FISHERY RESEARCH
GALVESTON BIOLOGICAL LABORATORY

FISCAL YEAR 1961

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

CIRCULAR 129

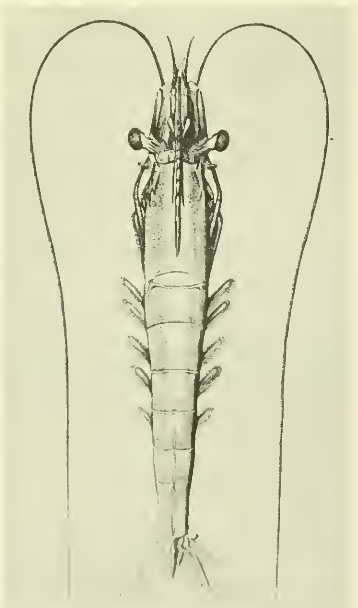
United States Department of the Interior, Stewart L. Udall, Secretary
Fish and Wildlife Service, Clarence F. Pautzke, Commissioner
Bureau of Commercial Fisheries, Donald L. McKernan, Director

GALVESTON BIOLOGICAL LABORATORY

FISHERY RESEARCH

for the year ending June 30, 1961

George A. Rounsefell, Director
Joseph H. Kutkuhn, Assistant Director



Circular 129

Washington, D. C.
July 1961

The Galveston Biological Laboratory and its field stations conduct fishery research in the Gulf of Mexico, as part of the work of the Bureau of Commercial Fisheries in the Gulf and South Atlantic Region (Region 2), which comprises the eight coastal states from North Carolina to Texas.

Office of the Regional Director, Seton H. Thompson, is in the Don Ce-Sar Federal Center, P. O. Box 6245, St. Petersburg Beach, Florida. Other offices are:

Biological Research

Biological Laboratory, Brunswick, Georgia
Biological Laboratory, Beaufort, North Carolina
Biological Laboratory, Gulf Breeze, Florida
Biological Laboratory, Galveston, Texas
- Biological Field Station, Miami, Florida
- Biological Field Station, St. Petersburg Beach, Florida
- Biological Field Station, Pascagoula, Mississippi

Industrial Research

Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi, auxiliary base at Brunswick, Georgia
Marketing - Market Development Offices in Dallas, Texas; Jacksonville, Florida; and Pascagoula, Mississippi
Technology - Technological Laboratory, Pascagoula, Mississippi

Resource Development

Statistical Center, New Orleans, Louisiana

TABLE OF CONTENTS

	Page
Report of the Director	1
Staff	7
Shrimp Fishery Program	9
Early life history of commercial and related shrimps	10
Identification and description of shrimp larvae	14
Identification of postlarval and juvenile shrimp	17
Migrations, mortality, and growth of pink shrimp	18
The Campeche pink shrimp population, 1956-1960	22
Industrial Fishery Program	26
Industrial bottom-fish fishery in the north central Gulf of Mexico	27
Preliminary survey of industrial-type bottom fishes in the northwestern Gulf of Mexico	31
Menhaden biology	33
Estuarine Program	34
Evaluation of estuarine data	35
Effects of engineering projects	36
Ecology of nursery areas	38
Trinity Bay project	41
Physiology and Pesticide Program	43
Shrimp physiology	44
Effects of pesticides	49
Red Tide Program	56
Culture and nutrition of Gymnodinium breve	58
Chemical control	59
Ecology of red tide	61
Hydrology of Tampa Bay and adjacent waters	65
Special Reports	
Sea-water system	68
Oyster studies	72
Distribution of pink shrimp larvae and postlarvae	75
Seminars and Meetings	77
Publications	78
Manuscripts Submitted	82

COVER: Recirculating sea-water system on the laboratory grounds, completed February 1961.

REPORT OF THE DIRECTOR

George A. Rounsefell

Fisheries of the Gulf of Mexico continue to expand   The record 1959 catch of fish and shellfish from Gulf waters, which exceeded a billion pounds (1,155,000,000) for the first time, was surpassed in 1960 by some 111 million pounds or about 10 percent. While the catch in other United States areas decreased by 5.1 percent, the Gulf catch increased by 9.7 percent. Although the size of the increase was due in large measure to a record catch of menhaden (841 million pounds), the shrimp catch also rose. Texas, Louisiana, and Florida ranked among the top six states in value of 1960 landings.

Research highlights of the past year   Completed analyses of 4 years (1956-1959) of detailed observations on catches of shrimp and fishing effort throughout the Gulf show that populations of all three major species, brown, pink, and white, undergo two periods of heightened spawning activity and thus produce two definable broods of young shrimp each year. There is good evidence that hurricanes, sweeping high turbulent waters over the estuaries, can cause decreased survival of a brood of young shrimp. Because fishermen in the high-seas fishery (especially on the Campeche Banks) cull the smaller sizes of shrimp from their catches, it will be difficult to obtain reliable estimates of relative abundance of stocks on these far banks until we can secure unculled samples of the catches.

Relatively high recoveries on the Sanibel fishing grounds of juvenile pink shrimp stained and released in Pine Island Sound, coupled with no recoveries on the Tortugas grounds, indicate that shrimp taken in the Sanibel and Tortugas fisheries may depend on different nursery areas. More exact definition of the boundary must await future releases in the area between Pine Island Sound and Shark River.

Larval stages of the seabob, *Xiphopeneus krøyeri*, have been identified and described for a forthcoming publication.

The numbers of postlarval shrimp entering Galveston Bay during March and April fell from 582 per sample (17 samples) in 1960 to 22 per sample (15 samples)in the same period of 1961. Associated hydrographic data are being analyzed for an answer to this sharp fall in numbers.

Preliminary studies of industrial-type fishes off the east coast of Texas over a 9-month period show that the most abundant species by both number and weight was the longspine porgy, *Stenotomus caprinus*. The second most abundant by weight was the lizardfish, *Synodus foetens*, followed by the Atlantic croaker, *Micropogon undulatus*. This contrasts with the findings of a similar study in the Mississippi Sound area in which the leading species was shown to be the Atlantic croaker.

Gulf States Marine Fisheries Commission The meetings of the Commission at St. Petersburg Beach, Florida, and Biloxi, Mississippi, were well attended by laboratory personnel. At the first meeting Mr. Haskell spoke on the industrial fishery of the northern Gulf, and at the second, a tentative program for coordinated estuarine research presented to the Estuarine Technical Coordinating Committee was given to the Commission for study.

U. S. Study Commission - Texas Dr. Graham and Mr. Naab attended the September 6 meeting of the Fish and Wildlife Collaboration Group in Fort Worth, Texas, where the effects of water resource plans on estuarine fauna were discussed. The Commission's final report, to be completed in the late summer of 1961, will include a program of research that should be accomplished along the Texas coast to determine the effects of water resource developments, involving impoundments and diversions in the study area, upon marine fish and shellfish of commercial importance. The program was prepared and submitted to the Commission in July.

Waste disposal in marine waters As the industrial complex grows the disposal of large volumes of toxic waste materials becomes increasingly difficult. During the year two large companies discussed this problem with us. Both were aware of the possibilities of oceanic disposal damaging marine fauna and were seeking advice. The possibility of disposal by wide dispersion from a moving barge over deep waters to give desired dilution has been under study by an academic research group. Also under study is the feasibility of underground disposal into drilled wells. The companies are to be commended on their desire and efforts to avoid any damage to fishery resources.

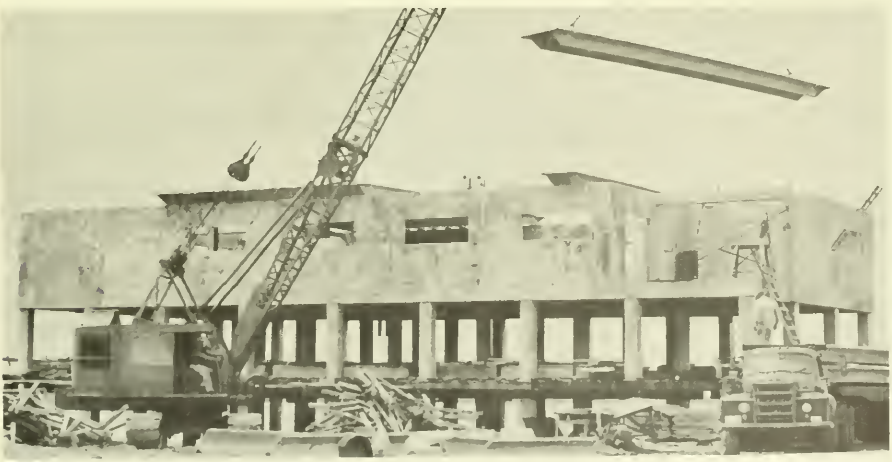
The Mississippi River-Gulf Outlet Project This study, carried on by The Texas A. and M. Research Foundation, is nearing completion after some $2\frac{1}{2}$ years of intensive work. The field station at Hopedale, Louisiana, was closed in April, and the final report will be completed by midsummer. The wealth of data on biota in the low, medium, and high salinity areas, and the extensive hydrographic observations will permit, perhaps for the first time, a full evaluation in later years of the long-term effects of a very large-scale channelization project.

The Hurricane Protection Project for Lake Pontchartrain is related to the Mississippi River-Gulf Outlet Project because of the wedge of higher salinity water that will enter Lake Pontchartrain along the bottom of the Gulf outlet canal. Laboratory personnel have participated in three meetings in New Orleans with Branch of River Basin Studies and Louisiana Wild Life and

Fisheries Commission personnel and with the Corps of Engineers concerning tests run in the Lake Pontchartrain model at Vicksburg to determine the effects of the Hurricane Project on the hydrography of Lake Pontchartrain. Dr. Robert Reid of the Texas A. and M. Research Foundation has acted as hydrographic advisor at these meetings.

Improvement in research facilities   A large recirculating sea-water system on the laboratory grounds was provided during the year, using an existing masonry building 51 by 37 feet. The system contains two redwood tanks, each holding 28,000 gallons of sea water, which circulates through plastic piping to numerous tanks in the insulated building and then is passed through two large sand and gravel filters. The system, described in detail later in this report, was dedicated on February 17 by Regional Director Seton H. Thompson, in the presence of guests from state and university laboratories, Corps of Engineers representatives, and industry members. It is already being used to hold specimens for the physiology and pesticide laboratories, for spawning of shrimp and rearing of shrimp larvae, and other purposes.

Construction commenced in January on a constant flow sea-water laboratory on a 140-acre tract owned by the Bureau on East Lagoon about 3 miles east of the laboratory. This building, raised about 15 feet above sea level to avoid hurricane damage, is on a 40- by 90-foot concrete slab with a large concrete tank on the roof. It will be finished in late summer. Whereas the recirculating system at the main laboratory provides rather well-controlled conditions of salinity and temperature, this system will give an opportunity, especially in the case of estuarine species, to study organisms under semi-natural conditions.



The East Beach sea-water laboratory under construction.

The pesticide laboratory has been equipped with a special water-spray, airflow hood for safe handling of the more toxic formulations. All of the ground-floor laboratories in Building A now have sea water running through P.V.C. pipe from two 1500-gallon tanks on the upper balcony. The pesticide laboratory has also been provided with an independent air-conditioning and heating system.

Special work conferences Mr. Inglis attended a Corps of Engineers meeting in San Antonio concerning the use of gold isotopes to trace sand movements and sedimentation at the jettied entrance to Galveston Bay.

Mr. Costello conferred with Branch of River Basin Studies from Vero Beach on the possible effects on the valuable Biscayne Bay fishery for bait shrimp of proposed offshore hurricane dikes paralleling the shoreline.

Two meetings were held at College Station, Texas, to discuss the preparation of the final report on the Mississippi River-Gulf Outlet Project.

Mr. Chin attended the Denver Pesticide Workshop, April 4-6, at the Fish and Wildlife Service's pesticide research center.

Annual staff meeting The fourth annual staff meeting held at the Galveston Laboratory, February 14-17, was attended by nine staff members from field stations at Miami and St. Petersburg Beach, Florida, and Pascagoula, Mississippi. Mr. Seton Thompson, Regional Director, and Mr. John Glude, Chief of the Branch of Shellfisheries, attended. Because one of the major topics was estuarine research and its uses in connection with engineering projects, the Branch of River Basin Studies sent Mr. Herbert Hunter from the Atlanta Regional Office, Mr. John Byrn from the Albuquerque Regional Office, and Mr. John Degani from their Fort Worth field office. Mr. Edgar Arnold, currently working with the Southeast Study Commission, came from our St. Petersburg Beach Regional Office.

The contributions of all types of our research to the solution of estuarine problems were discussed. A second major topic was the increasing of research production through the use of expanded facilities such as sea-water systems, vessels, field instrumentation, etc.

Trainees Mr. Malloothara J. George of the Central Marine Fisheries Department, India, spent 4 weeks at our Miami Field Station and then came to Galveston where he spent 6 weeks reviewing and participating in the shrimp research program. He then went to the Grand Terre Laboratory of the Louisiana Wild Life and Fisheries Commission to aid in studies of larval shrimp.

Regional coordination Both at Pascagoula and Galveston, several days were spent in the periodic collection, preparation, and shipment of menhaden specimens and of menhaden gillrakers to the Beaufort Laboratory and the Virginia Fisheries Laboratory. Dr. Rounsefell met with the other Laboratory Directors and the Pascagoula Base Director at Pascagoula in July to finish the draft of the supply and production section of the Regional report on the status of Gulf and South Atlantic fisheries. In May Messrs. Haskell and Ragan visited the Brunswick Laboratory to discuss problems in identifying larval fishes.

Cooperation with Branch of River Basin Studies The laboratory has worked closely with the Branch of River Basin Studies in the Bureau of Sport Fisheries and Wildlife concerning effects of engineering projects on marine fauna. The details are given in the Estuarine section.

Public relations The Texas Game and Fish Commission requested and received assistance in establishing the nature of three discolored-water occurrences, one in Matagorda Bay and two in the Galveston Bay area. Dinoflagellates were indicated in two cases and a blue-green alga in the third.

Dr. Kutkuhn gave an illustrated talk on our research to the Galveston Junior Chamber of Commerce. Dr. Rounsefell spoke on FAO and Turkish fisheries to the Quota Club. Mr. Haskell showed the movie "Trawls in Action" to Pascagoula trawl fishermen. Mr. William Renfro gave a talk on the research activities of the laboratory to the Exchange Club of Galveston. Mr. Skud sponsored Eagle Scout Robert Thompson, a Texas City high school senior, at an installation dinner at the Houston International Airport. He is winner of a Math, English, and Science award and is interested in oceanography and fisheries as a career.

Display of Gulf of Mexico fishes in foyer of the recirculating sea-water laboratory.

The Laboratory put on a 3-day exhibit at the Galveston Farm and Home Show in Moody Center, March 24-26. Featured were collections of fishes, live fish and invertebrates, research photographs and equipment, and projection of colored slides. This exhibit date coincided with National Wildlife Week.

The Laboratory's collection of fish and invertebrates has been rebottled and arranged in dust-free glass cases in the foyer of the new seawater laboratory building. Several busloads of school children, scout troops from Galveston, Texas City, and La Marque, as well as groups of business people and out-of-town visitors, have examined it.

STAFF

George A. Rounsefell, Laboratory Director
Joseph H. Kutkuhn, Assistant Laboratory Director
Bernard E. Skud, Assistant Laboratory Director (To Feb. 15)

Biological Laboratory at Galveston, Texas
Field Stations at St. Petersburg Beach and Miami, Florida; and Pascagoula, Mississippi

Shrimp Fishery Program

Joseph H. Kutkuhn	Program Leader (to May 1)	Galveston
Thomas J. Costello	Head, Field Station	Miami
Donald M. Allen	Biologist	Miami
William C. Renfro	Biologist	Galveston
Robert F. Temple	Biologist	Galveston
Jack G. Robinson	Biologist(on military furlough)	Galveston
Harry L. Cook	Biologist	Galveston
Carl H. Saloman	Biologist	Miami
Harold A. Brusher	Biologist	Galveston
Kenneth N. Baxter	Fishery Technician	Galveston
Carlton H. Furr	Fish. Mkt. Specialist	Galveston
H. W. Altenhoff	Summer Aid	Galveston
Elroy L. Young	Summer Aid	Galveston
Carl E. Wood	Summer Aid	Galveston
Samuel C. Jernigan	Summer Aid	Galveston
Jonathan J. Bernstein	Summer Aid	Galveston
John H. Tweedy	Temporary (shrimp marking)	Miami
Benjamin F. McPherson	Temporary (shrimp marking)	Miami
Donald R. Nelson	Temporary (shrimp marking)	Miami
Andrew E. Jones	Temporary (shrimp marking)	Miami
Joseph J. Ewald	Temporary (shrimp marking)	Miami
David T. McBain	Temporary (shrimp marking)	Miami
Howard R. Foulk	Temporary (shrimp marking)	Miami

Estuarine Program

Joseph J. Graham	Biologist	Galveston
Ronald C. Naab	Biologist (transferred 12/60)	Galveston
Anthony Inglis	Biologist	Galveston
Richard A. Diener	Biologist	Galveston
Charles H. Koski	Biologist	Galveston
Cornelius R. Mock	Biologist	Galveston
Genevieve B. Adams	Statistical Clerk	Galveston

Industrial Fishery Program

Winthrop A. Haskell	Head, Field Station	Pascagoula
James A. Ragan	Biologist	Galveston
John M. Hutton, Jr.	Biologist (resigned 9/60)	Pascagoula
James G. Smith	Biologist (resigned 5/61)	Pascagoula
Charles M. Roithmayr	Biologist	Pascagoula

Physiology and Pesticide Program

Edward Chin	Program Leader	Galveston
Zoula P. Zein-Eldin	Biochemist	Galveston
John G. VanDerwalker	Biologist	Galveston
Grant L. MacNichols	Biologist (transferred 1/61)	Galveston
Gilbert Zamora, Jr.	Fishery Aid	Galveston
Imogene A. Sanderson	Physical Science Aid	Galveston

Red Tide Program

William B. Wilson	Program Leader (on special training program)	Galveston
David V. Aldrich	Acting Program Leader	Galveston
Billie Z. May	Head, Field Station	St. Petersburg
Alexander Dragovich	Biologist	St. Petersburg
John H. Finucane	Biologist	St. Petersburg
John A. Kelly, Jr.	Biologist	St. Petersburg
Gordon R. Rinckey	Biologist	St. Petersburg
John D. McCormick	Master, M/V KINGFISH	St. Petersburg
McKinley W. Jambor	Biological Aid (resigned 5/61)	St. Petersburg
Lucius Johnson, Jr.	Physical Science Aid	St. Petersburg
Alice Murphy	Biological Aid	Galveston
Domingo R. Martinez	Biological Aid	Galveston

Chemistry and Sea-Water Laboratories

Kenneth T. Marvin	Chief Chemist	Galveston
Ray S. Wheeler	Biologist	Galveston
Raphael R. Proctor, Jr.	Chemist	Galveston
Larence M. Lansford	Chemistry Aid	Galveston

Library

Stella Breedlove	Librarian	Galveston

Technical Services

Ruth W. Yanch	Secretary	Galveston
Esther E. Sell	Secretary	Galveston
Daniel Patlan	Draftsman	Galveston
Petronila C. Prado	Scientific Stenographer	Galveston
Mary E. Hipple	Clerk-typist	St. Petersburg
Nellie P. Benson	Clerk-typist (WAE)	Miami

Administration and Maintenance

Lawrence E. Wise	Administrative Officer	Galveston
Laura M. Hermann	Asst. Admin. Officer	Galveston
Corinna L. Denbo	Purchasing Clerk	Galveston
Glo S. Baxter	Clerk-Stenographer	Galveston
Peter M. Villarreal	Maintenanceman	Galveston
Robert L. McMahon	Maintenanceman	Galveston
Tidas C. Alcorn	Maintenanceman	Galveston

SHRIMP FISHERY PROGRAM

Joseph H. Kutkuhn, Acting Program Leader

Understanding the dynamics of pre-exploited and exploited phases of any commercial fish or shellfish population is prerequisite to implementing a management program for the fishery it supports. Studies on each of three well-defined phases which characterize development in important Gulf of Mexico shrimp populations, viz., larval and postlarval (pre-exploited), juvenile (semiexploited), and adult (fully exploited), continued during the year.

In the east Texas coast area, a 1-year survey designed to delimit spawning areas and ascertain the seasons and extent of spawning activity in brown and white shrimp populations was undertaken. Superimposed on this survey is a continuation of a project carried out during the period March 1959-March 1960 which sought to explore the feasibility of measuring the density of larval shrimp during their passage from offshore spawning to inshore nursery grounds. Analysis of the earlier project's data is now underway. The results thereof together with those of the current study will provide (1) a basis for documenting mortality suffered by shrimp populations at successive developmental stages; (2) evidence for linking spawning populations with inshore nursery areas utilized by their progeny; and (3) answers to the question of what mechanisms govern the movement of larvae from spawning to so-called nursery areas.

Closely meshed with these early life history studies is a project concerned with outlining procedures for distinguishing larvae and early postlarvae of coexistent Penaeidae. In the 2 years since its inception, considerable progress in identifying, describing, and comparing the early life history stages of these shrimp can be shown. The most successful technique for obtaining material which is validly describable has involved capturing shrimp ready to spawn, allowing them to spawn in aquaria free of foreign matter, nurturing the eggs and any resulting larvae, and rearing the latter through as many growth stages as possible. Unfortunately, the inability to rear larvae beyond a certain critical point (Protozoea I) still limits this technique's usefulness.

Information providing a means for evaluating juvenile (or inshore) population phases continues to be secured systematically from the commercial bait shrimp fishery (Galveston Bay). Bait fishery production around the Gulf is still rising annually, but methods which would permit assessment of the relationship between increasing exploitation during immature stages and each species potential maximum yield have yet to be devised.

Movement patterns, mortality, and growth in exploited (offshore) population phases underwent increasingly intensive study in the south Florida area. Additional mark-recapture experiments in a series started 4 years ago materially supplemented our knowledge of the Tortugas pink shrimp population's geographical range. A better-than-anticipated rate of mark-recovery in one experiment has encouraged extension of the staining technique for marking shrimp to studies of population mortality.

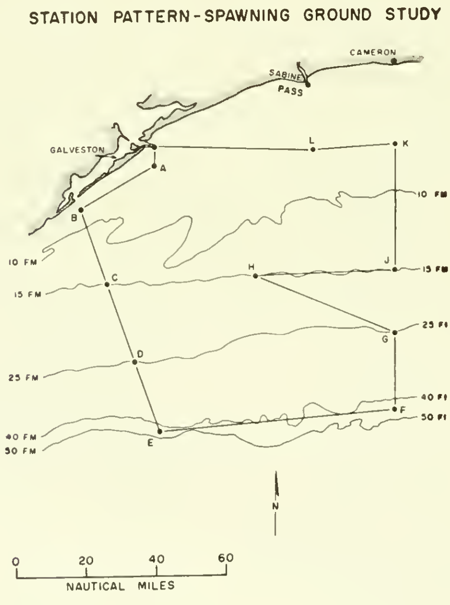
A statistical analysis of Gulf shrimp stocks for the period 1956-1959 indicated that the more important species are generally faring well.

Early Life History of Commercial and Related Shrimps

William C. Renfro

Spawning populations   Major objectives of a new sea-sampling project which began in January of this year and is scheduled for completion next December are: (1) to delineate penaeid shrimp spawning grounds in the Gulf of Mexico off east Texas; (2) to determine reproductive status in populations of various species with respect to season and area; (3) to study the effects of environmental factors (such as temperature, salinity, and bottom composition) on penaeid distribution, abundance, and spawning activities; and (4) to ascertain seasonal and areal distribution of shrimp larvae and the importance of ocean currents in their movement to inshore nursery areas.

To implement this project, the double-rigged shrimp trawler MISS ANGELA of Freeport, Texas, was chartered through June 1961. A cruise pattern to be run at 3-week intervals was designed so that as large an area as possible could be covered in a reasonably short interval of time (3-4 days). Eleven stations were positioned over an "effective" sampling area of about 6,200 square miles such that two or more sets of hydrographic observations and biological collections could be obtained in subareas characterized by depths of $7\frac{1}{2}$, 15, 25, and 45 fathoms.



Station pattern for shrimp spawning ground survey off east Texas coast.

At each station a "standard" 45-foot flat trawl is towed for 1 hour. Since vessel speed is measured during each haul, the resulting biological samples (assuming ratio between ground and surface speed is reasonably constant) may be treated quantitatively. Captured shrimp are identified as to species and sex, measured, and an ovary sample taken and fixed for cytological examination in the laboratory. During each trawl haul a 20-minute oblique plankton tow is made with a Gulf V sampler. Profiles of temperature and salinity are obtained at each station using a temperature and conductivity recorder ("Dynalog," Foxboro). Current direction and velocity at several standard depths are determined by means of a telerecording current meter (Savonius type, Hytech Corp.).

Trawler MISS ANGELA with Gulf V plankton sampler being lifted aboard.

Through June 1961, nine 3- to 4-day cruises were made. The following are some observations drawn from data collected during the first four cruises (January 17-19, February 8-10, February 28-March 3, and March 21-23):

1. Cytological examination revealed that none of the penaeid species encountered possessed ovaries in the more advanced developmental stages. Ovaries of adult brown shrimp, Penaeus aztecus, and rock shrimp, Sicyonia brevirostris, exhibited the greatest degree of maturation. These species appeared most abundant in the depth range 15 to 45 fathoms. White shrimp, Penaeus setiferus; pink shrimp, Penaeus duorarum; Sicyonia dorsalis;

Trachypeneus similis; and Solenocera atlantidis had not progressed as far toward the completion of their reproductive cycles and were more prevalent in 7½ and 15 fathoms.

2. There seemed to be little correlation between size of shrimp and degree of maturation.

3. Determination of the degree of ovarian development employing visual criteria proved to have dubious utility. Compared with determinations based on cytological examination of the same ovaries, 40 to 70 percent of visual determinations constituted misclassification.

4. The average catch of larval penaeids was approximately five per tow from mid-January to early March. During the fourth cruise (March 21-23) it rose to 31 as a result of the increasing abundance of S. brevirostris larvae.

5. Penaeus larvae were not taken at those stations located in depths less than 15 fathoms during the first two cruises, but were found at the 7½-fathom stations in late February and March. Of special interest was the occurrence of five Penaeus postlarvae at stations more than 70 miles offshore.

6. Larvae of S. brevirostris were found at the 15-, 25-, and 45-fathom stations. Trachypeneus, Solenocera, and Parapenaeus larvae occurred sporadically in samples taken throughout the study area.

Distribution and abundance of larvae The last half of 1960 was devoted to processing and examining 3,111 plankton samples taken systematically from passes connecting Galveston Bay with the Gulf of Mexico, and from the Gulf itself. These samples, obtained with a Gulf V sampler from March 1959 through March 1960, form the basis for a study designed to determine the feasibility of assessing relative seasonal and areal abundance of penaeid larvae. Larvae were sorted from each sample, catalogued and enumerated according to their stage of development and probable identity, and stored in small vials. A system of coding facilitated tabulation. For example, the code 2NI referred to a Nauplius I which was most likely the brown shrimp, Penaeus aztecus; 3MII referred to a Mysis II of the white shrimp, Penaeus setiferus; etc. Fifty-seven such code designations have been employed, but as morphological relationships between and within species become better understood, this number will gradually be reduced through consolidation of material on a genus or species basis.

An important aspect of this project is the accuracy and comparability of the abundance indices determined for each species. Volumes of water strained by the Gulf V plankton net when taking each sample had to be estimated by appropriate conversion of flowmeter readings. To this end, calibration factors for plankton net-flowmeter assemblies were computed from data obtained expressly for this purpose. Sample counts of individuals comprising each (coded) larval type have been adjusted accordingly and tabulated. Quantitative analysis is now underway.

Sampling of postlarval penaeids twice weekly at a station inside Galveston Entrance near the South Jetty terminated in May. These collections began in November 1959 and resulted in 141 "standardized" samples yielding more than 14,000 postlarvae. During 1960 postlarvae were found from early January to mid-December with peaks in abundance occurring in the periods mid-March to mid-April and mid-June to late August. None were taken at this station between mid-December and mid-February. In contrast to the large numbers of postlarvae taken during March and April 1960 (9,900 from 17 samples), relatively few (330 in 15 collections) were taken during the same period in 1961. Analysis of these data and associated hydrographic observations will begin shortly and should provide valuable knowledge regarding movement of young commercial shrimps into estuarine areas.

One year of systematic plankton sampling in the Galveston Island surf ended in April. Samples and hydrographic observations were secured semiweekly at four equally spaced stations along the beach front. Penaeid postlarvae occurred at these stations throughout the year and with about the same frequency as those at the Galveston Entrance station. The question arises as to whether the small (8-11 mm. total length) postlarvae found in mid-January hatched during December or even earlier and, avoiding the unsuited inshore waters, were spending the ensuing winter months in nearshore waters in a state of reduced activity.

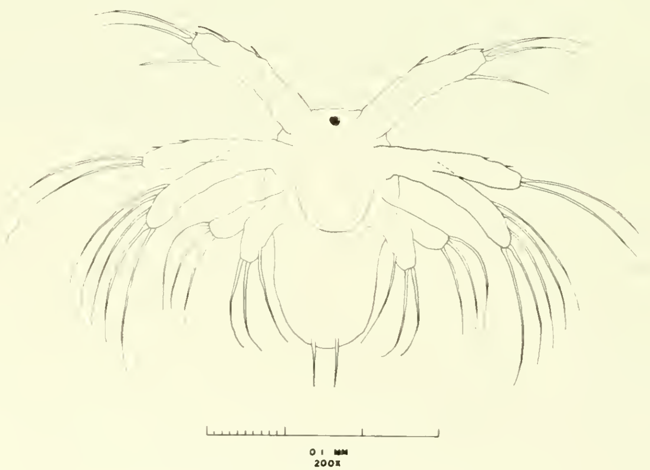
Identification and Description of Shrimp Larvae

Harry L. Cook

Studies of the distribution, abundance, and biology of the larvae of commercially important shrimps depend upon the facility with which the various species and their developmental stages can be differentiated. Initiated in 1959, efforts to rear and describe the larval stages of common penaeids continued during the past year.

Rearing trials Gravid females of five species were captured periodically and held in the laboratory for the purpose of securing viable spawn. Larvae hatched from eggs and reared to the stages indicated were obtained for the following species:

1. *Xiphopeneus krøyeri* (seabob) - Larvae reared through Nauplius IV; resulting specimens of Nauplius III and IV supplemented descriptive material obtained from a spawn in 1959.
2. *Sicyonia brevirostris* - Larvae reared to Protozoea I; most of the specimens preserved were in poor condition (broken setae or badly entangled in detritus) and could not be used for descriptive purposes.



Nauplius I of *Sicyonia brevirostris* Stimpson, ventral view.

Protozoea I of *Sicyonia brevirostris* Stimpson, ventral view.

3. *Sicyonia dorsalis* - Larvae reared to Protozoea I; preserved specimens are now being examined.

Captive shrimp frequently aborted non-viable eggs which were usually misshapen, discolored, and deposited in clumps. Sometimes a few developed into nauplii or to a point where the nauplius could be seen within the egg. Examination of thelyca[1/] indicated that the above conditions resulted more from a lack of (or incomplete) fertilization than from incomplete development of the eggs themselves. Of 11 *X. krøyeri* which spawned in the laboratory, those releasing eggs that failed to develop had retained the implanted spermatophores, whereas those spawning viable eggs had lost all or at least a portion of theirs. As soon as captive shrimp spawn, an examination of each thelcyum might indicate which of several individuals spawning simultaneously most likely yielded viable eggs. From the standpoint of minimizing the time spent searching for viable material, such lots of eggs would subsequently receive most attention.

Modifications of methods used in earlier rearing trials have given encouraging results. Attempts to reduce the adverse effects of excessive detritus and various micro-organisms had involved the use of sand-filtered and

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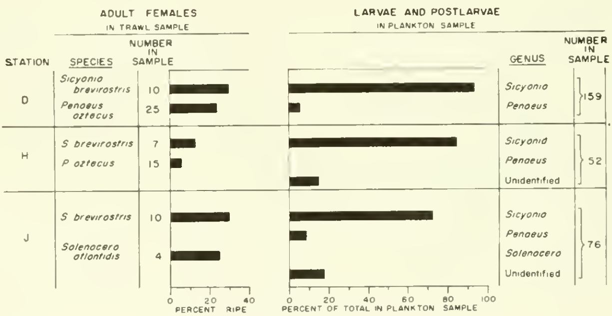
1/ Female structure which receives spermatophore (sperm sac) from male.

artificial sea-water media, treating these with antibiotics, various chemicals, and ultra-violet radiation, and by gentle preheating. Transfer of eggs and larvae through serial baths of clean water was also tried. None of these methods, however, proved entirely satisfactory. Better results are now being obtained using a circulating rearing medium which is first passed through glass wool and cellulose ("Aqua-pure", Cuno) filters and then irradiated ("Steritron", Englehard Hanovia, Inc.).

Identification of larvae   On several occasions larvae and postlarvae were brought to the laboratory for rearing to identifiable sizes. Some were reared in isolation, attempts being made to recover casts for descriptive purposes from each instar. Although this technique has proved feasible in the case of postlarvae, casts from nauplii and protozoea are usually too badly damaged during the molting process to be so utilized. Casts of mysis stages have not been evaluated.

Larvae belonging to the genera Penaeus, Sicyonia, Solenocera, and Parapenaeus can now be identified as such using existing reference material. Nauplii and Protozoea I of the species X. krøyeri and S. brevirostris may be identified through comparison with specimens of known identity reared in the laboratory.

The concurrent spawning population survey, which employs cytological techniques to determine extent of gonad maturation, shows promise of also aiding in the identification of larvae. On several occasions, for example, large numbers of larvae identified as Sicyonia sp. occurred together with ripe and spent adults of S. brevirostris, the only Sicyonia species (adults) collected. The conclusion logically following is that the larvae were also largely S. brevirostris.



Coincidence of ripe female and larval shrimp at selected stations, Cruise No. 4 (March 21-23, 1961), spawning population survey.

Identification of Postlarval and Juvenile Shrimp

William C. Renfro

Postlarvae of the three species of Penaeus common in the Louisiana-Texas area are difficult to separate when less than 20 mm. long. White shrimp, P. setiferus, 20 mm. or more in total length, are easily identified and hence distinguished from the others by the absence of grooves flanking the postrostral ridge. On the other hand, separation of the "grooved" shrimps, P. aztecus and P. duorarum, is not easily accomplished until they reach a size at which their external genitalia are well developed. In an attempt to identify postlarvae systematically collected inside Galveston Entrance and along the Galveston Island beach front, specimens were brought to the laboratory for rearing individually or en masse to sizes at which non-grooved (white) and grooved species could be distinguished.

Specimens reared individually were isolated in small covered dishes and fed newly hatched brine shrimp nauplii. Although mortality was low, they grew slowly, their monthly length increments averaging less than 9 mm. over $1\frac{1}{2}$- to $2\frac{1}{2}$-month periods. The rearing containers were inspected daily and any casts removed and preserved for study. In this manner a series of exoskeletons was obtained from shrimp during metamorphosis through postlarval to separable juvenile sizes. Examinations of casts obtained from non-grooved (white) and grooved shrimp as length increased from 12 to 17 mm. have not yet revealed morphological characters sufficiently diagnostic to separate the two groups within this size range. It was noted, however, that "grooved" shrimp (postlarvae) as short as 15 mm. could be identified as such through faint grooves alongside the postrostral ridge, which become readily discernible when the partially dried cast of the cephalothorax is viewed under strong incident light.

Groups of postlarvae reared en masse in aquaria of up to 300 gallons capacity were fed fine pieces of shrimp or fish in addition to brine shrimp nauplii. Mortality due to cannibalism was high, and the highest rate of growth within any group was a rather low 13.5 mm. per month. Weekly samples of shrimp were measured and preserved for morphological studies.

The results of six rearing trials showed that postlarvae of grooved shrimp, most likely the brown shrimp, P. aztecus, were present in Galveston Entrance from April through mid-December. Only one group of postlarvae subsequently proved to be white shrimp, these having been collected in late November 1960.

Migrations, Mortality, and Growth of Pink Shrimp

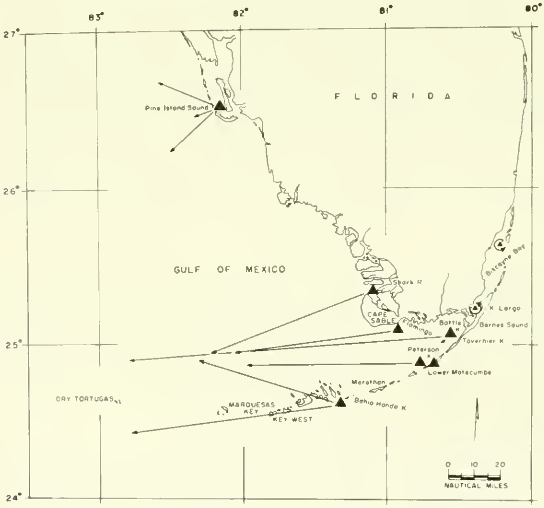
Thomas J. Costello and Donald M. Allen

Migrations Two mark-recapture experiments executed during the period November-May (1960-61) extended a series of similar experiments initiated in 1958 to circumscribe the geographical range of stocks supporting the Tortugas pink shrimp fishery.

Responding to intensified publicity (and a sizeable monetary inducement), commercial fishermen turned in 56 and 149 recaptures, respectively, of shrimp stained and released as juveniles at Bottle Key (13,309) in November, and Lower Pine Island Sound (32,913) in December. Of the Bottle Key recaptures, 10 came from Florida Bay within 6 miles of the release site, and 46 from the Tortugas grounds about 120 miles to the west. The last of these was made early in May, 6 months following release, confirming the stated durability of certain biological dyes as shrimp-marking agents.

All Pine Island Sound recaptures were made on the Sanibel fishing grounds within a 30-mile radius of the release site.

The accompanying table and figure summarize the results of completed experiments. These results tentatively indicate that all of Florida Bay constitutes nursery area for pre-recruit segments of the Tortugas pink shrimp stock, whereas Barnes Sound and Biscayne Bay on the Florida east coast, and estuaries north of Cape Romano on the west coast do not. Moreover, migration patterns exhibited by these experimental populations suggest the general movement of immature shrimp to be , somewhat radially, in an east-west (onshore-offshore) rather than in a north-south (coastwise) direction. This relationship between inshore nursery areas and directly opposing offshore spawning areas seems to hold regardless of the migration distances involved. The questions still remain, however, as to (1)



Release sites for mark-recapture experiments, and probable routes of juvenile pink shrimp to recapture area, Florida Bay and Gulf of Mexico, 1958-1961.

Summary of pink shrimp mark-recapture experiments in Florida Bay and contiguous waters, 1958-1961.

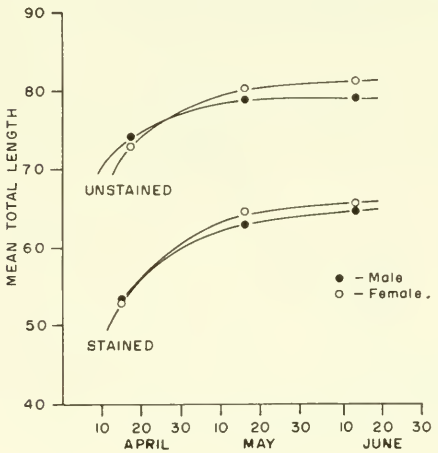
Release site	Color of mark	Date of release	Number released	Number recovered*	Period of recapture	Area of recapture
		1958				
Biscayne Bay	Green	Apr.-May	19,358	57	May-July 1958	Biscayne Bay
Flamingo	Blue	Oct.	7,264	4	Jan.-Feb. 1959	N. of Dry Tortugas
		1959				
Peterson Key	Green	Jan.	1,729	11	Mar.-May 1959	N. of Dry Tortugas
Matecumbe Key	Red-blue	Mar.	1,672	0	--	--
Barnes Sound	Blue	July	7,084	29	Aug. 59-Jan. 60	Barnes Sound
Shark River	Green	Nov.	16,638	31	Dec. 59-Jan. 60	N. of Dry Tortugas
		1960				
Bahia Honda Key	Blue	Feb.	6,815	17	Mar.-May 1960	N. of Dry Tortugas
Bottle Key	Green	Nov.	13,306	10	Nov. 60-Jan. 61	Florida Bay
				46	Jan.-May 1961	N. of Dry Tortugas
Pine Island Sound	Blue	Dec.	32,913	149	Jan.-May 1961	SW and NW of Sanibel Island
Totals			106,779	354 (0.3%)		

*Recoveries verified as of June 30, 1961.

the extent of coastwise intermingling of mature shrimp after they pass through the fishery and (2) the origin of larvae nurtured in specific estuary systems.

Mortality   Studies of mortality in pink shrimp populations are scheduled to begin in late 1961. Further application of the staining technique to facilitate mortality measurement has been encouraged by the generally good results obtained from the Bottle Key and Pine Island Sound experiments.

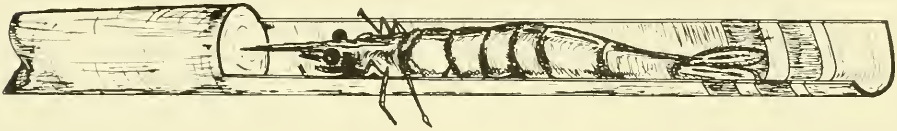
Growth   Attempts to describe pink shrimp growth over an increasingly wider range of developmental stages continued during the year. Two mark-recapture experiments involving shrimp ranging in total length from 47 to 77 mm. were initiated in Biscayne Bay in August 1960 (11,000) and April 1961 (2,775), respectively. Marking agents consisted of three dyes (Trypan blue, Trypan red, fast green) applied by "feeding" (ingestion) and injection. As only four recaptures (3 blue, 1 green) were reported by Biscayne Bay commercial bait fishermen, both experiments may be considered to have ended in failure. The single green recapture did, however, provide a good indication of how rapidly shrimp will grow during juvenile stages. A female, 70.5 mm. long at release in mid-April, had increased in total length at the rate of 27.5 mm. per 30-day period over the 65 days preceding recapture.



Growth of pink shrimp in a small sea-water pond, Virginia Key (Miami), Florida, April-June 1961.

The dearth of recoveries from either experiment was most likely due to a combination of (1) relatively small releases of marked shrimp and (2) rapid movement of marked populations beyond the range of effective fishing. A possible explanation for no recoveries in cases where Trypan red was used as the marking agent is that this stain did not present enough contrast to the shrimp's normal color to be readily noticed by fishermen or dealers. Trypan red in all individuals comprising a sample held in captivity for 3 months was, however, still detectable at the end of that period.

An additional mark-recapture experiment involving slightly over a thousand small (50-75 mm. total length) pink shrimp marked with various stains and held in a small sea-water pond yielded, after a lapse of 5 weeks, the results graphed above. These compare favorably with the results of earlier experiments conducted in the same pond at the same season but with somewhat larger shrimp. Survival appeared good and was comparable in marked and unmarked groups. In both series of experiments individuals were recaptured by seining and trapping. At no time were natural food supplies augmented artificially. In the latest experiment, pond temperature ranged from 26° to 33° C. and salinity from 27‰ to 36‰.



Device for rapid measurement of small shrimp. Basic construction is of plastic tubing. Note variously colored size-range calibrations.

Penaeid species complex in south Florida waters Until recently, *Penaeus duorarum*, the pink shrimp, was believed to be the only member of the genus *Penaeus* occurring in south Florida waters. In 1960 Florida State Board of Conservation scientists detected small numbers of *P. brasiliensis* in samples of shrimp taken from Biscayne Bay, and the Bureau of Commercial Fisheries exploratory vessel SILVER BAY took large *P. aztecus* (brown shrimp) from 50-60 fathoms southwest of the Matecumbe Keys. Since these coexistent species are practically indistinguishable at all but the most advanced stages, the question arose as to what degree such a complex might invalidate the results of research directed toward pink shrimp *per se*.

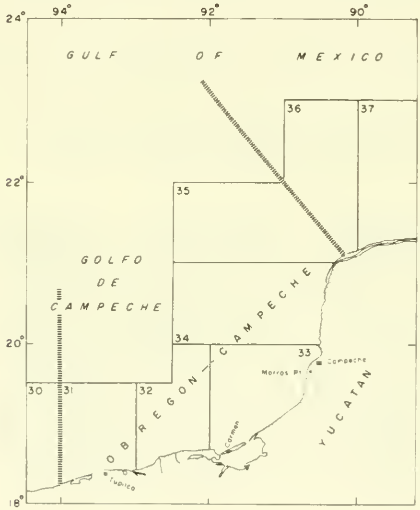
To answer this question, systematic samples of commercial shrimp catches are being taken at various points along the south Florida coast to ascertain, insofar as possible, the seasonal occurrence and distribution of each species. Examination of samples from Biscayne Bay and Hawk Channel are revealing small percentages of *P. brasiliensis* in catches dominated by pink shrimp. A form resembling *P. aztecus* has been found in a few of the Biscayne Bay samples. Samples from the southwest Florida coast area (Pine Island Sound) have thus far indicated the presence of *P. duorarum* exclusively.

The Campeche Pink Shrimp Population, 1956-1960

Joseph H. Kutkuhn

Shrimp stocks lying off the northern coast of Yucatan, although reconnoitered as early as 1936 by the Japanese, were not fished significantly until the close of World War II. Operations on the so-called Obregon-Campeche grounds by United States trawlers began about 1950 and have steadily expanded ever since.

Three species of Penaeidae support the Gulf of Campeche fishery. Brown and white shrimp are found in commercial quantities off Tupilco and Obregon (statistical areas 31 and 32), while pink shrimp predominate north of Carmen and west of Campeche (statistical areas 33 and 34).



The Obregon-Campeche trawling grounds showing subdivision into statistical coding units.

On the basis of comparisons with data supplied by the Mexican Bureau of Fisheries and Allied Industries for the years 1956 and 1957, the Mexican fleet accounts for roughly 56 percent of all shrimp harvested annually in the Campeche area. Reflecting to some extent a respect for Mexico's claim to a 9-mile territorial limit, the United States fleet takes only about 6 and 1 percent, respectively, of the total brown and white shrimp harvest, but almost 65 percent of the total pink shrimp catch. United States vessels concentrate their activities on the extensive flats within a radius of 15 to 80 miles west of Morros Point.

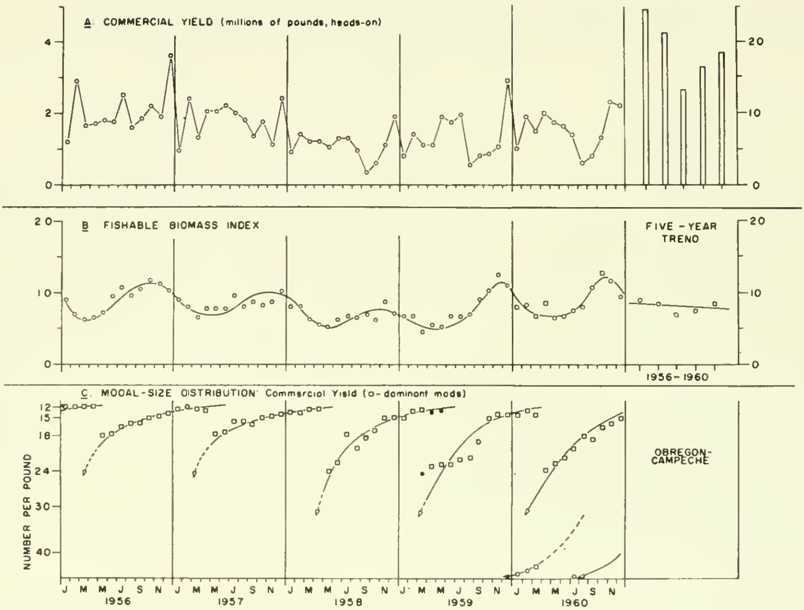
Statistical coverage of the fleet fishing the Obregon-Campeche grounds is complicated somewhat by the fact that trawlers completing a trip may land portions of catches of as many as a half dozen other trawlers still on the fishing grounds, and only a fraction of what they themselves caught while away from port. Trips to the Campeche area may last upwards of 6 to 7 weeks. This very efficient system of "freighting", wherein vessels stagger their departures to and from these distant grounds, greatly enhances the quality of shrimp arriving at United States ports but renders difficult the problem of assigning effort and catches to individual trawlers. Fortunately, most of the Campeche fleet operates out of a few Florida and Texas ports where statistical agents, with the full cooperation of the fishing industry, have devised effort and catch accounting methods so effective that statistics of United States fleet operations in the Gulf of Campeche may be included among the most accurate of all statistics describing the Gulf shrimp fishery.

Commercial yield After reaching a high of about 33 million pounds in 1953, annual landings of Campeche pink shrimp by United States fishermen stabilized at 24 to 25 million pounds over the period 1954-1956. Thereafter (1957-1960), they steadily declined to a low of 13.4 million pounds in 1958 but then began to climb again, reaching 18.5 million pounds in 1960. The lowest annual take recorded prior to 1958 was 8 to 9 million pounds in 1951, early in the fishery's development.

In contrast to seasonal catch patterns in most Gulf of Mexico shrimp-producing areas, the 1956-1960 pattern for pink shrimp on the Campeche flats showed relatively steady year-round production (see figure, A). Greatest month-to-month variation occurred during midwinter with the highest monthly production in December and (until summer and fall catches dropped below "normal" in 1958-1960) the lowest in January. This sharp drop is believed to reflect intensification of adverse fishing conditions rather than marked seasonal changes in shrimp abundance.

Fishable biomass The "fishable biomass" is defined as that fraction (in terms of weight) of a commercial fish or shellfish population, which comprises those individuals susceptible to capture by the gear commonly used in the fishery. An index thereto is provided by the ratio of catch to fishing intensity, such an index being calculated for each of reasonably small time increments, in this instance, periods of 1 month. Fishing intensity is defined as the quantity of fishing effort expended per unit area of the population's geographical range.

However, in the Campeche pink shrimp fishery as in the Texas brown shrimp fishery, all segments of the fishable biomass are not represented in the commercial landings despite the fact that the gear employed is essentially the same as that used throughout the Gulf. This is due to the rather rigid restrictions concerning the sizes of shrimp landed that the fishery imposes upon itself. The United States fleet fishing the Campeche shrimp populations is, perhaps, the most selective of any comparable unit operating in Gulf waters. Rarely are Campeche landings composed of shrimp predominantly smaller than 19-24 heads-on (31-40 heads-off) count size. And only in recent years has the average size fallen below 16-18 "whole" (26-30 "headless") shrimp to the pound. The task of maintaining quality control, i.e., sorting the decreasing numbers of large shrimp from increasing catches of small shrimp, is reportedly becoming more and more difficult. The consequence of such practices is that landings are not representative of that portion



Analysis of commercial pink shrimp statistics,
Obregon-Campeche grounds, 1956-1960.

of the population ordinarily vulnerable to the gear employed, and interpretations given analyses of associated statistics apply only to members occupying the upper size or age strata.

Involving only the population phases composed of pink shrimp equivalent to 19-24 count size (heads-on) and larger, a plot of monthly biomass indices for the period 1956-1960 yields the seasonal abundance curve typical of Gulf shrimp populations (see figure, B). Its amplitude of relatively low order can be attributed to the fact that landing statistics pertained solely to older population segments, the curve in no way reflecting actual status of the greater part of pink shrimp aggregations occupying the grounds. Thus, the most useful conclusions that can be drawn are that available quantities of premium pink shrimp on the Campeche flats reached a seasonal peak during late fall, and over the 5-year study period experienced a significant decline. The steady rise in annual mean biomass since 1958 does, however, offer some hope for recovery in the near future.

Population characteristics   Little information on population age structure could be obtained by plotting weight-frequency modes of monthly Campeche landings. As intimated earlier, weight-composition curves were almost exclusively unimodal with large shrimp predominating at all times (see figure, C). Conclusive evidence of more than one period of heightened spawning per year is lacking, but bimodal weight-frequency curves for spring landings in 1959, and winter and midsummer landings in 1960, suggest that two peaks in annual spawning activity are characteristic of the Campeche pink shrimp population.

Summary of 5-year status   Accurate but restrictive statistics give only a vague picture of conditions in the Campeche pink shrimp population. Composed primarily of large-size shrimp, yields to United States fishermen declined over the period 1956-1958, but increased measurably during the ensuing 2 years. Of significance was the drop in apparent abundance of large shrimp commencing in 1958 and sustained through 1960. Whether this was caused by excessive fishing alone, or by a combination of fishing and adverse environmental conditions, will always remain problematical. The Campeche fishery serves as a good example of a situation where lack of all-inclusive yield data (i. e., landings plus discards) inhibits proper population analysis. If landings statistics truly represented what was actually caught, further investigation of the Campeche population's dynamics would be justified.

INDUSTRIAL FISHERY PROGRAM

Joseph H. Kutkuhn, Program Leader

Since the inception of the now-extensive Gulf of Mexico shrimp fishery, commercial trawlers have been taking moderate to large quantities of fish incidental to the highly sought shrimp. In nearly all seasons and especially off the north central Gulf coast, bottom fishes of many kinds are extremely plentiful. Because of their small average size and general undesirability, they have never been found suited to marketing for human comsumption. Not until the early 1950's was it conceived that such fishes might constitute ideal animal food supplements. A pilot plant established at Pascagoula, Mississippi, in 1952 successfully implemented this idea and a large-volume "industrial" fishery has since developed in that area.

Utilization of Gulf of Mexico demersal fish populations first came under surveillance by the Bureau of Commercial Fisheries in 1958 when yields in the Delta area rose sharply to almost 68 million pounds. In that year a program for securing statistics of the fishery's operations was initiated, as was a program of biological research on the major contributing species. In addition to research being conducted at its Pascagoula Field Station, preliminary studies of bottom-fish populations and their commercial potential in the western Louisiana-Texas area are now underway at the Galveston Laboratory. Objectives of the research at both locations are, generally, (1) to describe the life histories of those species dominating the fishery (actual and potential); (2) to ascertain their geographical and seasonal distribution; (3) to provide means for measuring and predicting their abundance; and (4) to define the mechanisms whereby artificial and natural factors govern their populations.

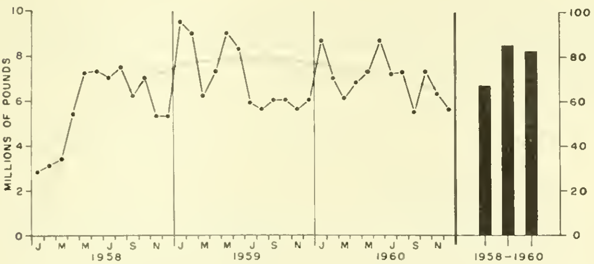
Although research on pelagic (excluding the menhaden) as well as demersal industrial-type fishes is programmed, it has been precluded thus far due to the failure of any fishery for such forms to develop, insufficient resources in terms of appropriate population sampling facilities, and hence the lack of biological material. Outside of some contract research supervised through the Galveston Laboratory, research on menhaden populations is now performed by the Bureau's Beaufort, North Carolina, laboratory.

Industrial Bottom-Fish Fishery in the North Central Gulf of Mexico

Winthrop A. Haskell

Industrial-fish landings in the Pascagoula, Mississippi, area continued to be sampled routinely for species composition and for certain attributes of the more important contributing species. During the calendar year 1960, 389 samples averaging $20\frac{1}{2}$ pounds each and collectively representing 14.9 million pounds or 18 percent of that year's total harvest were taken. Sampling was confined to 2 days each week on a rotating schedule when landings occurred regularly. In periods of sporadic fishing, sampling proceeded on a judgment basis with every attempt being made to ensure adequate representation of catches according to when and where they were made.

Fishery Statistics supplied through the courtesy of the animal food industry revealed that slightly more than $82\frac{1}{2}$ million pounds of industrial-type bottom fishes, taken on the continental shelf in the vicinity of the Mississippi River Delta, were landed and processed in 1960. This represented a $2\frac{1}{2}$-percent decline from the previous year's take and may have signified the beginning of a downward production trend (see accompanying figure). Though certainly not



Industrial bottom-fish landings in the north central Gulf of Mexico area, 1958 - 1960. Shaded line indicates 3-year trend.

well established, such a trend can be attributed solely to economic factors, particularly to the depression of the 1960 fish meal market. Whereas 15 meal and petfood plants operated in 1959, 10 processed industrial fishes in 1960, and by June of that year most of the meal plants had closed down. Had it not been for an appreciable expansion of the petfood market, the decrease in industrial-fish landings would have been considerably greater.

The total number of fishing trips in 1960 dropped 11 percent from that made by the commercial fleet in the preceding year. On the other hand, the average catch per trip rose by $11\frac{1}{2}$ percent. Average-length-of-trip data for both years are not available, but this jump in fishing success is believed mostly due to a significant increase in trawler size (and power) and the correspondingly greater number of vessels with refrigeration facilities.

Also worthy of note is the tendency toward westward extension of the fishing grounds. With the advent of larger vessels and refrigeration equipment, increasing poundages of industrial species are being taken west of the Delta. Contrasted to only 16 percent in 1959, an estimated 60 percent of the total industrial-fish harvest originated here in 1960. As in the past, all fishing was concentrated inside the 20-fathom contour.

Composition of landings   As determined from catch samples, representatives of the Sciaenidae, especially the Atlantic croaker, Micropogon undulatus (49%); spot, Leiostomus xanthurus (11%); and silver seatrout, Cynoscion nothus (11%) continued to dominate industrial bottom-fish landings. Also reflecting no change in composition over previous years was the prevalence of Atlantic cutlassfish, Trichiurus lepturus (5%); inshore lizardfish, Synodus foetens (2%); scaled sardine (razorbelly), Harengula pensacolae (2%); and sea catfish, Galeichthys felis (2%).

Life history studies   Supplementary sampling of bottom-fish landings for attributes of the dominant species, viz., Atlantic croaker, spot, and silver seatrout, was initiated in 1960 for the purpose of enhancing our knowledge of the biology of these important fishes. Analyses of data are incomplete, but some indication of annual reproductive patterns is provided by the accompanying schematic which shows, on a monthly basis, the category of development into which the highest proportion of gonads for each species was classified.

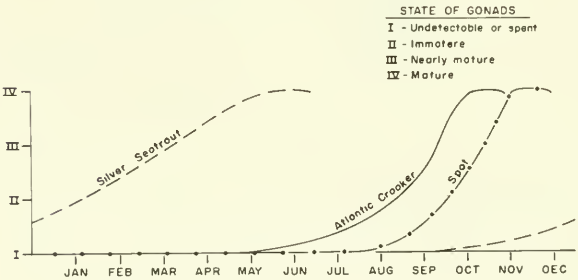


Diagram showing seasonal progression of gonad maturation in three Gulf of Mexico bottom fishes (1 - 20 fathoms just east and west of Mississippi River Delta).

The Atlantic croaker spawns in the fall in the open waters of the north central Gulf of Mexico near the mouths of passes leading into shallow bays and lagoons. At this time the number of ripe adult croakers entering the commercial catch increases noticeably. The first collection of croakers with well-developed roe and evidently in spawning condition was taken on September 18 in the Horn Island Pass area, whereas the last ripe or nearly ripe fish was collected about the first of December. The largest gravid croaker observed was a female, 207 mm. long and weighing 117 grams, taken from east of the Mobile ship channel on October 7. The smallest spawning adult was a female, 143 mm. in total length and 32 grams in weight, captured in the same area on October 29.

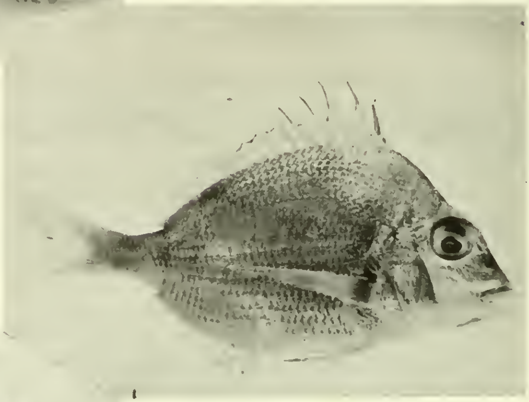
Spot apparently spawn somewhat later than croaker. The first ripe specimens were sampled on November 10, and by November 25 all fish examined were ripe and running ova or milt. By January all fish were spent, indicating that the height of the spawning period is somewhat earlier than that of the same species in the Texas coast area. The largest gravid spot observed was a female 215 mm. long and weighing 94 grams, taken off Horn Island on December 22. The smallest was a sexually mature female, measuring 154 mm. in total length and 37 grams in weight, captured off Dauphin Island on November 20.

The spawning period for silver seatrout appears more protracted than that of either of the other species. Moreover, this species reportedly spawns within bays and lagoons in contrast to the croaker and spot which spawn in the open waters of the Gulf of Mexico. Individual fish were found in all stages of sexual development throughout the spring and summer. Ripening seatrout were collected from February 7 through August 18. A few ripe females were sampled as late as October 2. The largest specimen observed was a gravid female, 295 mm. long and weighing 216 grams, taken from the area of Petit Bois Island on July 22.

The scaled sardine, or razorbelly, began ripening in early May, and by late June most specimens were sexually mature. Those collected on July 7 were largely spent, the last sexually mature specimen being taken on July 10.

Atlantic croaker
(*Micropogon undulatus*)

Average length about 6 inches

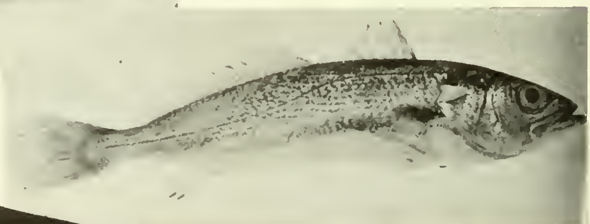


Longspine porgy
(*Stenotomus caprinus*)

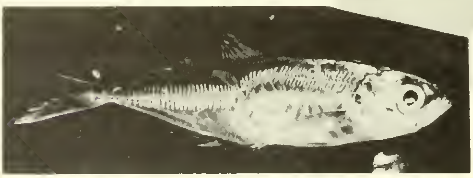
Average length about 5 inches

Spot
(*Leiostomus xanthurus*)

Average length about 7 inches



Silver seatrout
(*Cynoscion nothus*)
Average length
about 8 inches



Rough scad
(*Trachurus lathami*)

Average length about 5 inches

Five of the most common fishes taken in trawls off
the northern Gulf coast.

Preliminary Survey of Industrial-Type Bottom Fishes in the Northwestern Gulf of Mexico

James G. Ragan

Sampling of demersal fishes off the east Texas coast was undertaken to determine (1) the species occurring in this area, (2) their seasonal distribution and relative density, and, in the case of the more abundant species, (3) various aspects of their life histories.

Most samples are being obtained with the cooperation of the Shrimp Fishery Program, which initiated a trawl sampling project in January of this year. Cruises are being made every 3 weeks with two "random" 5-pound samples being taken from 1-hour trawl hauls at each of 11 stations. Depths range from $7\frac{1}{2}$ to 45 fathoms (see Station pattern, Early Life History of Commercial and Related Shrimps). A few samples were taken by the M/V OREGON during exploratory cruises off Texas in the late summer and fall of 1960.

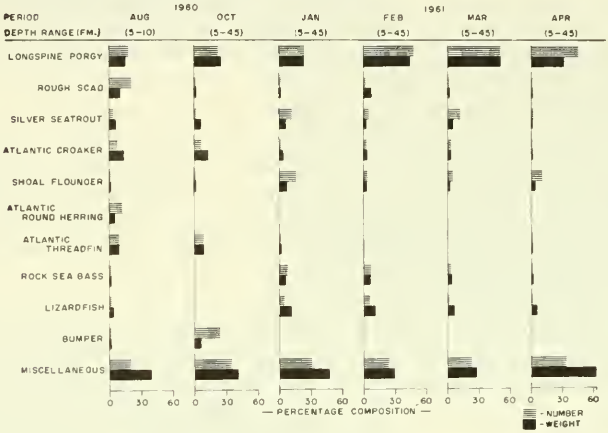
Data obtained from sampled fishes include: species identity, length, weight, sex, and stage of maturity. Thus far, 205 samples, most of which were taken with 45-foot, $2\frac{1}{4}$-inch mesh "flat" trawls, have been processed. Data analyses are incomplete, however, the following observations being based on 109 or about one-half of the processed samples. These cover the period August 1960 to April 1961.

Of 94 species identified, 10 constituted about three-fourths of the total catch (by number). In descending order of importance, these were:

Common name	Scientific name	Percentage composition (by number)	Mean total length (mm.)
Longspine porgy	(*Stenotomus caprinus*)	33	114
Rough scad	(*Trachurus lathami*)	7	113
Silver seatrout	(*Cynoscion nothus*)	6	126
Atlantic croaker	(*Micropogon undulatus*)	5	146
Shoal flounder	(*Syacium gunteri*)	5	117
Atlantic round herring	(*Etrumeus sadina*)	4	105
Atlantic threadfin	(*Polydactylus octonemus*)	4	119
Rock sea bass	(*Centropristes philadelphicus*)	3	140
Inshore lizardfish	(*Synodus foetens*)	3	232
Bumper	(*Chloroscombrus chrysurus*)	3	90

On a percentage composition by weight basis, the longspine porgy, lizardfish, and croaker ranked, in that order of importance, as the leading species.

The longspine porgy proved to be the most common species taken in every period except August when only comparatively shallow areas were sampled. Its proportion in all samples increased sharply from January to February and reached a peak in March.



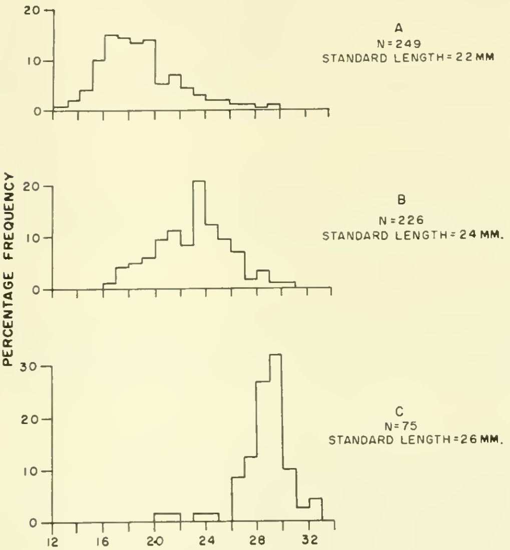
Seasonal composition of bottom-fish samples taken off east Texas, Gulf of Mexico, August 1960-April 1961.

Distribution by depth seemed well defined for some of these fishes. The longspine porgy dominated samples from 20 to 45 fathoms but was infrequently taken within the 10-fathom range. Conversely, the seatrout, croaker, threadfin, and bumper, all most abundant inside the 10-fathom curve, were not found at depths greater than 20 fathoms. The shoal flounder predominated between 10 and 20 fathoms. These findings should be compared with those from 3 years' sampling of commercial bottom-fish catches made in the Delta area. The Atlantic croaker predominates there, making up about 50 percent of annual landings. Ranked closest behind it are the spot and silver seatrout, each contributing 10-12 percent. Recall, however, that the fishery in this area confines itself to those waters within the 20-fathom curve. It is likely that beyond this zone, species such as the longspine porgy and rough scad are as abundant as they appear to be at the same depths off the Texas coast.

Menhaden Biology

James Y. Christmas, Jr.
Gulf Coast Research Laboratory, Dr. Gordon Gunter, Director
(Contract No. 14-19-008-9335)

Field work during the year was limited to (1) the collection of Gulf menhaden, Brevoortia patronus, juveniles throughout the summer months and adults during the spawning season; and (2) the observation of larval and postlarval movement patterns in the Mississippi area. A few small menhaden were caught in plankton samples late in November. Specimens were found in Mississippi Sound in December. Although greater numbers of individuals were taken in January, schools of postlarval menhaden were not evident in Mississippi estuaries until late February.



Body depth as percent of standard length, to show change in body proportions of the Gulf menhaden during transition from postlarval to juvenile stages.

Life history studies Reduction of plankton samples yielded 106 vials of fish larvae thought to be menhaden and approximately 110 samples of fish eggs. Although spawning menhaden have not been observed, their eggs have been tentatively identified by comparison with eggs from nearly mature ovaries. Round eggs in various stages of development found in plankton tows and thought to be menhaden eggs have a diameter of approximately 1.2 mm. The yolk sphere is 0.8-0.9 mm. in diameter and contains a single oil globule 0.13-0.15 mm. across. The egg membrane is very thin and clear. Embryos with 12-14 somites extend about two-thirds of the distance around the yolk sphere. Numerous small black chromatophores are evident along the dorsal surface and extend laterally in the anterior region of embryos that have reached a length of 2.3-2.4 mm.

Morphometric characters of approximately 2,300 young menhaden in the transformation stage were measured. These specimens were taken from samples obtained in 1958, 1959, and 1960. Using material from the 1958 samples, the accompanying figure illustrates the changing body depth-standard length ratio as the species progresses through this stage.

Additional information concerning time and length of spawning, growth, seasonal movements, natural enemies, and parasites is being incorporated into a final report on menhaden life history.

ESTUARINE PROGRAM

George A. Rounsefell, Acting Program Leader

Because of the growing need to understand the effects of man-made changes on the estuarine environment, a small estuarine program was initiated in 1961. The purpose was to develop a nucleus of personnel and preliminary knowledge, and to explore the type and scope of research necessary to predict the effects of engineering projects on the fisheries.

For the present the estuarine work is divided into three projects:

1. Evaluation of estuarine data. The study of existing published and unpublished data to obtain a clear picture of the present state of our knowledge in order to determine how most effectively to attack the basic problems without duplication of effort.

2. Effects of engineering problems. Aimed at more or less empirical determination of the causes of effects on the fauna through study of conditions before and after construction of specific projects. Also advises on particular projects.

3. Ecology of nursery grounds. To determine the types of estuarine habitat suitable for different sizes and species of fish and invertebrates, how they are affected by fluctuations in the environment, and their interrelationships.

Much of the knowledge must be obtained from studying conditions before and after construction of specific projects; thus, in some cases, the project and adjacent waters constitute our "laboratory." The Corps of Engineers constructs large-scale models of some of its projects at the Waterways Experiment Station in Vicksburg, Mississippi. Tests with these models can be very useful in the prediction of project effects on the hydrography of an area.

Evaluation of Estuarine Data

Joseph J. Graham

This project evaluates existing data to decide on future estuarine research. As a first step, a study of the literature and unpublished data on Gulf estuaries is underway. Secondly, plans and field operations of minor and major engineering projects are being studied. Minor projects are concerned primarily with small dredging and filling operations; major projects involve water development, flood and hurricane protection, and dredging of waterways. Considerable attention is given to those projects which utilize models to predict the effects of artificial alterations in certain estuaries. A seminar on model studies at the Waterways Experiment Station at Vicksburg, Mississippi, was attended.

One major problem is disposal of spoil from channel dredging so as not to seriously curtail water exchange between different sections of a bay or between a bay and the peripheral marshes. Solution of this problem may require research on the rates of sloughing of spoil banks according to soil types.

The Gulf Basins plan for Texas contemplates the transport of fresh water by a canal paralleling the coast from the eastern humid basins to the semiarid and arid basins farther west. Much of this water will be used for irrigation or other consumptive uses, reducing the fresh-water inflow into many estuaries. In some cases the reduction through water storage of peak discharges during certain seasons may be of actual benefit provided the flow is not drastically curtailed in other seasons. The problem merits full attention, and existing data and reports are being studied to discover what they show of preconstruction conditions.

A general program for estuarine research in the Gulf was presented to the Gulf States Marine Fisheries Commission at their March 16-17 meeting in Biloxi. In this report stress was laid on the necessity for federal, state, and academic cooperation to solve problems that are beyond the scope and the means of any single agency. Three broad fields of research comprise problems to be attacked in the laboratory, in the estuaries, and on the adjacent continental shelf. Basic laboratory problems include studies of the resistance of various species to physical and chemical properties of the water, determination of the conditions optimum to their performance, growth and survival, and determination of their nutritional requirements. In the estuaries we need to inventory the types of habitat and the related fauna, determine the relative abundance and distribution of species, and collect background environmental data at selected stations to understand long-term fluctuations. On the continental shelf we need to understand the distribution of oceanic properties and the oceanic ecology of those species that are dependent at some stage of their life history on suitable estuarine habitat.

Effects of Engineering Projects

Richard A. Diener

The ultimate goal of this project is to amass sufficient knowledge of the effects of various types of engineering projects on the hydrographic conditions of estuaries to enable prediction of changes that will ensue. Through this knowledge we may be able to recommend reasonable modifications of projects when indicated to ensure the least damage to, and in some instances to even enhance the value of, estuarine waters.

Although our present knowledge is somewhat deficient, it is nevertheless necessary to advise on current projects. For the Texas section of the coast the Galveston Laboratory is working directly with the field personnel of the Albuquerque Regional Office of the Bureau of Sport Fisheries and Wildlife and the Texas Game and Fish Commission. In other sections of the Gulf Coast the laboratory has been working with the Atlanta Regional Office of the Bureau of Sport Fisheries and Wildlife and state agencies only on major projects which obviously require research. Thus, Mr. Naab inspected the Freshwater Bayou Project in cooperation with the Louisiana Wild Life and Fisheries Commission and personnel from the Wildlife Research and River Basin Studies Branches. The Louisiana Wild Life and Fisheries Commission has released several thousand stained shrimp in the adjoining western Vermilion Bay to determine the importance of this marsh complex to the shrimp fisheries.

Inspecting Freshwater Bayou, Louisiana, on a mudboat.

Freshwater Bayou, Louisiana, junction with a fur company canal.

The Everglades area was inspected by Dr. Graham in cooperation with River Basin personnel to plan studies on the effects of larger fresh-water discharges into the Everglades from the proposed Central and Southern Florida Floodway Project on the productivity of the Everglades estuaries, with special regard to their value for the young stages of the pink shrimp. Recent releases of young stained pink shrimp have shown that they contribute to the highly valuable Tortugas shrimp fishery adjacent to Key West.

Preliminary studies by Dr. Aldrich of water releases into the Caloosahatchee River strongly suggest that the amount of discharge has a positive long-term effect on the occurrence of red tide.

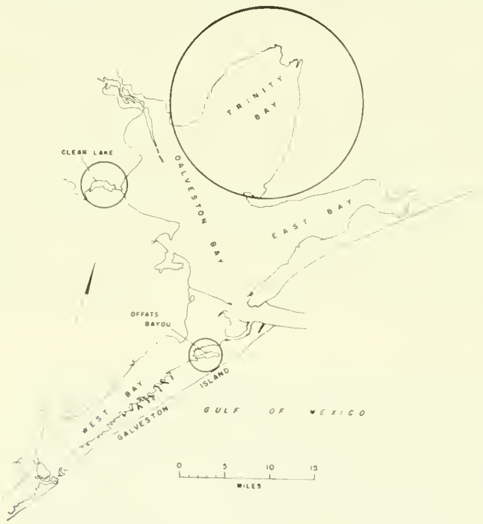
Issuance of drilling permits A meeting was held in Houston in September concerning the possibility of prompt issuance of blanket permits by the Corps of Engineers for drilling wells in estuarine waters to minimize delay in obtaining permits. Attending were representatives of the Corps of Engineers, the Texas Game and Fish Commission, the Geological Survey, several major oil companies, and Service personnel from both Bureaus. Subsequently, an *ad hoc* committee of Service and Texas Game and Fish Commission biologists met twice at the Galveston Laboratory and formulated a set of special conditions for normal operations and spoil disposal that might be attached to blanket permits.

Maintenance dredging Maintenance dredging of the Intracoastal Canal and connecting channels poses a problem of spoil disposal. Unfortunately, spoil was not well placed from the standpoint of water circulation during the initial dredging of many of these channels. The Corps of Engineers has cooperated by furnishing a vessel and crew to inspect sections requiring heavy maintenance dredging, and on-the-spot inspection of spoil disposal plans were made along sections of the Intracoastal Canal adjacent to Galveston Bay and in the Laguna Madre.

Ecology of Nursery Areas

Anthony Inglis

Reference has frequently been made to the importance of the estuarine habitat and specifically the "nursery" areas, in the life histories of many of our commercial and sport fishes. To determine the role which the various environmental factors play in the survival and growth of these species, a study was initiated in 1958 in Clear Lake, a shallow estuary emptying into Galveston Bay. One year's intensive sampling of this area was completed, and the results will soon be submitted for publication.



Nursery areas under study in Galveston Bay.

Since Clear Lake represents only one type of estuarine habitat, it was decided to make a comparative study of another type during 1960-61. Offats Bayou, closer to the mouth of Galveston Bay, was selected for comparison as it differs from Clear Lake in several respects

Though of comparable physical size, it is deeper and more saline, and its waters are considerably less turbid. It is within the boundaries of the City of Galveston, and consequently is probably more directly influenced by municipal development. Unlike Clear Lake, Offats Bayou supports a sport fishery of some importance and, at the same time, is far less productive of shrimp and crabs.

The intensity of sampling of Clear Lake during 1960-61 was reduced by diminishing sampling from seven to five stations and reducing periodicity of sampling from weekly to biweekly, to permit comparable sampling of nine stations in Offats Bayou. A complete comparison between the two areas awaits weighting the station data by the areas and seasons involved, but since the sampling was continuous during the three 12-month periods, a rough preliminary estimate of relative species abundance can be gained from the catch-per-trawl haul:

Species	Clear Lake		Offats Bayou
	1958	1960-61	1960-61
	363 1/	143	193
White shrimp, *Penaeus setiferus*	38	106	8
Brown shrimp, *P. aztecus*	20	55	9
Blue crab, *Callinectes sapidus*	6	8	7
Croaker, *Micropogon undulatus*	48	47	14
Menhaden, *Brevoortia patronus*	9	13	1
Anchovy, *Anchoa mitchilli*	8	6	14
Spot, *Leiostomus xanthurus*	4	7	34
Pinfish, *Lagodon rhomboides*	-	-	11
Sand trout, *Cynoscion arenarius*	2	4	-
Mullet, *Mugil cephalus*	-	3	-

1/ Number of samples

Though the same species were present in both areas, there are obvious differences in their relative abundance. For the more active surface and midwater species, e.g., sand trout and mullet, the sampling gear was much less effective, and the numbers taken are therefore relatively lower than for the bottom-dwelling species.

The most striking difference between areas was the relative importance of pinfish, *Lagodon rhomboides*, in Offats Bayou as opposed to the near absence of this species (a total of 21 in 1958 and 3 in 1960-61) from Clear Lake. Note also that spot and anchovies assumed more dominant positions in Offats Bayou than they did in either year in Clear Lake.

Shoreline of Clear Lake showing emergent vegetation affording excellent shelter for immature shrimp.

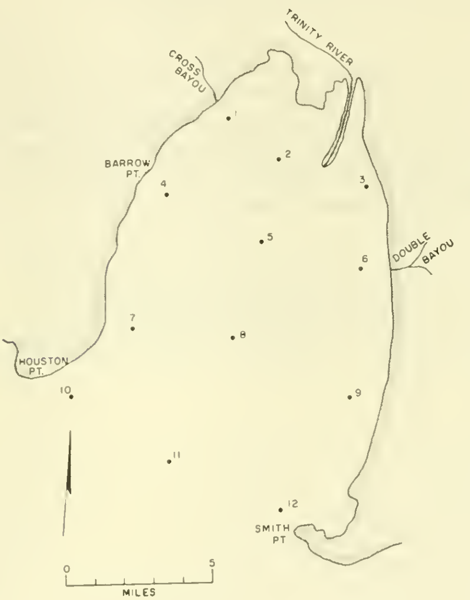
Salinities and temperatures in 1960-61 in Clear Lake were similar to those recorded in 1958. The maximum salinity of 14.3‰ was recorded June 15, 1960, while the fresh-water conditions (less than 0.1‰) began during the latter half of November 1960 and extended into February 1961. This was a slightly longer period of fresh-water conditions than recorded for previous years. The maximum temperature of 40° C. was recorded June 7, 1960, and the minimum of 7.6° C. was recorded December 15, 1960.

As expected, salinities in Offats Bayou were higher than in Clear Lake. A maximum salinity of 33.6‰ was recorded on July 6, 1960, in the deep central basin of the bayou. The minimum salinity recorded was 11.4‰ at the head of the bayou on January 9, 1961. Temperatures ranged from a high of 36.5° C. in June 1960 to a low of 8.0° C. in December 1960.

Trinity Bay Project

Anthony Inglis

Trinity Bay   During January the laboratory commenced a study of Trinity Bay, the portion of Galveston Bay receiving the discharge of the Trinity River, for the Albuquerque Regional Office of River Basin Studies. The proposed water development plans contemplate a large share of the Trinity River flow being transferred to the Houston area where it will enter Galveston Bay through the San Jacinto River, possibly affecting the hydrographic and biological conditions in upper Galveston Bay.



Trinity Bay sampling stations.

During January, 12 stations were set up in Trinity Bay, located along three grid lines oriented with the long axis of the bay, running from the area near the mouth of Trinity River to a line from Houston Point to Smith Point. Four stations along each grid line roughly divide the bay into four segments designed to cut across the salinity gradient which normally occurs during the summer months. Sampling at each station includes salinity, temperature, and turbidity measurements -- both top and bottom -- as well as surface Secchi disc readings and a trawl haul for biological specimens.

Due to inclement weather (high winds), only four field trips were made in February and March. These, and the April trips, were made in a chartered inboard vessel since our 16-foot outboard boat proved to be inadequate under the prevailing weather conditions. About mid-April we obtained a 17-foot cabin cruiser, powered with two 40 h. p. outboard engines. With a few modifications, this boat has proven suitable and is being used for regular weekly trips in Trinity Bay.

Bottom salinity has varied between less than 0.1‰ and 11.4‰ while surface salinity ranged from less than 0.1‰ to 11.7‰. As expected, the salinity at stations in the lower Bay (Houston Point to Smith Point) tended to be higher due probably to tidal influences.

Water temperature has been normal during the period with a minimum of 45.5° F. and a maximum of 82.8° F. Generally, the temperature in the peripheral portion of the bay was higher than that at the center.

Secchi disc readings ranged from a minimum of 8 centimeters to a maximum of 65 centimeters. The more turbid waters occurred from the mouth of Trinity River to the vicinity of Smith Point along the east shore, while the west shore characteristically was slightly less turbid.

Trawl-caught samples were typical of low salinity estuaries in this area for this season. The fish fauna has been dominated by three species of estuarine fishes, including Atlantic croaker, *Micropogon undulatus*; anchovy, *Anchoa mitchilli*; and the hogchoker, *Trinectes maculatus*. The catfishes, *Ictalurus punctatus* and *Ictalurus furcatus*, were the most abundant fresh-water fishes during the months of February, March, and April.

Until May, the invertebrate fauna, excluding mollusks, has been dominated by the fresh-water river shrimp, *Macrobrachium ohione*, and the blue crab, *Callinectes sapidus*. Brown shrimp, *Penaeus aztecus*, began to show in the samples in May, replacing the river shrimp as the most dominant invertebrate species.

PHYSIOLOGY AND PESTICIDE PROGRAM

Edward Chin, Program Leader

Experiments to determine nutritional requirements of brown shrimp, *Penaeus aztecus*, and white shrimp, *P. setiferus*, continued. An analysis of respiration rates in these species was completed, and the final report is being prepared. Work concerning the effects of environmental factors on the growth, survival, and behavior of estuarine organisms was delayed because of a personnel shortage.

Studies initiated last year on the effects of pesticides on estuarine species continued. Results show that most of the chemicals used to control insect pests along the Gulf coast are toxic at low concentrations to many inshore species. The extent to which pest-control practices affect the abundance of estuarine species either directly or through effects on their food supply can not be ascertained merely by noting the toxicity of pesticides in the laboratory. It is also necessary to determine the extent of pesticide contamination in the estuarine environment. Analysis of pesticide residues in animal tissues and in estuarine waters and soils is therefore being planned as a complement to studies to be undertaken in the forthcoming year.

Shrimp Physiology

Zoula P. Zein-Eldin

During the past year additional specimens of both white and brown shrimp have been tested to determine oxygen requirements. They were selected for sex and size and included two extremely large white shrimp a female of 51.1 g. and a male of 42.6 g. The brown shrimp were smaller but included a large number of males to complete the picture of size and sex in relation to oxygen consumption.

Accurate records of molting in individual shrimp have been maintained. At least 4 animals have been held through 10 molts or more. Of these individuals one male white shrimp was found to increase in carapace length only 1.8 mm. (21.4 to 23.2) in a $7\frac{1}{2}$-month period (13 molts). In a second male the carapace increased 3.1 mm. (22.5 to 25.6) in a $5\frac{1}{2}$-month period (in which the animal molted 11 times). More rapid growth was recorded in two brown shrimp. One female with an original carapace length of 25.3 mm. increased 1.9 mm. in 4 months (6 molts), and a male with original carapace 19.8 mm. increased 3.1 mm. in only 3 months. This latter animal also increased in weight from 5.0 to 9.2 g. during 5 months in the laboratory. This group of animals, held for a long period in the laboratory, was then retested to determine the oxygen consumption. In all cases there was a significant decrease in oxygen consumption per gram (as much as 0.1 ml. oxygen per gram per hour). This was not entirely attributable to increase in size since the values for the "held" animals were significantly lower than those for other animals of the same sizes.

Individual specimens of *Trachypeneus similis* and *Squilla mantis* were also tested. Both of these animals used less oxygen than either the brown or the white shrimp. The *S. mantis* tested used about half as much oxygen per hour as a brown shrimp of similar size (1.4 ml. per hour for the 17 g. *Squilla*; 2.6 ml. per hour for the 20 g. *P. aztecus*). It is true that *Squilla* has more of its body weight as exoskeleton than does the shrimp, but even after discounting this, Squilla appears to metabolize more slowly. All data on both white and brown shrimp are being analyzed in preparation for a final report.

Nutritional studies have attempted to define mineral and vitamin requirements of two common species of shrimp. All experiments were carried out in recirculating artificial sea water (see tables). The earliest experiments indicated the importance of the calcium ion, for reduction of calcium below 25 percent that of normal sea water caused test shrimp to die within 30 hours. For this reason, the calcium concentration was increased above that in normal sea water.

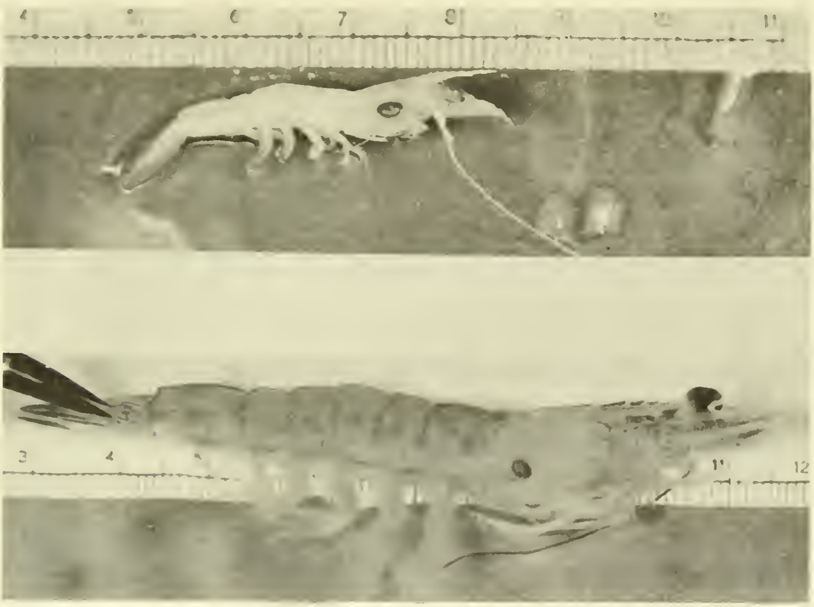
Artificial sea water (modified McClendon)

Sodium chloride	26.7 g.	
Magnesium chloride	2.26 g.	
Magnesium sulfate	3.25 g.	
Calcium chloride	1.71 g.	
Potassium chloride	0.72 g.	
Potassium iodide	1.0 mg.	
Trace metals mixture U-II	20 ml.	
Ferric chloride		1 mg.
Cupric chloride		1 mg.
Manganous chloride		10 mg.
Zinc chloride		5 mg.
Nickel chloride		1 mg.
Aluminum chloride		5 mg.
Cobalt chloride		5 mg.
Rubidium chloride		10 mg.
Barium chloride		1 mg.
Selenous acid		5 mg.
Ammonium vanadate		1 mg.
Titanium oxide		5 mg.
Zirconyl chloride		5 mg.
Potassium dichromate		5 mg.
Sodium molybdate		5 mg.
Boric acid		5 mg.
Cesium chloride		5 mg.
Cerium ammonium nitrate		1 mg.
Cadmium chloride		1 mg.
Stannic chloride		1 mg.
Ruthenium chloride		1 mg.
EDTA		150 mg.
Water to make		1,000 ml.
Distilled water to make	1,000 ml.	

Artificial diet

Casein	55 g.	
Gelatin	15 g.	
Hydrogenated fat (Crisco)	9 g.	
Dextrin	8 g.	
Vitamin mix	9 g.	
Alphacel		100 g.
Riboflavin		100 mg.
Pyridoxine		20 mg.
Choline chloride		1600 mg.
Nicotinic acid		200 mg.
Calcium pantothenate		100 mg.
Inositol		800 mg.
Biotin		2 mg.
Folic acid		6 mg.
Ascorbic acid		400 mg.
Thiamine		44 mg.
B_{12}		2 mg.
Alpha-tocopherol		40 mg.
Menadione		8 mg.
Beta-Carotene		20 mg.
Activated 7-dehydro cholesterol		4 mg.
Tryptophan		2 g.
DL-Methionine		4 g.
Mineral mix	4 g.	
USP Salt Mixture No. 2		100 g.
Aluminum chloride		15 mg.
Zinc sulfate		300 mg.
Cupric chloride		10 mg.
Manganous sulfate		80 mg.
Potassium iodide		50 mg.
Cobalt chloride		100 mg.
Water	200-250 ml.	

Comparisons of P. setiferus fed the artificial diet with those fed a variety of natural foods (liver, shrimp, oatmeal, and wheat germ) indicated that the animals fed artificial food had only a slightly increased laboratory life span. Of more significance was the decrease in frequency of the pathological condition shown in the figures. Fifty percent of the animals fed natural foods developed these dark, blistered areas on the ventral portion of the carapace; less than half as many animals fed the artificial food showed the change. Microscopic examination of this lesion showed it to be between the layers of the carapace itself--a dark fluid-filled blister which did not harden after the completion of the molt. Animals usually died within 24 hours after the development of the blister. The lesion was found in both P. setiferus and P. aztecus, but it occurred with less frequency in P. aztecus.



White and brown shrimp showing a dark blister on the ventral area of the carapace.

The latter observation may support the belief that P. aztecus as a species is hardier than P. setiferus. Further evidence may be adduced from experiments in which both species were tested simultaneously. Brown shrimp completed more successful molts (at least two, often three) and survived longer (up to 28 days) in artificial sea water than did white shrimp. However, no significant growth was found in either species. In neither species did percent survival approach that of animals fed the artificial diet but held in recirculating natural sea water. Apparently some compounds that may have some influence upon molting are still lacking from the artificial medium, this being indicated by the lesion already described and by a second lesion in which the most ventral portion of the carapace did not harden nor apply closely to the body so that the animal appeared to have "wings." The second type, more common in the brown than in the white shrimp, was not immediately fatal. Other apparent molting disorders, or indications of abnormal stress, occurred. Many of the animals in molt were unable to shed the carapace. Whether this was caused by general weakness or lack of a specific compound is unknown. It should be noted that the test animals lost appetite and became somewhat sluggish after several days in the laboratory. It may be concluded that at present we are unable to raise shrimp satisfactorily in artificial sea water, even when the animals are supplied with trace elements and essential vitamins.

Effects of Pesticides

Edward Chin

Tests of pesticides on estuarine species were continued this year, with emphasis on the commercially important penaeid shrimps in Galveston Bay. The relative toxicity of various chlorinated hydrocarbons to brown shrimp, *Penaeus aztecus*, and white shrimp, *P. setiferus*, is shown in the table following. The index of relative toxicity adopted is the median tolerance limit (TLm) which is the concentration at which 50 percent of the test animals are able to survive for a specified period of exposure. Except for the results using postlarval crustacea, the TLm values are based on tests conducted in 100 liters of medium in disposable polyethylene bags. Because of their small size and cannibalistic tendencies, postlarval crabs and shrimps were tested individually in 250-ml. glass vessels. Methods were described in greater detail in last year's annual report.

Testing toxicity of pesticides on postlarval shrimp contained individually in 250-cc. reagent bottles.

The relative toxicity of solid and liquid commercial formulations of chlorinated hydrocarbons to brown shrimp. Results noted in 1960 Annual Report indicated by asterisks

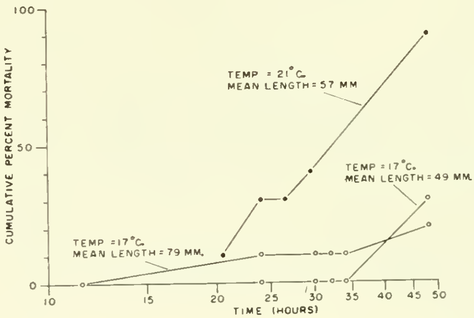
Solid formulations					Pesticide	Liquid formulations				
Size (mm.)		Temp.	TLm values (p.p.b.)			Size (mm.)		Temp.	TLm values (μp.b.)	
Mean	Range	range (°C.)	24-hr.	48-hr.		Mean	Range	range (°C.)	24-hr.	48-hr.
76	69-86	20-21		2.5	Endrin	80	72-93	23-24	6	3
					do.	76	70-87	22-23	< 5	4
					Aldrin	69	63-82	22-23	7.5	5
38	28-51	23-24	8*	7	Lindane					
56	46-67	21-22	27*	16	Sevin					
77	62-91	26-28	35	25	DDT	78	67-90	26-27	< 5	< 5
80	63-100	26-27	50	42	do.	81	72-93	23-24	9.5	6.5
84	75-96	21-23	50	35	BHC					
67	60-76	20-21	100*	44	Toxaphene					
76	60-88	20-21	> 50	50	Dieldrin	46	37-60	23-24	10*	< 5
					do.	69	60-83	20-21	5-20	11
					do.	88	77-108	22-23	20	13
76	67-86	22-23	100	< 100	TDE					
87	74-96	22-23	200	158	do.					
87	77-100	22-23	400	400	Methoxychlor					
84	72-95	22-23	1170	< 1000	Sabane					
81	67-90	23-24	1180	705	Heptachlor	49	38-66	22-24	20*	14
81	70-91	22-23	1000-2000	745	Rotenone					
94	83-102	22-23	1000-1500	1000	do.					

The relative toxicity of solid and liquid commercial formulations of chlorinated hydrocarbons to white shrimp. Results noted in 1960 Annual Report indicated by asterisks

Solid formulations						Liquid formulations				
Size (mm.)		Temp.	TLm values (p.p.b.)		Pesticide	Size (mm.)		Temp.	TLm values (p.p.b.)	
Mean	Range	range (°C.)	24-hr.	48-hr.		Mean	Range	range (°C.)	24-hr.	48-hr.
99	82-117	23-24	>7.5	6.5	Endrin					
86	80-95	24	14	<10	do.					
112	93-129	22-24	34*	13	Sevin					
83	68-94	20	>40	25-40	DDT	88	81-95	19	15*	12.5
75	65-88	22-23	123	<25	Dieldrin	94	85-101	21-22	60*	25
82	71-95	23	>150	50	do.					
79	68-97	23	125	89	Toxaphene					
82	70-94	21-22	>350	75	TDE					
77	63-93	21-22	523	<250	Methoxychlor					
90	74-103	21	750	250	do.					
83	74-92	21	500	250	Hepta-chlor	86	74-104	21-22	43*	<10
104	92-120	21-22	>1500	715	do.					

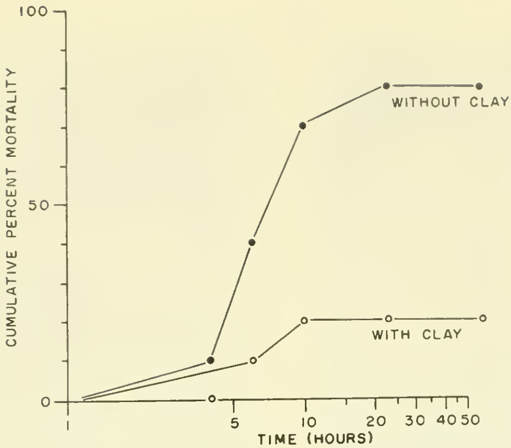
With few exceptions, the toxicity of solid formulations was considerably lower than that of their liquid counterparts. The greater toxicity of the liquid formulations can probably be attributed to the organic compounds used as solvents and diluents. The carrying agents used in the preparation of solid formulations are inert clays which by themselves have no effect on the animals tested. Differences in the availability of the active ingredients in liquid and solid formulations may also be a factor.

The above compounds are listed according to their decreasing toxicity to the two species, but the ranking is somewhat tentative because the bioassay results may be affected by size of test animals, temperature, etc. For instance, the table suggests that pesticides are more toxic to smaller individuals. The effect of temperature on toxicity is indicated by the significantly higher mortality of Gulf killifish (*Fundulus grandis*) when exposed to 70 p.p.b. dieldrin at 21° C. than when exposed to the same concentration at 17° C.



Mortality of Gulf killifish exposed to 70 p.p.b. of dieldrin at two temperatures.

The probable importance of turbidity on the toxicity of pesticides is shown by a test in which the toxicity of a 50 p.p.b. solution of technical grade DDT to pinfish (*Lagodon rhomboides*) was notably reduced by the addition of 4 grams of inert clay to simulate silt.



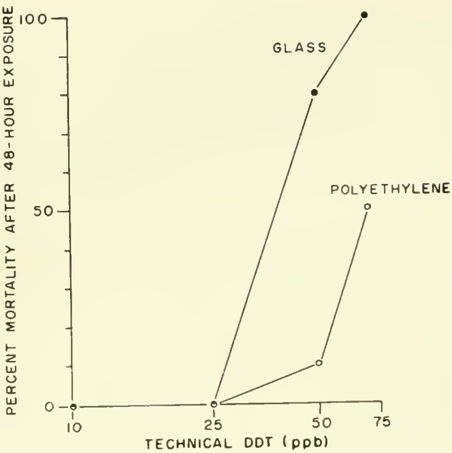
Effect of clay on toxicity of DDT (50 p.p.b.) on pinfish, Lagodon rhomboides. Four grams of clay were added to 40 liters of medium.

Technical grade compounds tested on postlarval brown shrimp ranging from 13 to 16 millimeters in total length and on blue crabs (Callinectes sapidus) ranging from 2 to 7 millimeters in carapace width, yielded the following 24-hour median tolerance limits:

Compound	Brown shrimp	Blue crab
Endrin	0.5 p.p.b.	10 p.p.b.
Heptachlor		44; 50
Dieldrin	6	50
Toxaphene		64
DDT		3

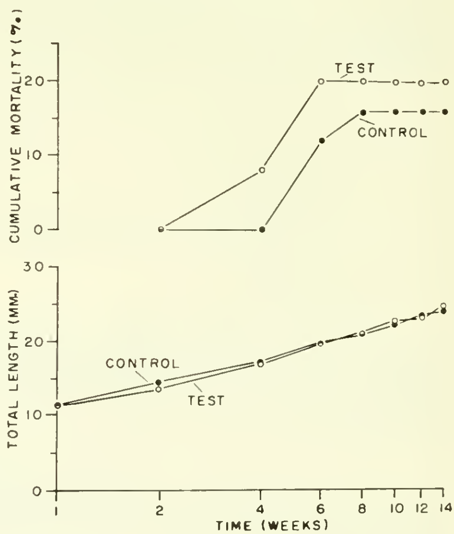
These results were obtained using glass containers and no diluent so they are not strictly comparable to the results shown earlier. They do show, however, that the postlarvae are extremely sensitive to very low concentrations of insecticides.

A change in bio-assay methods was instituted early in March of this year because of evidence that polyethylene containers reduce the strength of pesticide compounds. Tests using fish and crustaceans are now being conducted in glass vessels.

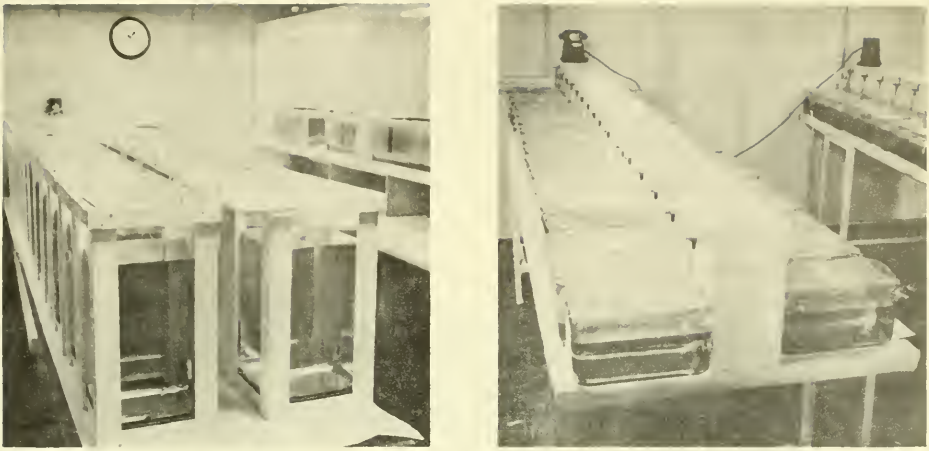


Tests of DDT on pinfish, Lagodon rhomboides in 40-liter volumes showing that toxicity was reduced by use of polyethylene bags for containers over use of glass vessels.

Experiments to determine methods for studying the long-term effects of sublethal levels of pesticides were initiated. In the first trial 25 sailfin mollies, Mollienisia latipinna, 16 to 17 days old were exposed to a continuous flow of technical grade DDT (2 p.p.b.) The glass tanks hold approximately 40 liters, and new medium is added at the rate of approximately 1 liter per hour. Every 2 weeks animals are removed, counted, measured, and returned to the tanks. After 14 weeks, animals in the test and control tanks show no difference between groups in either growth or survival.



Showing similarity at end of 14 weeks in growth and survival of sailfin mollies, Mollienisia latipinna, exposed to a sublethal concentration of 2 p.p.b. of technical grade DDT.



Glass jars which have replaced polyethylene vessels used in bioassay of pesticides. Four to six concentrations of each compound are tested simultaneously. Jars at left are used for fish, each holding 40 liters of medium and 10 specimens. Because of canibalism, shrimp and crabs require isolation. Individual animals are held in 4 liters of medium in smaller containers (right), 10 being required for each concentration tested.

RED TIDE PROGRAM

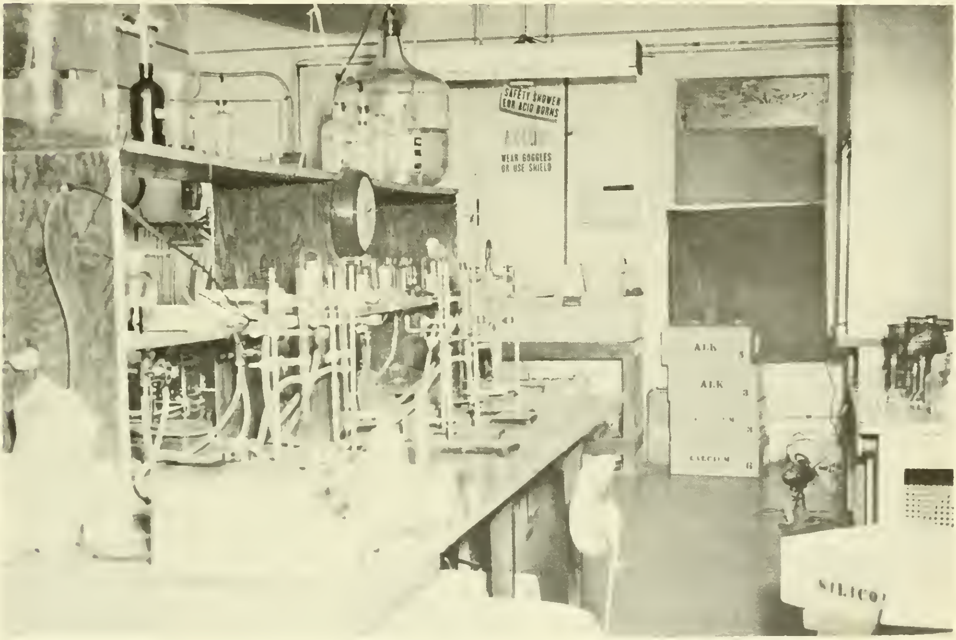
David V. Aldrich, Acting Program Leader

In a year during which Florida escaped serious red-tide damage, we continued to study the characteristics of *Gymnodinium breve*, the Florida red-tide flagellate, and its environment. The results show that: (1) the survival of this organism is favored by the relative stability of hydrological conditions in deeper waters, where a low resident population seems to subsist between outbreaks; (2) *G. breve* cannot utilize organic substances for growth in the absence of light; and (3) natural levels of the classical phytoplankton nutrients, phosphate and nitrate, are not clearly related to the blooming of this organism. The third point is of particular interest in emphasizing the lack of information regarding the basis of sea-water fertility. Previous *G. breve* nutrition studies indicate metal and vitamin or amino acid growth requirements. Continuing study of the natural levels of nitrogen in its various forms may help to throw some light on the importance of amino acids.

Field station at St. Petersburg Beach, Florida.

Retesting the most active group of potential control agents indicated each of 88 organics to be at least as toxic as copper sulfate to this organism. Tests to determine the degree of specificity of these poisons will begin soon.

A large portion of time was devoted to preparing manuscripts to make available in publications the mass of information collected in prior years. A report was also prepared for the Corps of Engineers on the relationship between Caloosahatchee River discharges and red tides. Our report suggests that increased annual volume of discharge favors red-tide development, but short-term variation has no such effect.



Chemistry laboratory at St. Petersburg Beach, Florida, field station.

Culture and Nutrition of *Gymnodinium breve*

David V. Aldrich

During the past year this phase of red-tide work suffered the absence of its project leader on a training program.

A direct relationship between the abundance of *G. breve* and annual rainfall in the Florida west coast area has been suggested by various workers. This theory arose from comparisons between field observations of *G. breve* and meteorological data. Subsequent studies by W. B. Wilson indicated that Florida peat extract and/or river water can promote growth of *G. breve*. We have recently compared the growth of *G. breve* in water from several rivers in red-tide and non-red-tide areas. A completely defined artificial sea water, incapable of supporting growth by itself, was employed as a diluent for the river waters. The Alafia, Hillsborough, Peace, and Caloosahatchee Rivers of Florida and the Atchafalaya and Sabine Rivers of Louisiana and Texas were tested. Growth occurred only with the addition of Hillsborough or Peace River water.

Since some other dinoflagellates are capable of heterotrophy, the possibility existed that *G. breve* might also exhibit this type of nutrition -- the utilization of organic substances for growth in the absence of light. More than 80 organic compounds and mixtures -- including soil extracts, amino acids, carbohydrates, fats, and proteins -- have been tested as potential foods, but all failed.

Chemical Control

Kenneth T. Marvin and Raphael R. Proctor, Jr.

During the past year about 1,000 organic chemicals have been evaluated as possible red-tide toxicants. This was a continuation of the screening program started in March 1959 to find a chemical means of controlling the blooming and thus the damage of the red-tide organism, *Gymnodinium breve*. The work is made possible by the many interested organizations who have submitted samples for evaluation.

The details of procedure for the first phase of the work are thoroughly covered in last year's report. Briefly, the procedure consists of rapidly evaluating each chemical and classifying it as toxic or nontoxic. By way of explanation, a substance is considered toxic if it kills the red-tide organism within 24 hours at 0.04 p.p.m. During the initial screening, many chemicals precipitate from the water-alcohol phase of the dilution procedure. The reason for this is that during the dilution process the tip of the transfer pipette, for safety reasons, is placed as close to the bottom of the solution flask as possible. Therefore, any undissolved material has a tendency to be picked up and carried through the series of dilutions in an undissolved state, thus resulting in a higher than desired concentration in the final solution. This increases the apparent toxicity of some of the samples that are not completely soluble in the alcohol-water phase.

When rechecking compounds in the "toxic" group to determine their minimum effective concentrations, an effort is made to correct this source of error by making all tests in triplicate and reducing the concentration of the initial alcoholic solution from 0.1% to 0.01%. Furthermore, taller flasks are used for preparing intermediate solutions so that the tip of the transfer pipette can be safely placed about an inch from, instead of on the bottom of the solution flask. This minimizes the possibility of withdrawing undissolved material. We realize that this latter precaution results in a bias having the opposite effect of the one mentioned above. In this case the final concentrations of the compounds that did not remain in solution would have a tendency to be lower than desired, and for this reason highly toxic ones could pass our tests undetected. Thus we have a third group, those that might be toxic at the 0.04 level but whose solubility is such that they are not adaptable to the screening technique employed. It is possible that successful toxicants could come from this group, since compounds of this type would dissolve very slowly, and therefore their possible toxic effects would be more lasting than the more soluble compounds. For this reason we plan to investigate this group later, using somewhat different techniques.

Since this work began, 4,679 samples have been tested, 250 being classified as "toxic." Thus far, 200 of these have been rechecked at concentrations ranging from 0.0001 to 0.04 p.p.m., and 88 continue to test toxic. This reduction from 200 is an indication of the effect of the errors mentioned. The major chemical groups involved and the minimum effective toxicity range of the 88 compounds that continued to test toxic, are as follows:

Compounds containing	Total tested	Total toxic at parts per million					
		0.0001	0.0004	0.001	0.004	0.01	0.04
Amines	98	0	2	2	5	12	55
Nitro	9	0	0	0	0	1	8
Phenol	26	0	0	0	0	4	20
Mercury	13	0	3	3	4	5	9
Sulfur	46	0	1	1	3	10	31
Cyanides	13	0	0	0	0	0	7
No. compounds toxic at the level shown		0	4	4	8	17	88

(The "total toxic" columns do not add up to give the "number of compounds toxic at the level shown," since some of the compounds tested contained more than one group each.)

Samples are still being received for evaluation. However, their incoming rate has decreased to a point where we will soon be in a position to commence the second phase of our work. This will consist of checking the selectivity of the more toxic samples. The method used will be somewhat similar to that employed for determining the relative toxicity of the samples of G. breve. In this case, however, the test organisms will consist of commercially important species. The facilities of our recently completed recirculating sea-water system will be of great benefit to us in this particular phase of the work because it will enable us to hold large numbers of commercially important organisms.

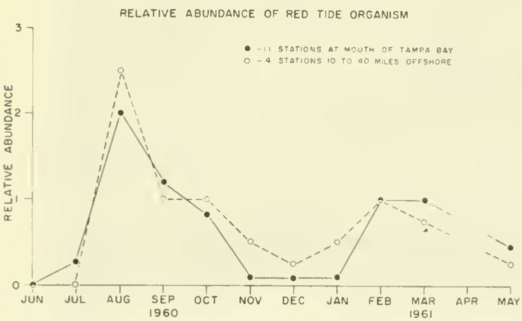
Ecology of Red Tide

John H. Finucane

Study of the ecology of the Florida red-tide organism, *Gymnodinium breve*, in Tampa Bay and adjacent neritic waters was continued.

Geographical distribution and seasonal occurrence Following the sampling program employed last year, stations were occupied on a monthly basis from upper Tampa Bay to 60 miles offshore. From June 1960-May 1961, over 800 water samples were collected to obtain counts of *G. breve* and associated phytoplankton. *G. breve* was found in 31 percent of these samples, compared with over 45 percent last year. The flagellate occurred at all times in the nearshore and offshore waters, the greatest number of samples containing *G. breve* occurring from August through October 1960 and February through March 1961. This was similar to the seasonal pattern established in the fall and winter of 1959 and 1960.

A minor red tide developed in the neritic waters off Tampa Bay during July and August 1960. Blooms of *G. breve* as dense as 420,000 per liter were found off Egmont Key, July 27, 1960. Fish kills, principally confined to that area, were of a very limited nature. During August the greatest numbers of this organism (up to 150,000 per liter) were present from 5 to 20 miles off Egmont Key. The number of samples containing *G. breve* increased from a low of 3 percent in June to 64 percent in August during this outbreak. No further fish kills were recorded after the first week in August. From September through May, *G. breve* was found only in very low numbers, occurring principally in areas offshore from the mouth of Tampa Bay.



Abundance index averaged from five abundance rankings ranging from 0 to 1,000,000 per liter.

Vertical distribution and light penetration Homogeneity of *G. breve* in the water column characterized the vertical distribution of this organism in Tampa Bay and the nearshore waters. During blooms in the deeper neritic waters, 7-30 miles offshore, the greatest numbers of *G. breve* were found on or near the surface. Very low numbers were present during October 1960, at a depth of 148 feet, 50 miles offshore.

Preliminary photocell readings within the area 5 to 40 miles offshore indicate a broad photic zone, with increased light transmission in a seaward direction. At stations 40 miles offshore, light values of 8-80 foot-candles were recorded at depths of 126-129 feet from November 1960 through January 1961. In the extremely turbid waters of central and upper Tampa Bay, light transmission diminished rapidly with depth during the same period. In waters of 25-41 feet, foot-candle readings ranged from 0-9 while near surface readings at the same stations ranged from 49-1,800 foot-candles. No relationship was noted between distribution of G. breve and the percentage of light transmission. The greatest numbers of Prorocentrum micans and Ceratium furca were associated with the clearest water during the November blooms in Tampa Bay.

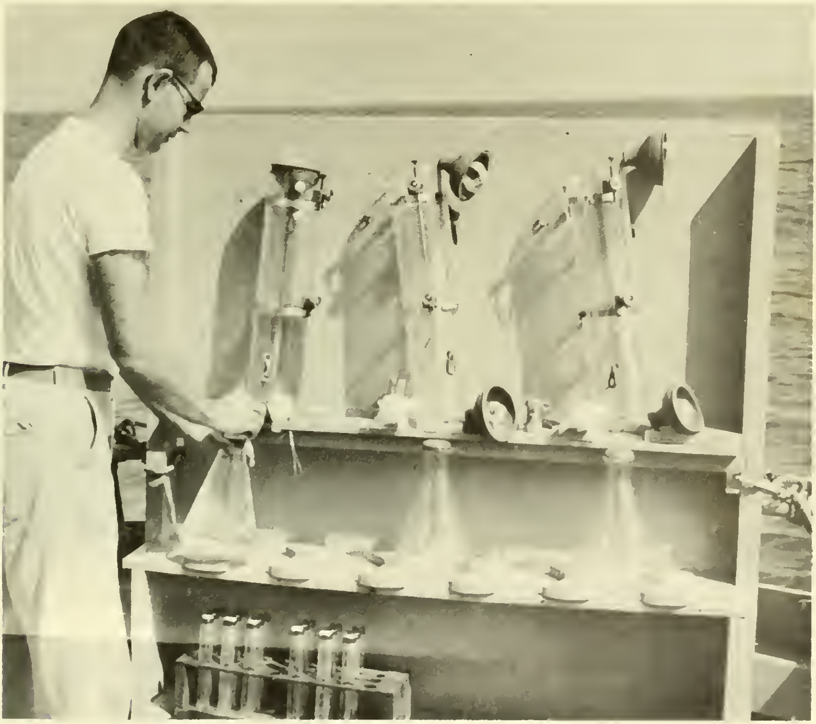
Vessel KINGFISH used in study of Tampa Bay and vicinity.

Observations on salinity, water temperature, and the distribution of G. breve

Salinity and water temperature are two important factors in determining the distribution of G. breve. The complete absence of G. breve in upper and central Tampa Bay at salinities between 13.93‰ and 30.86‰ indicates that low salinities may serve as a barrier to this organism. The highest numbers of G. breve during blooms occurred at salinities from 31.33‰

at the mouth of Tampa Bay to 35.79‰, 20 miles offshore. The organism was not found in waters having salinities less than 29.29‰ or greater than 36.26‰. The relatively stenohaline character of this dinoflagellate suggests that it subsists in the neritic waters.

Water temperatures during blooms of this organism ranged from about 28° to about 30° C. This was almost 2° C. higher than the temperatures associated with G. breve blooms last year. G. breve was not found below 14.42° C. or above 31.32° C. These organisms occurred in only 6 percent of the samples below 18° C. as compared to 33 percent between 18°-23° C. and 52 percent between 21°-31° C. Thus, the greatest incidence of this organism in the fall and spring may be due to the more favorable water temperature at these times.



Taking water samples with modified Van Dorn bottles from aft deck of KINGFISH.

Associated phytoplankton Diatoms increased in incidence and numbers during the summer and fall of 1960. The following genera and species were found in great numbers in these areas: *Ceratium furca*, *Ceratium fusus*, *Prorocentrum micans*, *Gymnodinium* spp., *Peridinium* sp., *Skeletonema costatum*, *Biddulphia sinensis*, *Asterionella japonica*, *Grammatophora* sp., and *Melosira* sp. The blooms of *P. micans* and *C. furca* may represent a normal seasonal pattern since they occurred during November of both 1959 and 1960. An unknown chain-forming species of *Gymnodinium* was noted for the first time during September 1960 in Tampa Bay in numbers as high as 1,650,000 per liter. *G. breve* was one of the dominant dinoflagellates from August through October 1960 in the offshore waters.

Dinoflagellates and diatoms diminished during the winter and spring of 1961. Diatoms were virtually absent in the neritic waters from 20-40 miles offshore, the greatest numbers occurring in Tampa Bay and the nearshore waters. In contrast to the distribution and abundance of *G. breve*, the most productive areas for other dinoflagellates were the estuarine waters of central and upper Tampa Bay. No apparent association of *G. breve* blooms with other phytoplankton was noted.

Hydrology of Tampa Bay and Adjacent Waters

Alexander Dragovich and Billie Z. May

Observations consisted of temperature (1, 136 observations), salinity (1, 137), total phosphate-phosphorus (1, 103), nitrate-nitrite nitrogen (1, 089), ammonia (195), total organic and inorganic nitrogen (333), silicon (1, 080), calcium (1, 077), and total alkalinity (1, 077).

Samples were collected monthly from 25 stations from Tampa Bay to 40 miles offshore with 2 additional stations 50 and 60 miles offshore during the summer and fall months.

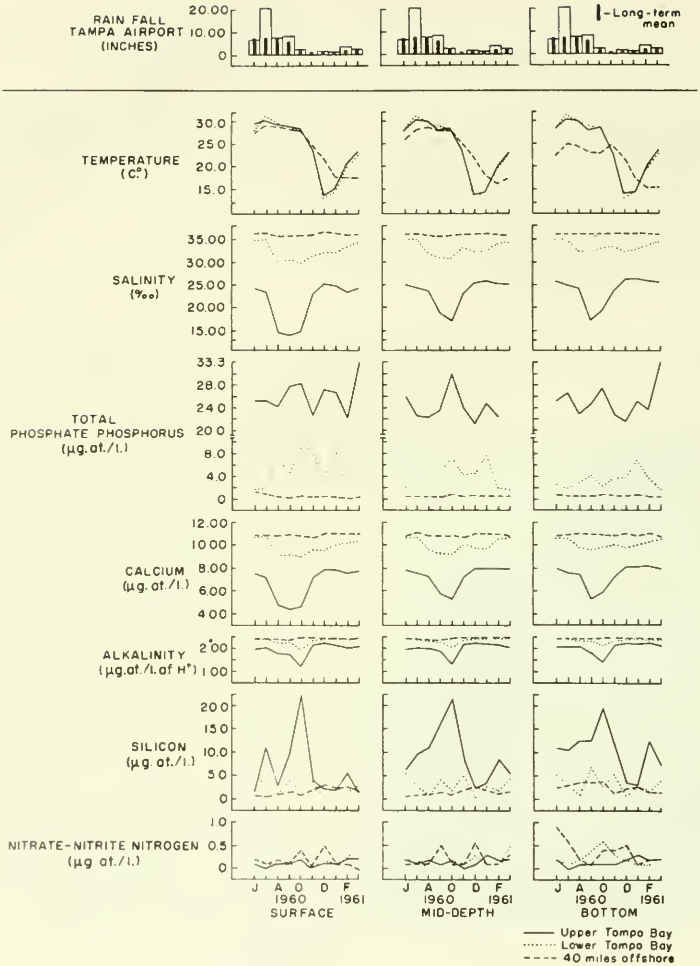
Temperature The maximum water temperature (31.6° C.) was recorded during July in Egmont Channel and the minimum (12.3° C.) during December in lower Tampa Bay. Owing to the shallowness of Tampa Bay and the waters up to 5 miles offshore, heat exchange is rapid and equilibrium between the water and air is readily attained.

Measuring light intensity with a photocell.

Comparisons of *G. breve* incidence with water temperatures yielded results similar to those given in last year's report. The distribution of *G. breve* seems to be restricted by temperature minima rather than maxima. *G. breve* was absent at temperatures below 14.2° C. which occurred in December and present at 31.3° C. in July.

G. breve was absent from Tampa Bay during the months with lowest temperatures. The organism's simultaneous presence in the farther offshore waters continues to suggest that the warmer neritic waters may be important to the winter survival of *G. breve*.

Salinity Salinity varied because of precipitation and stream discharges. During most of the year precipitation was below normal or near to the long-term means. Extremely heavy rainfalls were associated with hurricane "Brenda" (July 28 and 29). According to the reported rainfall, hurricane "Donna" (September 9-11), which swept through the general Tampa Bay drainage basin, was not a particularily wet hurricane. An exceptionally dry period was recorded during November. This year's salinities were higher than last year's.



Chemical and physical parameters at three depths and three selected stations from July 1960 to March 1961.

Salinity distribution was similar to that of last year. Occasionally salinity slightly lower than in surrounding areas occurred offshore during the summer and fall months but to a lesser degree than last year. Lower abundance of G. breve this year compared to last suggests that last year's lower salinity may be associated with increased growth of G. breve.

Total phosphorus Owing to the well-established fact that phosphorus is important to phytoplankton growth, field observations of this nutrient were continued. The major features of phosphorus distribution were (1) the maximum zone in upper Tampa Bay and (2) rapidly diminishing seaward concentrations.

The monthly changes in total phosphorus show higher concentrations (21.1->29.0 µg.at./l) in upper Tampa Bay during September and October after hurricanes "Brenda" and "Donna" passed through Florida. Extremely high total phosphorus concentrations (33.3->33.3 µg.at./l) were recorded in March throughout the waters of upper Tampa Bay. These high values were observed during relatively strong onshore winds (20-25 m.p.h.), suggesting phosphorus enrichment from stirring of bottom sediments. This supposition was verified by phosphorus analysis of bottom sediments and supernatant water containing bottom sediment.

Total phosphorus was more than adequate for phytoplankton growth in the waters of Tampa Bay and up to 10 miles offshore. Seaward from 10 miles offshore phosphorus concentrations rarely exceeded 1.0 µg.at./l. and in three instances were recorded as low as 0.1 µg.at./l.

Nitrogen There was no apparent relationship between the incidence of *G. breve* and nitrate-nitrites. Comparatively low concentrations (0.0-2.0 µg.at./l) of nitrate-nitrite nitrogen continued to persist in Tampa Bay and adjacent waters. The concentrations of nitrate-nitrites during 1959, a year with heavy rainfalls, were higher than during the period of this report. During this latter period nitrogen varied from 0.1 to 0.5 µg.at./l. in 87.2% of the samples; in 6.1% of the samples the concentrations varied from 0.6 to 2.0 µg.at./l., while in 6.8% of the samples there were no measurable quantities. Atypical of the nitrate-nitrites distribution usually observed in an estuary, there were no maxima near the fresh-water end of Tampa Bay. Although some higher concentrations of nitrate-nitrites were noted during the fall, winter, and early spring months, the seasonal distribution pattern continued to be very irregular. The greatest depletion occurred during July, when in 20.8% of the samples the nitrate-nitrites were completely exhausted.

Concentrations of ammonia ranged from 0.0 to 30.0 µg.at./l. During the first 11 months (April 1960 - March 1961) the spatial distribution of ammonia shows concentrations in upper and central Tampa Bay two to three times higher than in the offshore waters.

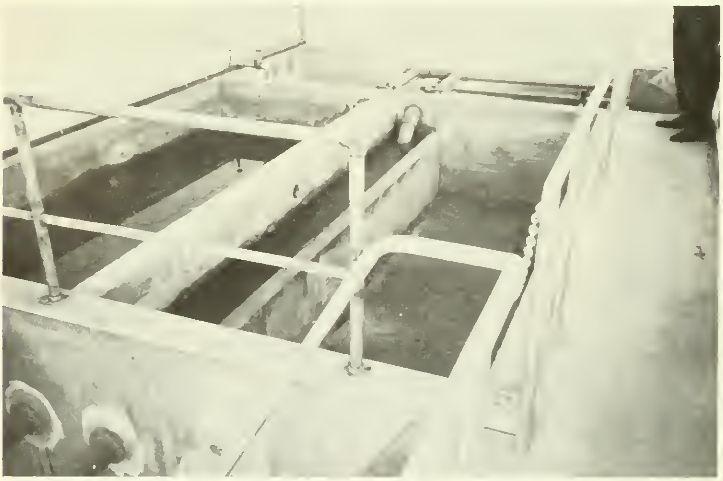
From April 1960 to the present, 241 inorganic nitrogen and organic nitrogen determinations have been performed on filtered sea water. In December 1960, experiments showed that the HA millipore filters used in microfiltration were adding erratic amounts of a substance which reacted with the sodium phenate reagent to give an erroneous color development. Since January 1961, all determinations have been made on unfiltered sea water. Total inorganic nitrogen in unfiltered samples varied from 0.0 to 6.7 µg.at./l. while total organic nitrogen ranged from 3.7 to 30.9 µg.at./l. Total organic nitrogen exceeded total inorganic as a rule and represented 87.4% of the total. The longitudinal distribution of total nitrogen indicates existence of maximum values in Tampa Bay with a decreasing trend seaward. In contrast to the low levels of nitrate-nitrite nitrogen, the observed concentrations of ammonia and total nitrogen are comparable to those of other marine areas of the world.

Sea-Water System

Kenneth T. Marvin and Ray S. Wheeler

The recirculating sea-water laboratory completed in January 1961 provides excellent space and facilities for holding large quantities of shrimp and fish, enabling us to undertake studies which should add measurably to our knowledge of these organisms. Studies now under way include the determination through bioassays of the effects of toxicant materials on marine organisms, the spawning and rearing of larval shrimp to aid in the identification of different species, and the testing of stains for marking shrimp to determine their growth, mortality, and migration routes. As space permits, the system's facilities will be available for research on marine problems by other than Bureau investigators, e.g., The Marine Laboratory of the A. and M. College of Texas is using it in experiments on oyster nutrition.

Sea water is brought to the system in a 4,000 gallon stainless steel water truck, run through the filter beds, and pumped into two 28,000-gallon redwood tanks. Water flows by gravity from either or both 28,000-gallon tanks to the laboratory through a 4-inch polyvinylchloride pipe. After entering the laboratory, the pipe branches into 3-inch ceiling pipes that supply water to the three laboratory tank rooms. Petcocks in the ceiling pipes conduct the water into the holding and experimental tanks. From the tanks water flows into concrete return troughs connected to the filter. Water from the tanks can also be directed into other troughs connected to a drain to facilitate cleaning. The two filter beds are similar in design to those of municipal water treatment plants and consist of washed (river) sand on a bed of graded gravel. The gravel overlays a network of small perforated polyvinylchloride pipes leading into a 4-inch pipe that discharges into a 9,000-gallon concrete sump located



The two filter beds which lie on top of a 9,000-gallon sump.

directly under the filter beds. Two $7\frac{1}{2}$-hp. centrifugal pumps (one a standby), located 15 feet below ground level, pump the water from the sump back to the redwood storage tanks, thus completing the cycle. The system is designed to circulate a maximum of 8,000 gallons of sea water an hour. The plastic valves and piping and the concrete return troughs and sump minimize the danger of metal contamination. Both laboratory and filter house are insulated, and the laboratory is air-conditioned to maintain the water at a relatively constant temperature.

East tank room showing the two tiers of fiber-glass tanks and a third tier of glass aquaria.

The three tank rooms cover more than 1,000 square feet of space and contain a sufficient variety of sizes of redwood, fiberglass, and plate-glass tanks to give the individual investigator a wide selection for his particular needs. In the east tank room (Laboratory A), which has an area of 428 square feet, advantage is taken of the high outlets by arranging the tanks in three tiers along one wall. Eventually all tanks in this room will be similarly arranged.

Laboratory B, the center tank room (170 square feet), is somewhat limited as to the number and sizes of tanks by the relatively short (15 feet) trough space. It is used primarily for experiments requiring small aquaria and also to house monitoring and other equipment.

West tank room showing large redwood holding tanks.

The west room (Laboratory C), containing the same space as Laboratory A, is filled to capacity with redwood tanks ranging in size from 100 to 500 gallons. We plan to place 30-gallon glass aquaria on shelving over the redwood tanks. A 5-hp. compressor, located in the equipment room between Laboratories B and C, supplies air to the three tank rooms. The food preparation room, which is situated in the southwest corner of the building, contains the necessary mixing, cold storage, disposal, etc., facilities for preparing the variety of diets to condition fish and shrimp for experiments.

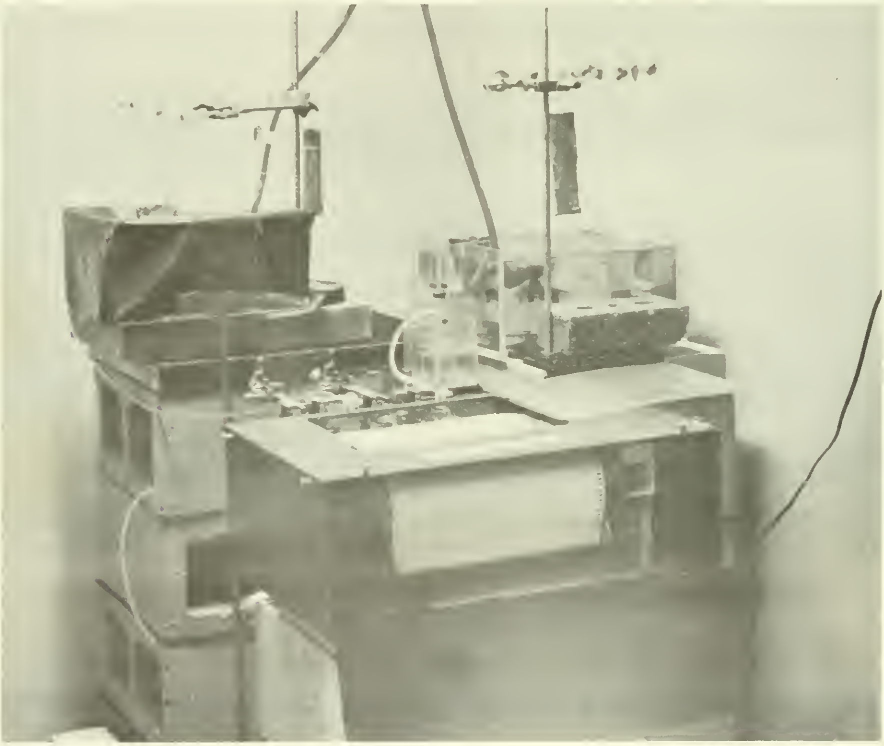
The leaching of wooden tanks and the concrete troughs and sump was accomplished by recirculating tap water through the system for a month. During this period minor changes were made to increase the velocity and decrease the water depth in the return troughs, and to increase the efficiency of oxygen exchange and thus the holding capacity of the entire system. The sand filters perform satisfactorily. Their effectiveness was particularly apparent after the first addition of muddy (15-inch Secchi disc reading) sea water. After several days of recirculation, the clarity equaled that of tap water. Periodically the beds have to be backflushed with large volumes of tap water to float off the accumulation of particulate matter. This is always followed with a salt-water backflush to avoid dilution problems.

Samples of the water are analyzed three times weekly for salinity, oxygen, ammonia, nitrate, nitrite, phosphate, pH, alkalinity, carbon dioxide, protein, and carbohydrate.

Oyster Studies

Sammy M. Ray
Galveston Marine Laboratory, A. and M. College of Texas
and
David V. Aldrich

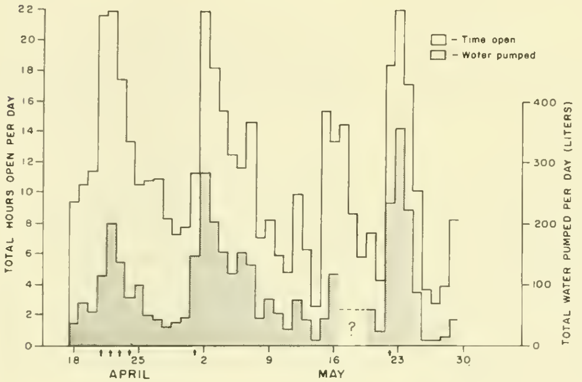
The following report summarizes the data obtained in preliminary studies to determine the response of oysters to conditions in the new sea-water laboratory. The shell movement and water pumping rate of two oysters were continuously



Experimental set-up used for recording shell movement and pumping rate of oysters in the sea-water laboratory.

recorded on a kymograph to check their feeding activity. In a parallel study the immersed weight of 50 other oysters under various conditions was followed as an index of growth.

The data obtained by the kymograph recordings for one of these oysters (about 4 inches long) are presented in the figure. The three highest peaks of water pumping and shell opening were associated with the addition of some fresh sea water to the system. A fourth peak of activity, especially shell opening, occurred from May 15 through May 17. Since the daily log book of the sea-water laboratory gives no indication of either fresh sea-water additions or other changes, we are unable to suggest any possible causes for this peak.

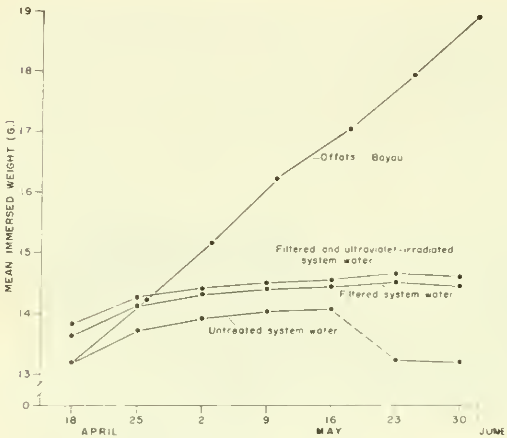


Daily record of number of hours open and volume of water pumped by an oyster maintained in sea-water laboratory. Because of failure in the experimental set-up no record of volume of water pumped was obtained on May 17, 18, and 19. Arrows indicate the dates that some fresh sea water was added to the system.

The volume of feces deposited by the two oysters used in our experiments was roughly proportional to the amount of water pumped. There are, however, indications that feces deposition per volume of water filtered decreases as the sea water ages. Such a decrease is to be expected since the water passes through a sand and gravel filter bed each time it is recycled.

A maximum pumping rate of about 20 liters per hour was obtained during these studies. The volume of water pumped during the first 2 or 3 days following the addition of fresh sea water was comparable to that observed for oysters of similar size in running sea water at Pensacola, Florida. Our preliminary studies indicate that frequent additions of fresh sea water will probably be necessary for the long-time maintenance of oysters in this system. If the reduction of the oyster feeding activity associated with the aging of the water is due solely to a diminution of the food supply, the problem may be solved by artificial feeding.

While shell movement and pumping rate serve as good indices of immediate responses of oysters, they cannot at present be directly related to growth. Four groups of West Bay oysters were used to study such relationships and to determine the effects on growth of various water treatments. Three of these groups, containing 10 individuals each, were maintained in the sea-water laboratory. These groups received untreated water, filtered water, and filtered ultraviolet-irradiated water, respectively, at the rate of about 60 liters per hour. Filters (Aqua-Pure, Cuno) containing elements with a porosity of 5 microns were used. The fourth group was maintained in Offats Bayou in a tray suspended from a pier.



Growth rate of oysters maintained in sea-water laboratory and Offats Bayou. The death of the largest oyster in the group receiving untreated system water accounts for the sharp decrease in the mean immersed weight of this group between May 16 and May 23.

Oyster growth was measured in terms of immersed weight, a method that circumvents the inaccuracies of either weight-in-air or length measurements. The range of the initial immersed weights for each group was about 5 to 20 grams. The results are presented in the figure.

The most striking result is the difference between growth rates of the Offats Bayou and sea-water laboratory groups. The more rapid growth of the former group probably stems from a greater abundance of food. Since oyster food is generally considered to be particulate, unfiltered water containing such material should support better growth than filtered water. This was not the case in this experiment. The growth rates of laboratory oysters in filtered water were highly similar to those of the oysters in unfiltered water. This similarity suggests that a shortage of particulate food is inherent to the laboratory water.

It is interesting that both immediate and long-term oyster responses to an artificial environment provide similar indications.

Distribution of Pink Shrimp Larvae and Postlarvae

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(Contract No. 14-17-002-29)

Investigation of the relative abundance and distribution of larvae and postlarvae of the pink shrimp (Penaeus duorarum) in Florida Bay and the adjacent Gulf of Mexico has been carried on by the Institute of Marine Science of the University of Miami. Research has been divided into three phases: (1) identification of the larval stages; (2) hydrography of Florida Bay and the adjacent Gulf of Mexico; and (3) geographical and seasonal distribution of the larvae.

The first phase of the program, involving the collection, identification, rearing, and description of pink shrimp larvae and postlarvae, has been completed.

Investigation of the current system in Florida Bay and on the Dry Tortugas fishing grounds (second phase) has not shown the presence of an onshore current which could of itself transport shrimp larvae from offshore spawning grounds to inshore nursery areas. The main water movements in this region are due to tidal currents with a superimposed wind-driven component. The influence of the tidal currents decreases with increased depth and distance from shore until the wind-driven component becomes the major factor in the water movement near the western limits of the spawning grounds.

High salinity values on the bottom at the time of tidal change together with theoretical considerations required a study of the bottom currents. Using a modification of the Carruther's bottom current meter and a newly developed Niskin "gimball" bottom current meter, measurements of bottom currents were determined within 1 foot to 6 inches of the bottom. Velocity data from these bottom current readings indicate that a continuous easterly current is not present in the area, and that the current is, as expected, of low velocity (well under 5 cm./sec.).

The third phase of the program, seasonal and geographical distribution of pink shrimp larvae and postlarvae, has continued. From July 1960 to April 1961, 11 sampling cruises were made. A total of 758 plankton samples was collected. Of these, 550 have been examined. Examination of the 740 samples collected over the period July 1959 to June 1960 was also completed. In addition, 95 plankton samples were taken this year from Florida Keys highway bridges, from Everglades National Park, and from the Tortugas fishing grounds with the Beyer plankton sled.

The Beyer sled, used to sample plankton occurring near the sea bottom.

Sampling was done in nearly every month of the year and over as wide a geographical area as possible in order to obtain a complete picture of the distribution of pink shrimp larvae in this area. Plankton was collected from Sanibel Island to south of the Florida Keys and from the 100-fathom line inshore to 2 fathoms. The majority of samples were taken in the middle of this area and few were taken in fringe areas.

Few pink shrimp in early life history stages were found to the east of Key West during any season of the year. In almost all cases those taken have been in the postlarval stage of development.

Samples during the current year revealed a center of abundance of larvae, which is believed to represent a center of spawning. This center of abundance is located on the Tortugas fishing grounds and shifted position during the season.

SEMINARS

Training program in Washington. Bernard E. Skud
Activities of the Honolulu Biological Laboratory. Joseph J. Graham
Methods and significance of salinity measurements. Kenneth T. Marvin
Navigation and navigational astronomy. William Renfro
Poison bait for nutria control. James Ragan
Estimating mortality in a tagged shrimp population. Joseph H. Kutkuhn
Shrimp fishery in India. Malloothara J. George, Mandapam Camp, South India
Respiration and metabolism in crustaceans. Zoula Zein-Eldin
Circulating water systems: pros and cons. Ray Wheeler
Marine pond culture in British Guiana. W. H. L. Allsopp, British Guiana
Biological responses to polarized light. David V. Aldrich
Oyster culture. John VanDerwalker
Biological factors affecting population fluctuations. Harry Cook
International Indian Ocean Expedition. Kenneth N. Baxter.

MEETINGS ATTENDED*

Tortugas Shrimp Commission, U. S. Section, Miami, July (2)
Tortugas Shrimp Commission, Havana, July (1)
American Institute of Biological Sciences, Stillwater, Oklahoma, August (4)
American Fisheries Society, Denver, September (2)
Southwest Field Committee, Denver, September (1)
U. S. Study Commission-Texas, Fort Worth, September (2)
Water for Texas, College Station, Texas, September (2)
Texas Bait Shrimpers Association, Highland Bayou, September (1)
Gulf States Marine Fisheries Commission, St. Petersburg Beach, October (5)
Gulf and Caribbean Fisheries Institute, Miami, November (3)
Southeastern Fisheries Association, St. Simons Island, Georgia, November (1)
Biological Research Laboratory Directors' Meeting, Washington, D. C., Dec. (1)
Arkansas-White-Red River Interagency Committee, New Orleans, Jan. (1)
Southwest Field Committee, New Orleans, Jan. (1)
Nutria Control Conference, Beaumont, January (1)
Texas Shrimp Association, Houston, January (3)
North American Wildlife Conference, Washington, D. C., March (1)
Gulf States Marine Fisheries Commission, Biloxi, March (2)
American Society of Ichthyology and Herpetology, Austin, March (1)
Welder Wildlife Foundation, Sinton, Texas, April (2)
North Atlantic Fish Marking Symposium, Woods Hole, Mass., May (1).

*Attendance shown in parentheses.

PUBLICATIONS

Aldrich, David V.
1960. The physiology of fishes, edited by Margaret E. Brown. [A review]. Transactions of the American Fisheries Society, vol. 89, no. 3, p. 316.

Aldrich, David V., and William B. Wilson.
1960. The effect of salinity on growth of Gymnodinium breve Davis. The Biological Bulletin, vol. 119, no. 1, p. 57-64.

Arnold, Edgar L., Ray S. Wheeler, and Kenneth N. Baxter.
1960. Observations on fishes and other biota of East Lagoon, Galveston Island. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries 344, 30 p.

Breedlove, Stella.
1961. Current bibliography for aquatic sciences and fisheries, compiled by Food and Agriculture Organization, Fisheries Biology Branch. [A review]. Transactions of the American Fisheries Society, vol. 90, no. 1, p. 86.

*Christmas, James Y., and Gordon Gunter.
1960. Distribution of menhaden, genus Brevoortia, in the Gulf of Mexico. Transactions of the American Fisheries Society, vol. 89, no. 4, p. 338-343.

*Christmas, James Y., Gordon Gunter, and Edward C. Whatley.
1960. Fishes taken in the menhaden fishery of Alabama, Mississippi, and eastern Louisiana. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries 339, 10 p.

Craig, William L., and Joseph J. Graham.
1961. Report on a co-operative preseason survey of the fishing grounds for albacore (Thunnus germo) in the eastern North Pacific, 1959. California Fish and Game, vol. 47, no. 1, p. 73-85.

Dragovich, Alexander.
1961. Relative abundance of plankton off Naples, Florida, and associated hydrographic data, 1956-57. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries 372, 41 p.

Dragovich, Alexander, John H. Finucane, and Billie Z. May.
1961. Counts of red tide organisms, Gymnodinium breve, and associated oceanographic data from Florida west coast, 1957-59. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries 369, 175 p.

Finucane, John H., and Billie Z. May.
1961. Modified Van Dorn sampler. Limnology and Oceanography, vol. 6, no. 1, p. 85-87.

*Gunter, Gordon, and James Y. Christmas.
1960. A review of literature on menhaden with special reference to the Gulf of Mexico menhaden, Brevoortia patronus Goode. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries 363, 31 p.

*Gunter, Gordon, and William J. Demoran.
1961. Lateral lines and an undescribed sensory area on the head of the Gulf menhaden, Brevoortia patronus. Copeia, 1961, no. 1 (March), p. 39-42.

Haskell, Winthrop A.
1961. Gulf of Mexico trawl fisheries for industrial species. U. S. Fish and Wildlife Service, Commercial Fisheries Review, vol. 23, no. 2 (February), p. 1-6.

Inglis, Anthony.
1961. Ecology of inland waters and estuaries, by George K. Reid. [A review]. Transactions of the American Fisheries Society, vol. 90, no. 2, p. 232-233.

*Iversen, Edwin S., Andrew E. Jones, and Clarence P. Idyll.
1960. Size distribution of pink shrimp, Penaeus duorarum, and fleet concentrations on the Tortugas fishing grounds. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries 356, 62 p.

*Koczy, F. F., M. O. Rinkel, and S. J. Niskin.
1960. The current patterns on the Tortugas shrimp grounds. Proceedings of the Gulf and Caribbean Fisheries Institute, 12th Annual Session, 1959, p. 112-125.

Marvin, Kenneth T., Zoula P. Zein-Eldin, Billie Z. May, and Larence M. Lansford.
1960. Chemical analyses of marine and estuarine waters used by the Galveston Biological Laboratory. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries 349, 14 p.

May, Billie Z.
1960. Stabilization of the carbohydrate content of sea water samples. Limnology and Oceanography, vol. 5, no. 3, p. 342-343.

McGary, James W., and Joseph J. Graham.
1960. Biological and oceanographic observations in the central North Pacific July-September 1958. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries 358, 107 p.

Naab, Ronald C.
1960. Principles of fisheries development, by C. J. Bottemanne. [A review]. Transactions of the American Fisheries Society, vol. 89, no. 3, p. 317.

Renfro, William C.
1960. Salinity relations of some fishes in the Aransas River, Texas. Tulane Studies in Zoology, vol. 8, no. 3, p. 83-91.

Rounsefell, George A.
1961a. How can research production be measured? Proceedings of the Gulf and Caribbean Fisheries Institute, 13th Annual Session, 1960, p. 139-150.

1961b. Living fishes of the world, by Earl S. Herald. [A review]. Transactions of the American Fisheries Society, vol. 90, no. 3, p. 341.

1961c. Fishery management, by R. S. Fort and J. D. Brayshaw. [A review]. Transactions of the American Fisheries Society, vol. 90, no. 3, p. 341-342.

Skud, Bernard Einar.
1961. Education and recruitment of oceanographers in the United States. A report by the Committee on Education and Recruitment, American Society of Limnology and Oceanography, Inc., August 30, 1960. [A review]. Transactions of the American Fisheries Society, vol. 90, no. 2, p. 232.

Skud, Bernard E., and William B. Wilson.
1960. Role of estuarine waters in Gulf fisheries. Transactions of the 25th North American Wildlife and Natural Resources Conference, p. 320-326.

Thompson, John R., and Winthrop A. Haskell.
1960. From trash to treasure. Petfood Industry, vol. 2, no. 12, p. 10-13.

U. S. Fish and Wildlife Service.
1960. Galveston Biological Laboratory Fishery Research, for the year ending June 30, 1960. U. S. Fish and Wildlife Service, Circular 92, 77 p.

Zein-Eldin, Zoula P.
1960. Endocrine control in crustaceans, by David B. Carlisle and Sir Francis G. W. Knowles. [A review]. Transactions of the American Fisheries Society, vol. 89, no. 4, p. 385.

1961. Plankton pigments in East Lagoon, Galveston, Texas. Transactions of the American Fisheries Society, vol. 90, no. 1, p. 32-41.

*Contract research

MANUSCRIPTS SUBMITTED FOR PUBLICATION

Allen, Donald M., and T. J. Costello.
Grading large numbers of live shrimp for marking experiments.

Kutkuhn, Joseph H.
Gulf of Mexico commercial shrimp populations--trends and characteristics 1956-1959.

Marvin, Kenneth T., and Larence M. Lansford.
Phosphorus content of some fishes and shrimp in the Gulf of Mexico.

Rounsefell, George A.
Classification of North American Salmonidae.

INT.DUP.,D.C.61-1 03138