stocked brook trout on the indigenous fish and invertebrate populations of the South Fork of the Yellowstone River. The thesis should be completed in 1968. Kallemeyn also worked with Dr. Fox on a special study of ammonium nitrate as an inexpensive explosive for stream improvement.

J. Congdon, M.S. candidate, surveyed fish populations in Lake Poinsett and hopes to complete this thesis in 1968.

T. Clifford, M.S. candidate, studied movements of bigmouth buffalo and carp in Lake Poinsett, South Dakota, planning to finish his study in 1969.

V. Starostka, M.S. candidate, studied the early life history and food habits of the bigmouth buffalo in Lake Poinsett. This work should be done in 1969.

S. M. Davis, M.S. candidate, evaluated success of spawning by brook trout in the Yellowstone River. A thesis is tentatively scheduled for 1969.

M. R. Hannon, M.S. candidate funded partly by the Experiment Station at South Dakota State University, worked on chemical biocide levels in the Lake Poinsett ecosystem. Dr. Y. A. Greichus, a biochemist, helped guide this work. The thesis should be completed in 1970.

T. Clifford, M.S. candidate, has studied the under-ice application of Fintrol using air to circulate the toxicant. Tentatively the study will end in 1968.

Utah Cooperative Fishery Unit

The Utah Cooperative Fishery Unit, the first Unit in the United States, was established on December 1, 1961.

Graduate student William Pearson using snowmobile as mode of transport to study invertebrates in Temple Fork of the Logan River. (Utah)

Graduate student William Pearson taking winter bottom samples in Temple Fork of the Logan River. (Utah)

The first Unit Leader, Dr. Donald R. Franklin, reported for duty on January 4, 1962, and held this position until his untimely death on February 6, 1966. Dr. Robert H. Kramer was Assistant Unit Leader at this time and was promoted to Unit Leader on July 17, 1966. The current Assistant Unit Leader, Dr. Clair B. Stalnaker, reported for duty September 30, 1966.

The Coordinating Committee is composed of four members: Dr. William F. Sigler, Utah State University; Mr. John E. Phelps, Utah State Division of Fish and Game; Mr. Lewis R. Garlick, Bureau of Sport Fisheries and Wildlife; and the Unit Leader.

The Unit program emphasizes research in the following areas:

1. The biological impact of major reservoir developments upon the Colorado River system.

2. Fitness of hatchery trout, with emphasis on the suitability of using respiratory metabolism, scope for activity, and learning behavior as criteria.

3. Ecology of stream-drift invertebrates, particularly those which form a major portion of the natural diet of trout.

4. Immunogenetics of fishes, particularly the rainbow trout.

The Unit Leader supervised graduate students and worked on development of facilities and experimental apparatus to determine active and standard metabolic rates of fishes, construction of equipment and development of methods to study various aspects of the stream-drift phenomenon, and continuation of field studies in Dinosaur National Monument.

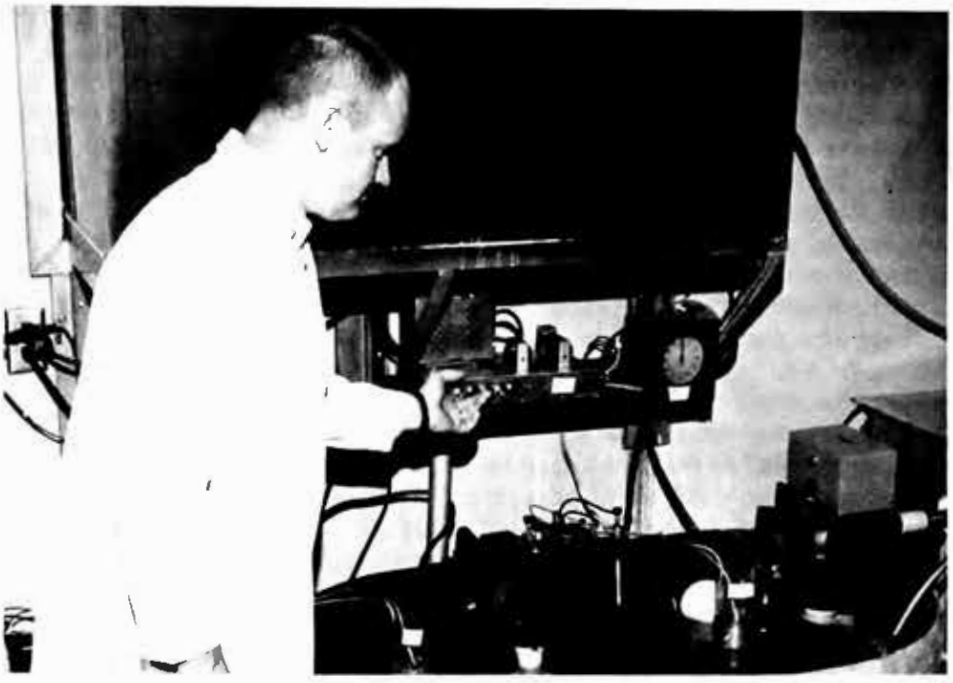
The Assistant Leader concentrated on development of facilities, construction of experimental apparatus and acquisition of equipment used for isoimmunization and progeny testing of rainbow trout. He also worked on acquisition of equipment and development of methods for immunodiffusion and immunolectrophoresis studies on indigenous Colorado River fishes.

Fishery studies by students:

W. D. Pearson, M.S. candidate with special support from the Bureau of Sport Fisheries and Wildlife, completed a thesis on the ecology, distribution and relative abundance of fish food organisms in the Green River after closure of Flaming Gorge Dam. This study was

undertaken to determine the effects of rotenone applied during a fish control operation in September 1962 and the installation of Flaming Gorge Dam in November 1962 upon the distribution of invertebrates in the Green River. Since these two events, the river has changed from a warm, turbid stream to a cold, clear trout stream for about 45 miles below the dam. Totals of 234 bottom samples and 394 drift samples were collected between the dam and Ouray, Utah (166 miles below the dam). The species composition of the fauna above Carr Ranch (42.7 miles below the dam) was much simpler during 1964-65 than the reported pre-impoundment composition. Below Carr Ranch the species composition of the invertebrate fauna has changed little. Bottom-fauna densities were highest near the dam (max. 6347/ft^2) and decreased with increasing distance below the dam. Population densities below Carr Ranch appeared to be similar to reported pre-impoundment densities. Drift rates of Baetis nymphs and Simuliidae larvae were highest near the dam. Illumination, population density of other organisms, and water temperature had significant effects on drift-net catches of Baetis and Simuliidae. Turbidity and water-level fluctuations had important effects under certain circumstances, while date, dissolved oxygen, and depth of water had little effect on drift-net catches.

C. D. Vanicek, Ph.D. candidate funded partly by special contract with the Bureau of Sport Fisheries and Wildlife, completed his thesis on ecological studies of native Green River fishes below Flaming Gorge Dam, 1964-1966. Investigations to study (1) the species composition and distribution of Green River fishes between Flaming Gorge Dam and Ouray, Utah, and (2) the ecology and life history of selected native species, including Colorado squawfish (Ptychocheilus lucius); Colorado chub (Gila robusta); bluehead sucker (Pantosteus delphinus); and humpback sucker (Xyrauchen texanus) in Dinosaur National Monument were conducted from May 1964 to October 1966. A total of 23,735 fish consisting of 9 indigenous and 11 exotic species were taken in 639 collections by electrofishing gear, gill nets, seines, and fry gear. Flaming Gorge Dam has caused a major change in the ecology of the downstream Green River by alteration of seasonal flow and water temperature patterns as far as the mouth of the Yampa River, 65 miles below the dam. As a result, native fish populations, particularly in the first 26 miles below the dam, have been largely replaced by introduced rainbow and brown trout (Salmo gairdneri and S. trutta). Below the Yampa River mouth, fish populations were similar to those reported here during the pre-impoundment years. Age and growth determinations were made from scales from 167 Colorado squawfish and 33 Colorado chubs. Both species grew slower in the years after dam closure (1963-1965) than before (1955-1962). The bonytail form of the Colorado chub grew slightly faster than the roundtail form. Length-frequency analyses of young Colorado squawfish, Colorado chubs,



Graduate student Ian Dickson conducting standard-metabolism experiment. (Utah)

Graduate student Paul Holden counting morphometric characters on Gila sp. x-rays. (Utah)

Graduate student David Campbell taking a blood samples for use in isoimmunization studies of rainbow trout. (Utah)

and bluehead suckers described seasonal growth of the first three year classes and provided evidence that these species reproduced successfully in Dinosaur National Monument every year since impoundment. During years of high summer discharge from the dam with resultant lower water temperatures (1964 and 1966), no reproduction of any native fishes was found above the mouth of the Yampa River. No juvenile humpback suckers were collected during the study. The roundtail and bonytail forms of the Colorado chub had significantly different length-weight relationships. Squawfish over 200 mm total length were entirely piscivorous, while shorter squawfish consumed microcrustaceans and aquatic insects. The diet of the Colorado chub consisted largely of aquatic and terrestrial insects.

T. J. Boario, M.S. candidate, completed a thesis on effects of exercise on the conditioning behavior of rainbow trout (Salmo gairdneri). Effects of exercise on the conditioning behavior of two strains of domestic rainbow trout were evaluated. An exercise chamber and conditioning apparatus offered a practical method to evaluate the effects of exercise. Trout were exercised 4 or 8 hours followed by 2 hours of conditioning trials. A conditioning trial consisted of: light on, 10 seconds; light and electric shock on, 10 seconds; no light or electric shock, 10 seconds. Exercised groups acquired the conditioned avoidance response at a faster rate than did controls in 12 of 16 experiments. Exercised groups usually reached a higher percentage maximum response and had faster rates of response loss than did controls. The effect of exercise upon conditioning behavior may be attributed to interactions of behavioral and physiological mechanisms.

I. W. Dickson, Ph.D. candidate supported in part by the Division of Fish Hatcheries, Bureau of Sport Fisheries and Wildlife, studied factors influencing respiratory metabolism of rainbow trout. Mr. Dickson hopes to receive the Ph.D. degree June 1968.

W. D. Pearson, Ph.D. candidate supported by the National Science Foundation, studied drift rates of a caddisfly (Oligophlebodes sigma) and a mayfly (Baetis sp.) in Temple Fork of the Logan River, Utah. Mr. Pearson hopes to complete his degree requirements in 1970.

P. B. Holden, M.S. candidate supported in part by the NDEA program, studied morphological variability in the Gila robusta complex. Mr. Holden should receive the M.S. degree in June 1968.

D. L. Campbell, Ph.D. candidate, conducted a serological study of the Gila complex in the Colorado River system. Mr. Campbell hopes to complete his work in 1970.

Virginia Cooperative Fishery Unit

This Unit was established on October 29, 1965. The Assistant Leader, R. D. Estes, and Leader, Dr. Kenneth Cumming, reported for duty March 21, 1966 and June 6, 1966, respectively.

The Coordinating Committee is composed of Dr. John F. Hosner, Virginia Polytechnic Institute, Mr. Jack M. Hoffman, Virginia Commission of Game and Inland Fisheries, and Mr. E. C. Martin of Bureau of Sport Fisheries and Wildlife, and the Unit Leader.

The Unit program is centered on the study of carrying capacity, productivity, and growth of fish in Virginia waters. Research is being carried out to measure and compare the carrying capacity of impounded, stream, and estuarine waters as well as factors which naturally or artificially regulate this capacity. Fish production is being studied from the aspect of food conversion and environmental control of effective assimilation. Growth as it relates to new waters, water hardness, alkalinity, and growing season is also being studied.

The Unit Leader participated actively in graduate student research and taught 2 courses.

Fishery studies by students:

R. D. Estes, the Assistant Unit Leader, also was a Ph.D. candidate. He continued a study of some effects of a pumped-storage project on downstream water quality and fish populations. His thesis should be completed in 1970.

C. W. O'Rear, Ph.D. candidate supported by the Anadromous Fish Program, studied limiting factors in the zinc and copper metabolism of striped bass. The thesis is tentatively scheduled to be completed in 1970.

R. W. Schneider, M.S. candidate, conducted a special study of limnological and biological features of Smith Mountain Reservoir. He plans to terminate in 1968.

R. H. England, M.S. candidate supported in part by the Federal Water Pollution Control Administration, conducted special studies related to acid-mine pollution demonstration projects. England plans to finish his work in 1968.

P. M. Brady, M.S. candidate, studied fish population characteristics of Lake Drummond in the Dismal Swamp. He should write his thesis by 1969.

E. T. Humphries, a Ph.D. candidate funded by River Basin Studies (Bureau of Sport Fisheries and Wildlife), investigated the ecology of striped bass in the Roanoke River, tributary to Kerr Reservoir. He hopes to write his thesis by 1971.

T. J. Becker, M.S. candidate, began development of a questionnaire on preferences of trout fishermen. His thesis should be written in 1969.

A. O. Smith, Ph.D. candidate, began an investigation of trophic relations of gizzard shad (Dorosoma cepedium) in Smith Mountain Reservoir. The work is planned to terminate in 1971.

J. V. Roland, M.S. candidate, began studying effects of the recent introduction of hard water into the water supply reservoir of Carvin Cove, Virginia. He expects to complete his work by 1969.

R. E. Sumner, M.S. candidate, began an evaluation of productivity changes associated with liming of Sherwood Lake, West Virginia. This work should be done by 1970. Sumner is a student on work-study plan with the West Virginia Department of Natural Resources.

Washington Cooperative Fishery Unit

The Washington Cooperative Fishery Unit was established at the University of Washington on December 21, 1966. The Unit became operational with the appointment of Dr. Richard R. Whitney, Unit Leader, in August 1967, and Edward S. Marvich joined the staff as Assistant Unit Leader in October 1967.

Unit cooperators include the University of Washington, Washington Department of Fisheries, Washington Department of Game and the Bureau of Sport Fisheries and Wildlife of the Fish and Wildlife Service. The Coordinating Committee includes Dr. Richard Van Cleve, University of Washington; Mr. Clifford J. Millenbach, Department of Game; Dr. Donald E. Kauffman, Department of Fisheries; and Mr. Delbert H. Rasmussen, Bureau of Sport Fisheries and Wildlife. The Unit Leader serves as Executive Secretary and advisor to the Committee.

The research effort of the Unit is closely coordinated with the work being conducted by state, federal, and other agencies, the objective being to complement the efforts of these groups. The Unit will engage in a wide range of investigations having application to the sport fisheries. The work will not be limited by the specialities of the Unit Leader or Assistant Leader, but will use, as graduate committee members and advisors, other professors in the College who possess special knowledge and interests pertinent to the problem chosen.

The Unit Leader has been primarily occupied with starting the new program on a sound footing at the University and in the selection and guidance of students in their research efforts. In addition, he has undertaken a study of the timing of the run of American shad (Alosa sapidissima), as it is related to water temperatures in the Columbia River. It has been found that the peak of the shad run occurs normally between 63 and 65°F. Data from some Atlantic Coast Rivers will be obtained for comparison.

The Assistant Leader has worked closely with students, assisting them in the design and assembly of apparatus for their studies and suggesting approaches to be used. He arranged meetings with representatives of local industry and governmental agencies with fishery problems to discuss the present and potential role of the Cooperative Fishery Unit.

Fishery studies by students:

A. M. Andersen, Ph.D. candidate, is conducting a study of the life history of Washington's largest clam, the geoduck (Panope generosa), including the rate of growth, natural and harvesting mortality, life expectancy, time of spawning, fecundity, larval development, distribution, rate of recruitment, and relative population densities in specific areas. Andersen's thesis should be completed in 1970.

B. J. Allee, M.S. candidate, is studying the behavioral interactions between juvenile coho salmon and steelhead trout to compare the different ecological requirements for juvenile coho salmon and steelhead trout, to determine how the various forces within the habitat influence segregation of the two species, and to determine the influences each species exerts in establishing territorial rights. His research should be completed in 1969.

Public Law 86-686
86th Congress, S. 1781
September 2, 1960

AN ACT

74 STAT. 733.

To facilitate cooperation between the Federal Government, colleges and universities, the States, and private organizations for cooperative unit programs of research and education relating to fish and wildlife, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That, for the purpose of developing adequate, coordinated, cooperative research and training programs for fish and wildlife resources, the Secretary of the Interior is authorized to continue to enter into cooperative agreements with colleges and universities, with game and fish departments of the several States, and with nonprofit organizations relating to cooperative research units: *Provided*, That Federal participation in the conduct of such cooperative unit programs shall be limited to the assignment of Department of the Interior technical personnel by the Secretary to serve at the respective units, to supply for the use of the particular units' operations such equipment as may be available to the Secretary for such purposes, and the payment of incidental expenses of Federal personnel and employees of cooperating agencies assigned to the units.

Fish and Wildlife.
Cooperative unit programs.

SEC. 2. There is authorized to be appropriated such sums as may be necessary to carry out the purposes of this Act.

Appropriation.

Approved September 2, 1960.

APPENDIX B

Publications by unit personnel in 1967
including certain material duplicated for distribution

Andrews, Austin K., Charles C. VanValin and Bruce E. Stebbings. 1966. Some effects of Heptachlor on bluegills (Lepomis macrochirus). Trans. Amer. Fish. Soc. 95: 297-309.

Brown, B. E. Schooling and shelter-seeking tendencies in fingerling channel catfish, Ictalurus punctatus (Rafinesque). Presented at the 47th Annual Meeting of the American Society of Ichthyologists and Herpetologists, San Francisco, June 18-22, 1967. Abstract printed, Abstract, Ichthyology. Amer. Soc. Ichthyol. Herpet. pp. 4-5.

Busbee, R. L. 1967. An aid in hand-picking benthic organisms. Prog. Fish Cult. 29:61.

Callaham, M.A. and M. T. Huish. 1967. An evaluation of antimycin as a selective bluegill toxicant under varying conditions of pH. Proc. 21st Ann. Conf. S.E. Assoc. of Game and Fish Comm.

Carlander, K. D., C. A. Carlson, V. Gooch and T. Wenke. 1967. Populations of Hexagenia mayfly naiads in Pool 19, Mississippi River, 1959-63. Ecol. 48: 873-878.

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Dollar, A. M., E. C. Smuckler and R. C. Simon. 1967. Etiology and epidemiology of front hepatoma. pp. 1-17 IN: Trout Hepatoma. Research Conference Papers (J. E. Halver and I. A. Mitchell, Ed.). Res. Rpt. 70, U.S. Dept. of HEW and USDI.

Dorris, T. C. and R. C. Summerfelt. A preliminary report on the Fishery of Lake Atitlan, Guatemala. Unpublished, mimeographed. 47 p. Available from the Oklahoma Cooperative Fishery Unit.

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Gould, W. R., and C.J.D. Brown. 1967. The distribution of Hybognathus (Cyprinidae) in Montana. Proc. Mont. Acad. Sci. 26: 54-56.

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Heaton, LeRoy H. and Ivan B. McElwain. 1967. Complement in Salmo gairdneri and Salmo trutta. Trans. Amer. Fish. Soc. 96: 351.

Horak, Donald L. and William D. Kline. 1967. Influence of capture methods on fishing success, stamina, and mortality of rainbow trout (Salmo gairdneri) in Colorado. Trans. Amer. Fish. Soc. 96: 220-222.

Huntsman, Gene R. 1967. Nuptial tubercles in carp suckers (Carpiodes). Copeia 1967 (2): 457-458.

Jensen, A. C. and Kenneth B. Cumming. 1967. Use of lead compounds and tetracycline to mark scales and otoliths of marine fishes. Prog. Fish Cult. 29: 166-167.

Kinnear, Brian S. and Robert E. Vincent. 1967. Fishes and fish habitats in Black Canyon of the Gunnison National Monument. Colo. State Univ., Ft. Collins. 45 pp. mimeo.

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Simon, R. C., A. M. Dollar and E. A. Smuckler. 1967. Descriptive classification on normal and altered histology of trout livers. pp. 18-28 IN: Trout hepatoma research conference papers (J. E. Halver and I. A. Mitchell, Ed.). Res. Rpt. 70, U.S. Dept. of HEW and USDI.

Summerfelt, R. C. Fishes of the Smoky Hill River, Kansas. Kansas Acad. Sci. 70(1): 102-139.

Summerfelt, R. C. and W. M. Lewis. Repulsion of green sunfish by certain chemicals. J. Water Pollution Control Federation. 39(12): 2030-2038.

Summerfelt, R. C., W. M. Lewis and M. G. Ulrich. Changes in certain blood components of goldfish maintained in sealed containers. Prog. Fish Cult. 29(1): 3-12.

Summerfelt, R. C., W. M. Lewis and M. G. Ulrich. Measurement of some hematological characteristics of the goldfish, Carassius auratus L. Prog. Fish Cult. 29(1): 13-20.

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BUREAU OF SPORT FISHERIES AND WILDLIFE
WASHINGTON, D.C. 20240

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