FISHERY RESEARCH
BIOLOGICAL LABORATORY, GALVESTON

FISCAL YEAR 1962

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

BUREAU OF COMMERCIAL FISHERIES

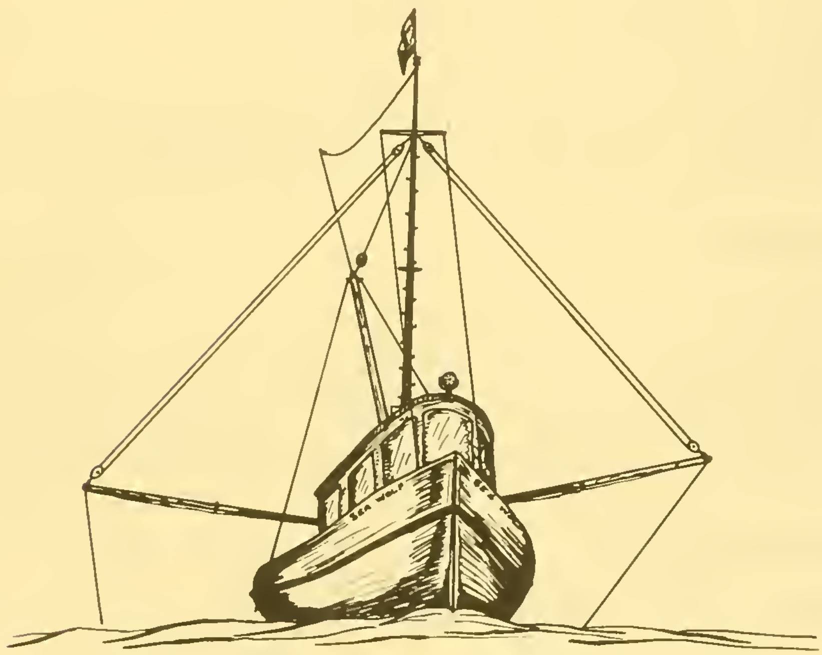
CIRCULAR 161

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*

BIOLOGICAL LABORATORY, GALVESTON, TEX.
FISHERY RESEARCH

for the year ending June 30, 1962

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



Contribution No. 168, Bureau of Commercial Fisheries
Biological Laboratory, Galveston, Tex.

Circular 161

Washington, D. C.
1963

The Bureau of Commercial Fisheries Biological Laboratory, Galveston, Tex., and its field stations, conduct fishery research in the Gulf of Mexico as part of the work of the Bureau's 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, Fla.

Biological Research

Biological Laboratory, Brunswick, Ga.
Biological Laboratory, Beaufort, N. C.
Biological Laboratory, Gulf Breeze, Fla.
Biological Laboratory, Galveston, Tex.
 Biological Field Station, Miami, Fla.
 Biological Field Station, St. Petersburg Beach, Fla.*
 Biological Field Station, Pascagoula, Miss.

Industrial Research

Exploratory Fishing and Gear Research Base, Pascagoula, Miss., auxiliary base at Brunswick, Ga.
Marketing - Marketing Offices in Dallas, Tex.; Jacksonville, Fla.; and Pascagoula, Miss.
Technology - Technological Laboratory, Pascagoula, Miss.

Resource Development

Statistical Center, New Orleans, La.

*Operating as an independent field station after January 1, 1962.

CONTENTS

COVER: The East Lagoon Field Station, completed and operative in 1962, only 4 miles from the main laboratory, affords an opportunity to work on living material in almost natural conditions.

REPORT OF THE DIRECTOR

George A. Rounsefell

Research Highlights of the Past Year Experiments in marking shrimp at sea by staining proved highly successful. With this new tool, we were able to mark and release shrimp carefully graded as to size. The analysis of the data from several hundred recaptured by the shrimp fleet demonstrated that the pink shrimp (*Penaeus duorarum*) grow very fast. Nevertheless, the mortality rate is so high that a larger total harvest can be made if fishing for them commences at relatively small sizes.

By means of counts of postlarval shrimp entering Galveston Bay during the spring of 1960, 1961, and 1962, and data on the catch per unit of effort of resulting juvenile shrimp in the Galveston Bay system, we were able to predict in late spring that the abundance of shrimp in 1962 would exceed that of 1961, and might equal that of 1960.

Two of the stained pink shrimp released on the Sanibel Island grounds were recovered 115 days later on the northwest portion of the Tortugas Grounds, showing that these two grounds may not have discrete populations.

The increased funds obtained in 1961 allowed us to commence simultaneous biological and hydrographical sampling on the continental shelf out to 60 fathoms along an 800-mile stretch of coastline from Brownsville, Tex., to the Mississippi delta. It is hoped that these data, if collected for several years, will show the causes for the year-to-year variations in the survival of the larval forms of shrimp.

Gulf States Marine Fisheries Commission The Commission has continued to support research to aid in solving industry problems and has been instrumental in obtaining increased resources for research. The Commission has formed a committee of biologists from each of the participating states and the Bureau of Commercial Fisheries to meet under its sponsorship to discuss research problems and to aid in the standardization of research techniques.

Shift in Pesticide Program Over the past 2 years, small programs on the effects of pesticides were carried on at Bureau of Commercial Fisheries Biological Laboratories both at Galveston, Tex., and Gulf Breeze, Fla. With increased emphasis to be placed on this important work, it is being concentrated at Gulf Breeze and has been discontinued at Galveston.

Termination of Red-Tide Field Operations Research on red tide was thrust upon the Bureau after the severe red-tide outbreak along the west coast of Florida in 1947. At that time, even the identity of the causative organism was unknown. Public hysteria (caused both by the littering of the beaches with millions of dead fish and the irritating effect on the lungs and throat of the toxin carried as an aerosol) demanded immediate action, and a great deal of money and effort were expended in merely monitoring by fast boat and airplane the areas where outbreaks might occur. Despite the handicap of attempting to carry on research while parrying the impatient attacks of an indignant public demanding action -- any kind of action -- considerable knowledge was accumulated.

The causative organism, a naked dinoflagellate (Gymnodinium breve Davis), was successfully reared in both unialgal and pure cultures. Much has been learned of the effects of various physical and chemical factors on its survival and growth, and of the concentrations of the organism required to exude sufficient toxin to render sea water toxic to other organisms.

Several years of field collection of this red-tide organism with concurrent measurements of salinity, temperature, and chemical composition of the water have failed to show any limiting relation between abundance of the organism and levels of phosphorus, nitrates, nitrites, copper, etc. The organism does not thrive in water of low salinity. Outbreaks appear to coincide with periods of heavy land drainage when wind velocities are low, especially if the light winds are blowing toward the shore. It would thus appear that the overblooms occur when and where nutrient-laden fresh water mixes with the salt waters of the Gulf.

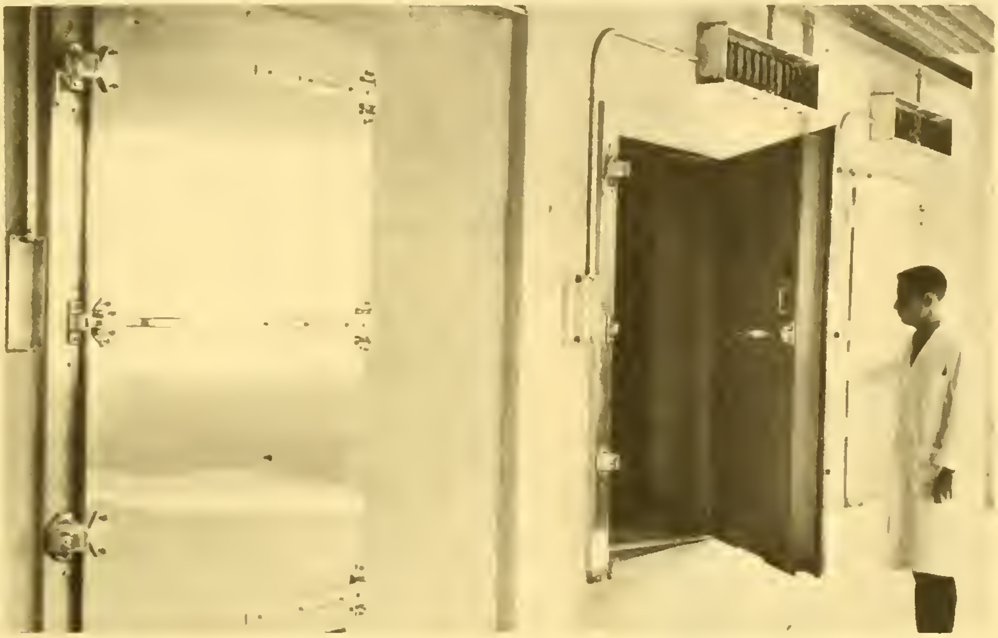
During the field operations, numerous hydrographic data were gathered that are of great value to other fishery investigations. Certain of these observations will be continued, but field work on red tide as such has been terminated. This does not mean that broader knowledge being gained in our other estuarine work will not eventually contribute to a greater knowledge of the causes of these sporadic outbreaks.

One phase of red-tide work is being continued. It is the search for a chemical agent that will control the red-tide organism without harming other valuable organisms. A report on current progress appears elsewhere in this report.

St. Petersburg Beach Field Station Upon termination of red-tide field activities, it was necessary to decide on the future role of this field station. Since the station has excellent hydrographic observations since 1957 for Tampa Bay and the adjacent waters of the Gulf, it was decided that Tampa Bay would be a suitable area for conducting needed research on the estuaries of the eastern Gulf. The field station is now operating independently of the laboratory at Galveston.

Research Vessel Several naval architects formally expressed their opinion that the funds available for construction of the proposed laboratory research vessel are insufficient to construct and equip the type of vessel needed. Negotiations for an architect are, therefore, being held in abeyance unless or until adequate funds become available.

East Lagoon Field Station The sea-water laboratory on East Lagoon in Galveston (illustrated on front cover) was dedicated by Assistant Secretary of the Interior, Frank P. Briggs, during the meeting in Galveston of the American Fisheries Advisory Committee.

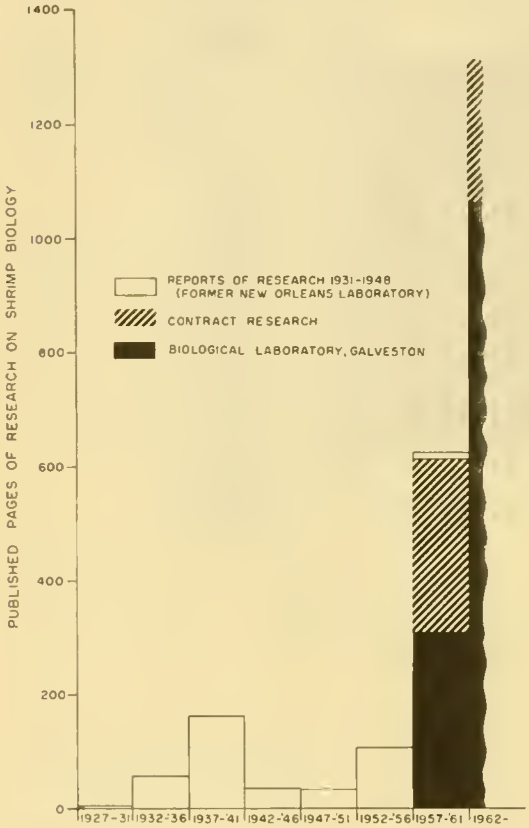


Four rooms for controlling temperatures within a narrow range for studies of shrimp physiology are nearing completion.

Increased Tempo of Research Effort It is instructive to occasionally glance back over your shoulder and see where you have been in comparison with where you are going. Biological research in fisheries in the Gulf of Mexico has lagged behind other areas but appears to be gathering steam. The shrimp fishery of the south is the most valuable U. S. fishery, and we have examined the research publications of the Bureau of Commerfial Fisheries on this subject as an index of fishery research effort in the area.

Shrimp research by the Bureau in the Gulf of Mexico began in 1931 with headquarters in New Orleans and continued in a small way until about 1948. For almost a decade thereafter, active field work was discontinued. The third phase was reactivation of shrimp research at the Biological Laboratory in Galveston in the late 1950's by means of Saltonstall-Kennedy funds. The fourth phase commenced in mid-1961 when, through efforts of the Gulf States Marine Fisheries Commission, regular funds were appropriated that have permitted large-scale biological and hydrographic sampling off the Gulf coast between the Rio Grande and the Mississippi Rivers, and port sampling of commercial landings to supply data needed for studying the dynamics of the populations.

In the first table and the figure, the pages of published research are shown by 5-year periods. The work begun in 1931 was modestly financed. The very small staff and lack of facilities severly limited the type and amount of work that could be undertaken. Despite these handicaps several very creditable reports were published. Eventually, it became apparent that without much better statistics, more staff, and adequate laboratory and seagoing facilities, little further progress could result, and work was held in abeyance.



Research reports on shrimp biology in the Gulf of Mexico emanating from the Bureau of Commercial Fisheries. Estimates for the 5-year period commencing in 1962 are explained in text.

In 1956, the statistical branch of the Bureau inaugurated the present system for collecting detailed statistics on shrimp landings by species, size, area, depth, and amount of fishing effort involved. At the same time, the Bureau prepared to resume research on shrimp at the Biological Laboratory in Galveston. Certain phases of the work were carried out by contract with universities. These include the development of a technique for staining shrimp by the University of Texas, a detailed atlas of the morphology of the white shrimp (*Penaeus setiferus*) by Tulane University, and studies on size distribution of pink shrimp on the Tortugas grounds by the University of Miami. Currently, the University of Miami is studying the distribution of pink shrimp larvae in relation to current patterns.

That the research is gathering momentum is indicated by the great increase in published reports in the 1957-61, 5-year period. The estimate of reports forthcoming in the 5-year period commencing with 1962 (see the first table and the figure) is undoubtedly conservative, as it is based largely on pages of manuscript in press by June 30, 1962. Furthermore, it has taken some time to tool up. The staining and handling techniques for marking shrimp have been considerably improved, and through underwater release of marked shrimp directly onto the bottom, we can now mark shrimp at sea. The sea-water system completed last year is permitting further improvement in marking methods and is also invaluable in holding and rearing larval shrimp for identifying the species in these young stages. The future construction of a small but modern research vessel to study the environment on the continental shelf would be an important step toward understanding the causes of annual fluctuations in survival of the larvae from different broods.

Published pages of biological research on Gulf of Mexico shrimp by the Bureau of Commercial Fisheries (as of June 30, 1962)

5-year period	1931-48 work by the former New Orleans Laboratory	Contract research for the Bureau 1/	Biological Laboratory at Galveston			Total
			Annual reports	Other	In press 2/	
1927-31	4					4
1932-36	162					162
1937-41	95					95
1942-46	36					36
1947-51	34					34
1952-56	106					106
1957-61	13	297	114	200		624
1962-		?	ca. 40	25	307	372
Total	450	297	154	225	307	1,433
1962-66 estimate	0	250	200	860 3/		1,310

1/ Work performed by Universities of Texas and Miami, and Tulane University.

2/ Manuscript pages in press June 30, 1962.

3/ Estimated from number pages published and manuscript pages in press during first 6 months of the 5-year period.

The broad scope and complexity of the problems encountered become apparent if one notes the subject matter of the reports already published or in press. Other research at the Biological Laboratory also has an important bearing on shrimp conservation. Thus, postlarval shrimp enter the estuaries, settle to the bottom, and grow rapidly for a period of 2 to 3 months before starting their return journey to the open Gulf. It is imperative that these estuarine nursery areas be preserved from pollution, encroachment, or undesirable hydrographic changes. Our estuarine research is aimed at determining the most suitable conditions for various species, including shrimp.

Pages of research by the Bureau of Commercial Fisheries on various phases of shrimp biology.

Subject	Published pages		Manuscript pages in press	Total pages
	In annual laboratory report 1/	Other		
Summaries and research programs		62		62
Problems of shrimp industry		113		113
Life history of white shrimp, including migrations		131		131
Taxonomy and morphology		223		223
Sampling equipment for taking young stages	3	3		6
Early life history	12	107	37	156
Distribution and abundance of larvae	9			9
Ecology of shrimp nursery areas	8			8
Effects of pesticides on shrimp	13	9	15	37
Nutrition and respiration	11			11
Predation on shrimp by juvenile fishes	4			4
The bait shrimp fishery	9	24		33
Techniques for marking shrimp with stains	4	43		47
Bibliography of shrimp literature		143		143
Length-weight relationship		20		20
Migrations of pink shrimp	14	5		19
Migrations of brown shrimp	7			7
Size distribution on Tortugas grounds	5	62		67
Currents on the Tortugas grounds		14		14
Trends in population abundance	15	13	255	283
	114	972	307	1,393

1/ Exclusive of this 1962 Annual Report.

STAFF

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

Biological Laboratory at Galveston, Tex.
Field Stations at St. Petersburg Beach and Miami, Fla.
and Pascagoula, Miss.

Shrimp Fishery Program

J. Bruce Kimsey	Program Leader	Galveston
Thomas J. Costello	Head, Field Station	Miami
Donald M. Allen	Biologist	Miami
William C. Renfro	Biologist	Galveston
Robert F. Temple	Biologist	Galveston
Edward F. Klima	Biologist	Galveston
David L. Harrington	Biologist	Galveston
Harry L. Cook	Biologist	Galveston
Carl H. Saloman	Biologist (transferred 1/62)	Miami
Harold A. Brusher	Biologist	Galveston
Kenneth N. Baxter	Biologist	Galveston
Ray S. Wheeler	Biologist	Galveston
Charles E. Knight	Biologist	Galveston
Clarence C. Fischer	Biologist	Galveston
Clyde A. Allbaugh	Biologist (resigned 6/62)	Galveston
Orville D. Brown	Biologist (resigned 5/62)	Galveston
Thomas W. Turnipseed	Biologist	Morgan City
James M. Lyon	Biologist	Aransas Pass
Aubrey A. LaFrance	Aid	Galveston
Imogene A. Sanderson	Technician	Galveston
Alice Murphy	Technician	Galveston
James P. Gilmore	Summer Aid	Ft. Myers Beach
Christopher D. Noe	Summer Aid	Galveston
David S. Greene	Summer Aid	Galveston
John G. Migliavacca	Summer Aid	Galveston
John H. Tweedy	Aid (Intermittent)	Miami
Donald R. Nelson	Aid (Intermittent)	Miami
Andrew E. Jones	Aid (Intermittent)	Miami
Joseph J. Ewald	Aid (Intermittent)	Miami
Richard L. Aaron	Aid (Intermittent)	Miami

Estuarine Program

Joseph J. Graham	Biologist (transferred 10/61)	Galveston
Anthony Inglis	Biologist	Galveston
Richard A. Diener	Biologist	Galveston
Charles H. Koski	Biologist	Galveston
Cornelius R. Mock	Biologist	Galveston
Gilbert Zamora, Jr.	Aid	Galveston
William Laming	Aid	Galveston
Terry C. Allison	Summer Aid	Galveston
Domingo R. Martinez	Summer Aid	Galveston
Genevieve B. Adams	Statistical Clerk	Galveston

Industrial Fishery Program

Joseph H. Kutkuhn	Biologist (Program Leader)	Galveston
Charles M. Roithmayr	Biologist	Pascagoula
Richard J. Berry	Biologist	Galveston
James G. Ragan	Biologist	Galveston
Jerry T. Goff	Summer Aid	Pascagoula
Ronald J. Arceneaux	Summer Aid	Galveston

Physiology and Behavior Program

Edward Chin	Biologist (Program Leader, resigned 2/62)	Galveston
David V. Aldrich	Physiologist (Program Leader from 2/62)	Galveston
Zoula P. Zein-Eldin	Biochemist	Galveston
John G. VanDerwalker	Biologist (transferred 12/61)	Galveston
Don S. Godwin	Aid	Galveston
Roger M. Friedberg	Aid	Galveston

Red-Tide Program (terminated 6/62)

William B. Wilson	Biologist (Program Leader, resigned 6/62)	Galveston
David V. Aldrich	Biologist (to 2/62)	Galveston
Billie Z. May	Chemist (transferred 1/62)	St. Petersburg Beach
Alexander Dragovich	Biologist (transferred 1/62)	St. Petersburg Beach
John H. Finucane	Biologist (transferred 1/62)	St. Petersburg Beach
John A. Kelly, Jr.	Biologist (transferred 1/62)	St. Petersburg Beach
Gordon R. Rinckey	Biologist (transferred 1/62)	St. Petersburg Beach
John D. McCormick	Master, M/V KINGFISH (transferred 1/62)	St. Petersburg Beach
Lucius Johnson, Jr.	Chemistry Aid (transferred 1/62)	St. Petersburg Beach

Chemistry and Sea-Water Laboratories

Kenneth T. Marvin	Chief Chemist	Galveston
Raphael R. Proctor, Jr.	Chemist	Galveston
Larence M. Lansford	Technician	Galveston
Elroy L. Young	Aid	Galveston

Library

Stella Breedlove	Librarian	Galveston

Technical Services

Ruth W. Yanch	Secretary	Galveston
Ester E. Sell	Secretary (resigned 2/62)	Galveston
Daniel Patlan	Draftsman	Galveston
Petronila C. Prado	Scientific Stenographer	Galveston
Mary E. Hipple	Clerk-typist (transferred 1/62)	St. Petersburg Beach
Nellie P. Benson	Clerk-stenographer (part time)	Miami

Administration and Maintenance

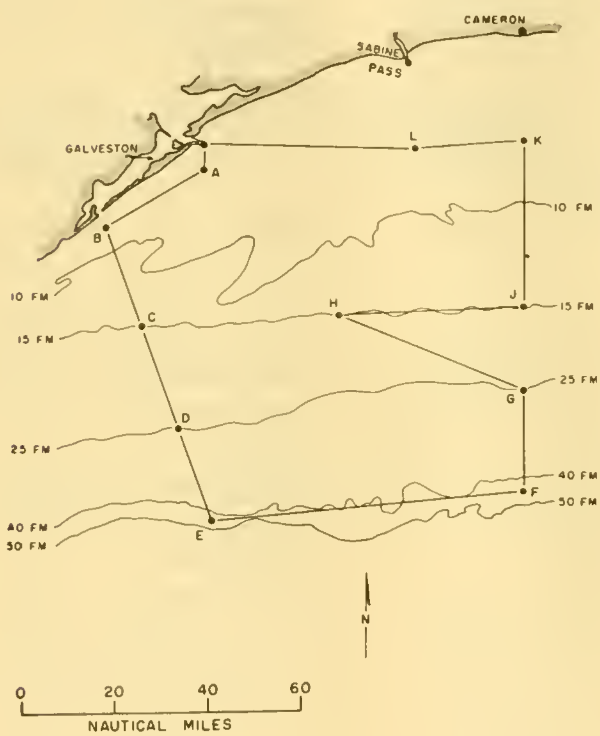
Lawrence E. Wise	Administrative Officer	Galveston
Laura M. Hermann	Asst. Administrative Officer	Galveston
Corinna L. Denbo	Purchasing Clerk	Galveston
Glo S. Baxter	Clerk-stenographer	Galveston
Peter M. Villarreal	Maintenanceman	Galveston
Robert L. McMahon	Maintenanceman	Galveston
Tidas C. Alcorn	Maintenanceman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

SHRIMP FISHERY PROGRAM

J. Bruce Kimsey, Program Leader

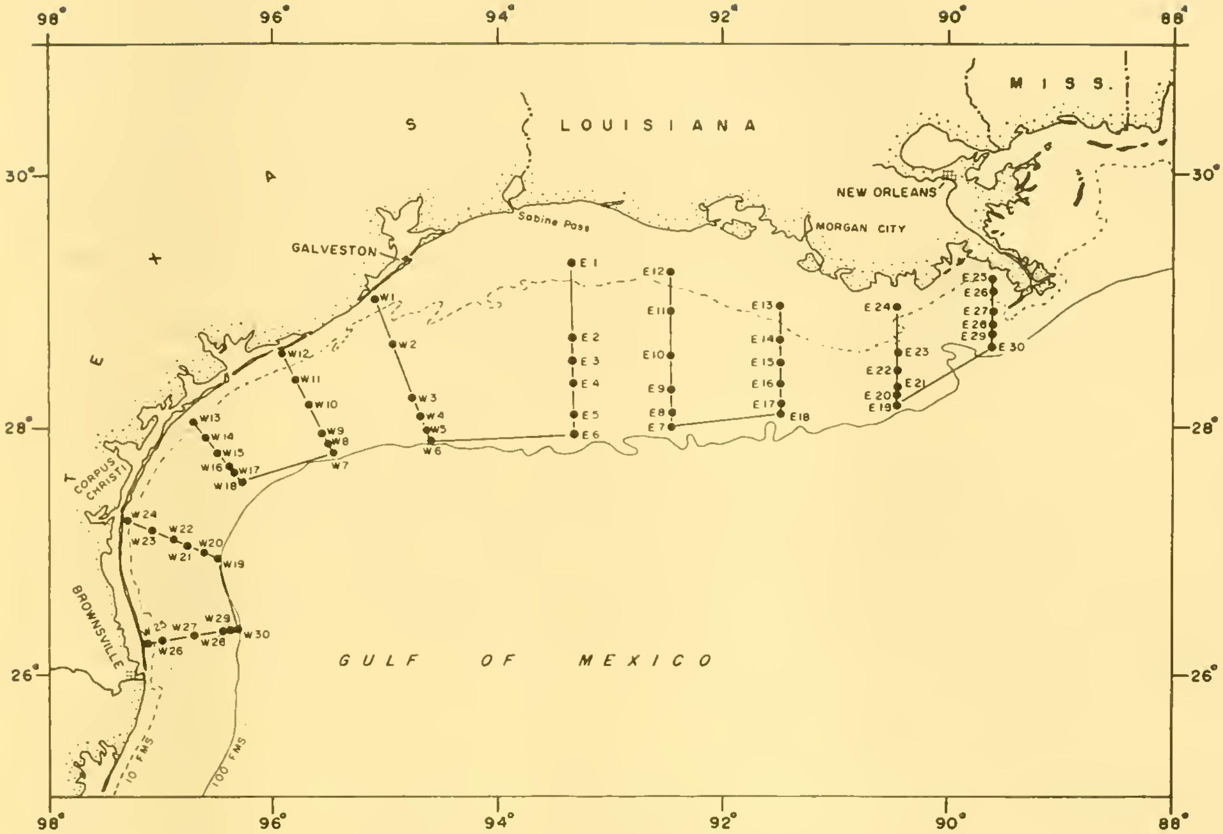
Broadly stated, the basic objective of the Shrimp Fishery Program is to obtain an understanding of the dynamics of the total population. This includes the preexploited as well as the exploited phases of the commercially important shrimp species. More specific objectives are associated with predicting yield and rationalizing exploitation so that maximum production levels can be maintained.

A study of offshore shrimp populations began in January 1961 with the sampling of 11 stations between Galveston, Tex., and Cameron, La., and was completed in January 1962. Some of the results are presented as project reports in this annual report, while other data are still being analyzed. In September 1961, the original station pattern was expanded to include four additional, six-station transects. In January 1962, further changes were made, and the offshore sampling study currently consists of 10, six-station transects, ranging from the Mississippi River to the Rio Grande River. Two shrimp trawlers, BELLE OF TEXAS and MISS ANGELA, are chartered to carry out the sampling. The 60 monthly stations are equally divided between $7\frac{1}{2}$, 15, 25, 35, 45, and 60 fathoms. At each station a 45-foot shrimp trawl is towed 1 hour, a 20-minute plankton tow is made with a Gulf V plankton sampler, and current, salinity, and temperature measurements are made at various depths. Beginning in February 1962, drift bottles and seabed drifters have been released.



Station pattern for 1961 cruises between Galveston, Tex., and Cameron, La.

The seabed drifter is a plastic umbrellalike device that barely maintains itself on the bottom, which it touches lightly by the tip of the "handle." Even very small water movements will cause it to drift along the bottom.



Station pattern adopted in January 1962 for the expanded shrimp program.

The research cruises are providing information on distribution and extent of spawning of commercial as well as associated noncommercial species of shrimp, according to season and area. The same information is also being obtained for the larval stages. Closely allied to the latter study is the shrimp larval identification project which successfully reared three more species of shrimp to the protozoea stage.

In addition to expanding the offshore aspects of the program, mark and recapture experiments designed to obtain information on movements, growth, and fishing mortality of offshore stocks of commercially exploited shrimp were begun. Three experiments were completed. Pink shrimp were marked with biological dyes on the Tortugas grounds in September 1961 and on the Sanibel grounds in April 1962. A similar marking experiment on brown shrimp (*Penaeus aztecus*) was completed off the central Texas coast in April 1962. Using data from the Tortugas study, it has been possible to make the first estimates of fishing mortality of a commercial shrimp population. Excellent growth rate information was also obtained.

The commercial fisheries statistics obtained by the Branch of Statistics are now being supplemented by biologists sampling the commercial shrimp catch for species and size composition at selected Gulf ports.

In 1961, there was a 35-percent drop from 1960 in poundage of shrimp landed in the South Atlantic and Gulf states. Much of the industry was in distress and seeking assistance regarding the future of the fishery. In early 1962, enough information on various aspects of the brown shrimp life history was available to make a prediction for improved shrimp prospects during the 1962 season.

This prediction was based on comparable measures of shrimp abundance obtained since 1959. Indexes of abundance were obtained for postlarvae at the Galveston entrance and for juvenile shrimp from the Galveston Bay commercial bait fishery statistics. In 1960 and 1961, a strong correlation was obtained between the postlarval and juvenile indexes and the subsequent catch of commercial-size shrimp.

In 1962, the postlarvae and juvenile indexes for the February-April period were similar to those of the good offshore fishing year of 1960. Bait shrimp (juvenile) production in May 1962 was the highest ever recorded for that month.

Primarily on the basis of these observations, good to excellent fishing was predicted for the 1962 season.

Spawning Populations

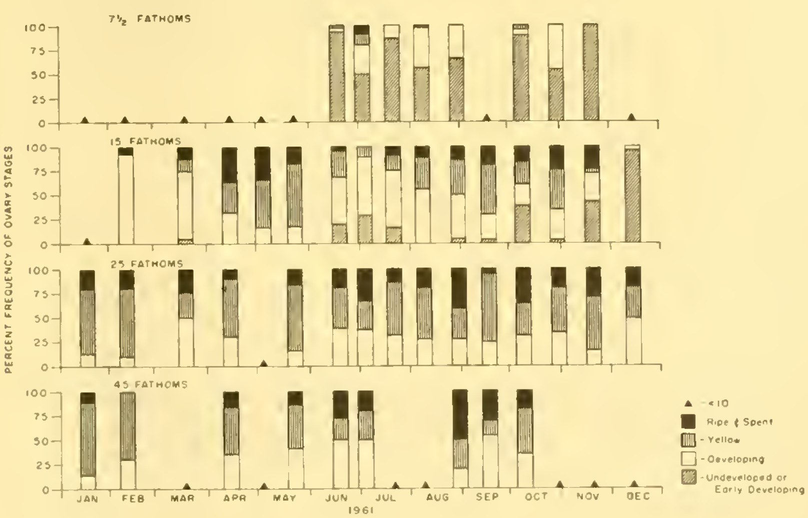
William C. Renfro and Harold A. Brusher

During 1961, 17 cruises were made in the area between Galveston, Tex., and Cameron, La., to as far as 100 miles offshore. At each of the 11 stations in the area, a 45-foot shrimp trawl was towed for 1 hour. Penaeid shrimps taken were counted, sexed, and measured, and predetermined numbers of females of each species were dissected to obtain samples of ovary tissue. Ovary samples were fixed in Bouin's solution and returned to the laboratory where they were prepared as stained slide mounts. Cytological examination of all brown shrimp (*Penaeus aztecus*) ovary sections to determine stage of ovary development was recently completed.

Of 1,374 brown shrimp ovary sections examined, 262 are from small females less than 140 mm. total length. The ovaries of most (73%) of these smaller specimens are either undeveloped or in very early stages of development. Less than 10 percent are in the "yellow" or more advanced stages of development.

"Developing" and "yellow" stage ovaries are most prevalent (79%) in females 140 mm. or larger, indicating that these two stages consume most of the time in the process of ova maturation. Less than 3 percent of the larger females sampled were undeveloped or in early developmental stages. This suggests that there is no "resting" or "dormant" stage in this species. Apparently in this area, once a brown shrimp female reaches sexual maturity, ova generation and maturation continue unabated throughout the remainder of her life.

Very few brown shrimp were found at the $7\frac{1}{2}$-fathom stations during the first 5 months of 1961. In June, small shrimp began to move offshore from the estuarine nursery grounds. Almost all females taken in $7\frac{1}{2}$ fathoms from June through December were small with "undeveloped" or "early developing" ovaries. There was little evidence for spawning of brown shrimp in $7\frac{1}{2}$ fathoms.

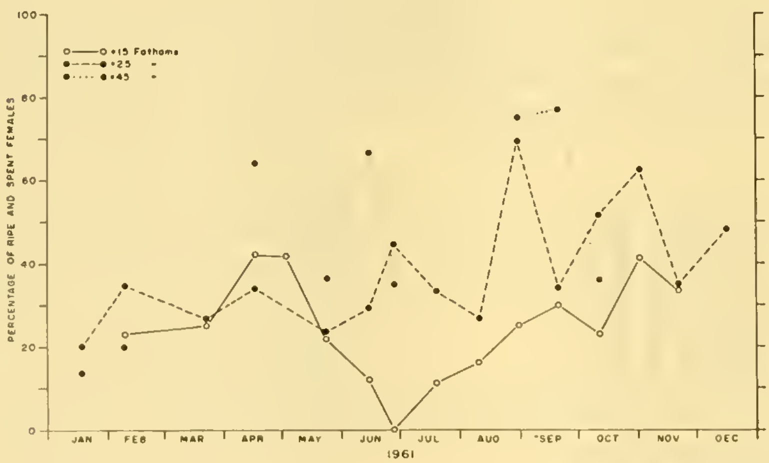


The spawning condition of brown shrimp collected during 1961 between Galveston, Tex., and Cameron, La.

Females found at the 15-fathom stations from June through December were of two sizes, either small with immature ovaries or larger, more mature specimens. Females from the deeper stations (25 and 45 fathoms) were consistently larger and in advanced stages of ovary development.

The presence in an ovary of (1) ripe ova undergoing resorption, (2) cell components remaining after ripe ova had been resorbed, and/or (3) abnormally large numbers of follicle cells is taken as evidence of prior spawning. By use of these criteria, many females classified as "developing" or "yellow" are also classified as having previously spawned.

Females with ripe and spent ovaries or which had previously spawned were found in one or more depth zones during every cruise. The percentage of ripe and spent females in the 15-fathom depth zone was greatest from mid-April to early May and during November. The highest percentages of ripe and spent ovaries occurred at the 25-fathom stations in February, April, from late June to late July, and from late August through mid-December. In the 45-fathom depth zones, the percentage of ripe and spent females was highest in mid-April, from late May through June, and from late August through early October.



The percentage of ripe and spent brown shrimp in the 1961 samples.

In addition to determining the spawning condition of the offshore shrimp populations, we also obtained data on abundance, distribution, size, and species composition.

In September 1961, four transects of six stations each were added to the original 1961 sampling patterns. Two of these were located to the west of the Freeport, Tex.-Cameron, La., sampling area, and two were located to the east. Data for population characteristics other than spawning conditions from these transects as well as from the original pattern have all been analyzed.

During the 24 cruises made between January 1961 and January 1962, 246 1-hour trawl samples were taken. Eleven species of penaeid shrimp were taken, although 97 percent of the total catch was made up of only five species, i.e., brown shrimp, white shrimp (Penaeus setiferus), rock shrimp (Sicyonia brevirostris and S. dorsalis), and Trachypeneus similis. The large number (10,880) of one species of rock shrimp, S. brevirostris, suggests this penaeid may be present in sufficient quantities to support a commercial fishery.

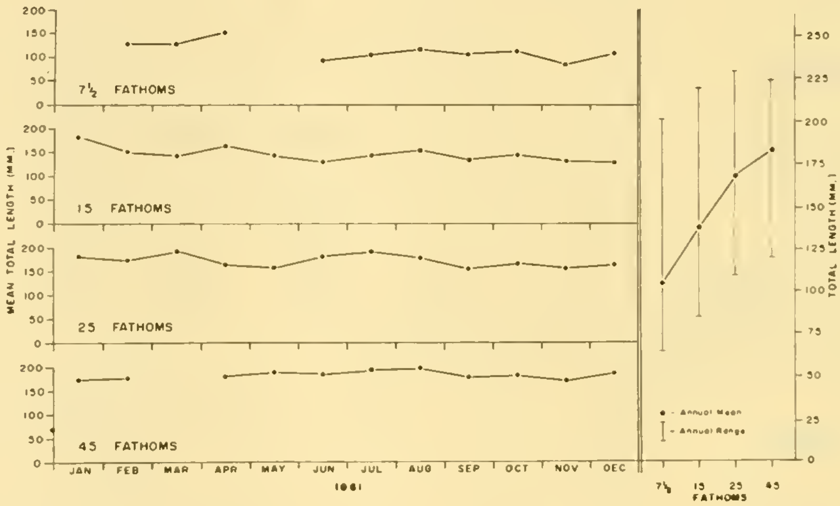
Numbers of shrimp caught, according to species and depth range taken in 246 1-hour tows made between January 1961 and January 1962

Species	Fathoms						
	7½	15	25	35	45	60	Total
Penaeus aztecus	1,828	4,019	4,212	1,414	1,442	185	13,100
Penaeus setiferus	7,988	378					8,366
Penaeus duorarum	73	342					415
Sicyonia brevirostris	594	5,798	3,155	1,072	261		10,880
Sicyonia dorsalis	38	4,173	798	1,511	349		6,869
Trachypeneus similis	1,914	1,280	87	300	64		3,645
Trachypenaeus constrictus	39	27					66
Solenocera vioscai			3	8	213	54	278
Solenocera atlantidis		9					9
Xiphopeneus krøyeri	446	1					447
Parapenaeus longirostris			1		3	1	5
Total of all species	12,920	16,027	8,256	4,305	2,332	240	44,080
Number of tows	76	62	44	12	42	10	246

The three species of commercial shrimps (brown, white, and pink) made up 50 percent of the total catch. Their abundance, distribution, and size have been compared with several oceanographic characteristics. The center of abundance for these three commercial shrimps is in the western transects southeast of the Freeport-Pass Cavallo area.

The greatest number of brown shrimp (63%) is taken in the 15- to 25-fathom range. Almost all of the white shrimp (99%) are taken at the $7\frac{1}{2}$-fathom stations. Pink shrimp, although taken in small numbers, occur only at the $7\frac{1}{2}$- and 15-fathom stations.

Large numbers of juvenile brown and white shrimp in the offshore fishery at the $7\frac{1}{2}$-fathom stations in the western transects suggest the importance of the Galveston-Matagorda Bay complex as nursery grounds.

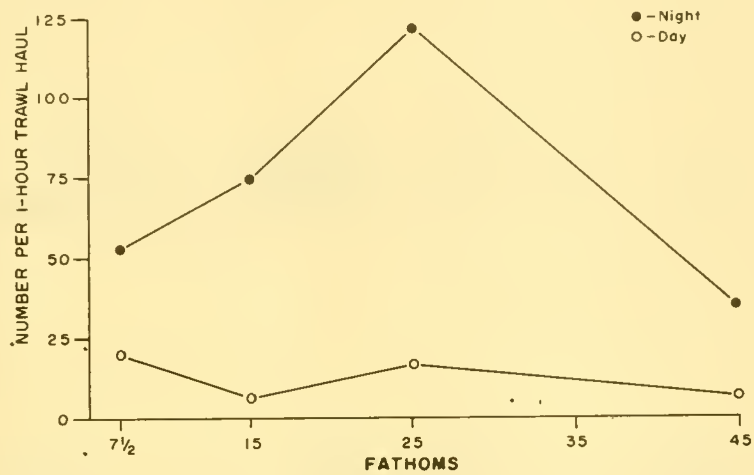


Size range of brown shrimp in 1961
according to depth and month.

Brown shrimp increase in average size with increase in station depth. The time of offshore movement for juvenile brown shrimp is indicated by a sharp increase in catches of small immature brown shrimp at the $7\frac{1}{2}$-fathom stations in June. This movement apparently continues until December. The catches of brown shrimp at the $7\frac{1}{2}$-fathom stations are small from January through May, but the individuals are consistently larger.

Nearly all of the white shrimp are taken at the $7\frac{1}{2}$-fathom stations, so no comparison with depth zones is possible. There is, however, an evident seasonal variation in size caused by the migration of juvenile white shrimp from estuarine nursery areas to the offshore grounds. This is first evident in September and again from December through January, after which an increase in average size is evident until August.

Day/night comparisons show a definite catch increase for brown shrimp at night at all depths, while the greatest catches of white shrimp were taken in day trawls.



Comparisons of day and night catch per unit of fishing effort for brown shrimp between Galveston, Tex., and Cameron, La., in 1961.

Based on the examination of 21,466 shrimp of commercial importance, the sex ratios for both white and brown shrimp show a 1:1 relationship which is relatively constant at all depths sampled.

Larval Distribution and Abundance

Robert F. Temple

The examination of the plankton samples from 17 cruises made during 1961 in the offshore areas between Galveston, Tex., and Cameron, La., is completed. At each of the 11 stations in this area a 20-minute, "step-oblique" plankton tow was made with a Gulf V plankton sampler. These samples are used in studying the early life history of shrimp, particularly the distribution, abundance, and survival rate of larvae. Eggs are not found in the samples, but the occurrence of the nauplius, the first stage after hatching, can be used as an indication of spawning.

Commercially important shrimp, genus Penaeus, comprised 18 percent of the total catch of 14,218 larvae of the family Penaeidae, while non-exploited shrimp of the genera Trachypeneus, Sicyonia, Solenocera, Parapenaeus, and Xiphopeneus constituted the remaining 82 percent. All larvae have been identified, and their seasonal and areal distribution and abundance tabulated and graphed.

The majority of larvae, genus Penaeus, were caught at $7\frac{1}{2}$-fathom stations between May and October. Larval abundance was greatest in July and August. Spawning, based on the occurrence of nauplii, began in May and continued until October. The seasonal distribution of larvae coincides closely with changes in bottom temperatures. Indications are that Penaeus in this depth zone spawns at temperatures over 75° F.

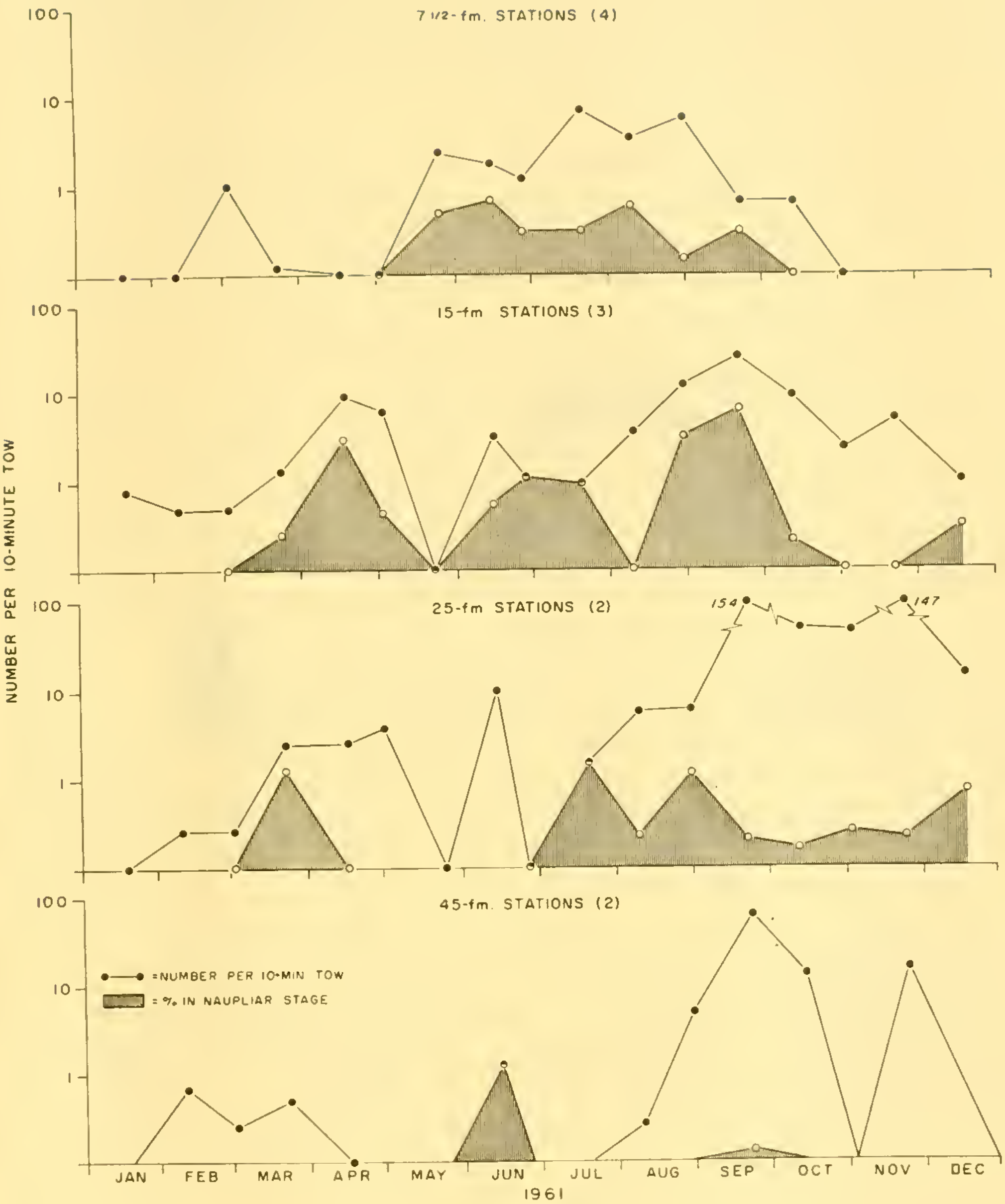
Average monthly bottom temperatures (° F.) for $7\frac{1}{2}$-fathom stations

March	April	May	June	July	August	September	October	November
62.6°	66.6°	76.1°	80.5°	83.4°	82.6°	80.6°	77.3°	65.4°

Penaeus larvae of one stage or another were taken every month of the year at the 15-fathom stations. Two general peaks of abundance were noted in April and September. Three distinct periods of spawning, indicated by the occurrence of nauplii, were evident at 15-fathom stations: the first in April, the second the last of June and first of July, and the third in September. The highest level of abundance, observed in September, was approximately three times greater than any peak noted at the $7\frac{1}{2}$-fathom stations.

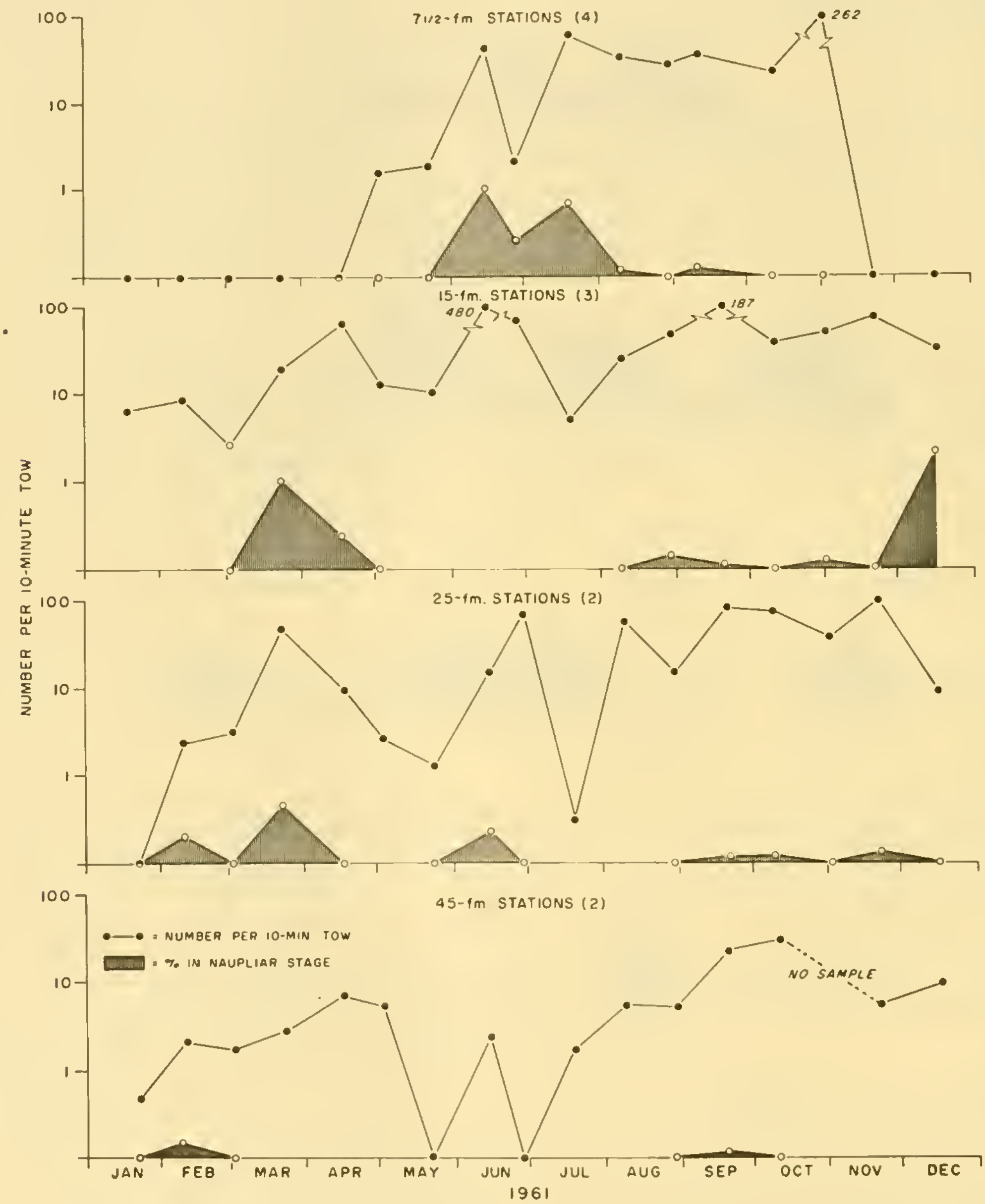
Penaeus larvae were more abundant at 25 fathoms than at any other depth. In the first 8 months, January to August, the abundance of larvae increased, with the greatest level of abundance occurring from September through November. Spawning at this depth first occurred in May. Additional spawning, although in varying degrees of intensity, was evident from July through December.

At the 45-fathom stations, larvae were taken sporadically throughout the sampling period. The highest level of abundance was observed in September. Nauplii, although not abundant, occurred in June and September.



The distribution of Penaeus larvae in the offshore area between Galveston, Tex., and Cameron, La., in 1961.

Distribution and Abundance of Nonexploited Species Larval Penaeidae of genera other than Penaeus were not encountered at the $7\frac{1}{2}$-fathom stations until the middle of May. In the ensuing months they persisted at this depth, fluctuating slightly in abundance until the first of November, when they reached their highest level of abundance. Immediately thereafter they disappeared. Spawning in the $7\frac{1}{2}$-fathom zone appears to have begun the latter part of May and continued until the first of October. Nauplii are most abundant, however, in June and July.



The distribution of non-Penaeus larvae in the offshore area between Galveston, Tex., and Cameron, La., in 1961.

The seasonal distribution and abundance vary considerably at the 15-fathom stations from those at the shallower stations. The larvae of one stage or another of the nonexploited shrimp were present throughout the entire year, although in varying degrees of abundance. Two peaks of abundance are noted: one in June and the other in September. Nauplii are most prevalent in March and the first of December.

The level of abundance of penaeid larvae at 25 fathoms fluctuated radically from February to July. Two peaks of abundance are evident: one in March and another in June. In the ensuing months, August through November, a level of abundance similar to that of March and June was reached and maintained until November. In December, there was a sharp decline in the abundance of larvae. Nauplii were caught sporadically over the entire sampling period with the greatest abundance in March. The overall larval abundance in this depth zone was not as great as at 15 fathoms, however.

At the 45-fathom stations the peaks of abundance occurred in April and October. Larvae are less abundant, however, than at shallower stations. The few nauplii taken at this depth were taken in February and September.

Penaeus larvae of one stage or another were present the entire year at 15-, 25-, and 45-fathom stations. The majority of larvae at $7\frac{1}{2}$-fathom stations, however, were caught between April and November. Indications are that temperatures have a direct effect on the seasonal occurrence of *Penaeus* larvae at the $7\frac{1}{2}$-fathom stations. The highest level of abundance was at 25-fathom stations between September and November.

All larval stages of *Penaeus* were most abundant at 25-fathom stations. Nauplii at 15- and 25-fathom stations were 3 to 16 times more abundant than at either $7\frac{1}{2}$- or 45-fathom stations. Protozoeae at 25-fathom stations were the most abundant larval stage encountered. It would appear that larvae at 25 fathoms are probably either *Penaeus aztecus* or *P. duorarum,* since *P. setiferus,* very seldom inhabit these depths.

Annual catch per standard tow of larvae of exploited shrimp

Station depth	Nauplii	Protozoeae	Mysis stages	Postlarvae
fm.	Number	Number	Number	Number
$7\frac{1}{2}$	.51	.52	.40	.23
15	1.57	.79	.60	.71
25	2.30	15.23	2.13	1.89
45	.15	4.41	.52	1.45

Larvae of one stage or another of nonexploited shrimp are present the entire year at 15-, 25-, and 45-fathom stations, although in varying degrees of abundance. The occurrence of larvae at the $7\frac{1}{2}$-fathom stations appears seasonal, inasmuch as larvae were taken only between May and November. As was the case in *Penaeus* larvae, a direct correlation is evident between the seasonal occurrence of larvae and increasing bottom temperatures.

All larval stages, except the nauplial stage, were more abundant at 15-fathom stations. Nauplii were more abundant at $7\frac{1}{2}$- and 15-fathom stations. Protozoeae at 15-fathom stations were the most abundant larval stages encountered. The larvae encountered at 45-fathom stations were deep-water shrimp, i.e., *Solenocera* and *Parapenaeus*.

Annual catch per standard tow of larvae of nonexploited shrimp

Station depth	Nauplii	Protozoeae	Mysis stages	Postlarvae
fm.	Number	Number	Number	Number
$7\frac{1}{2}$	2.33	13.05	7.95	.40
15	2.26	34.45	28.16	2.57
25	1.08	12.31	13.86	.55
45	.08	3.44	2.61	.03

Currents on the Continental Shelf of the Northwestern Gulf of Mexico

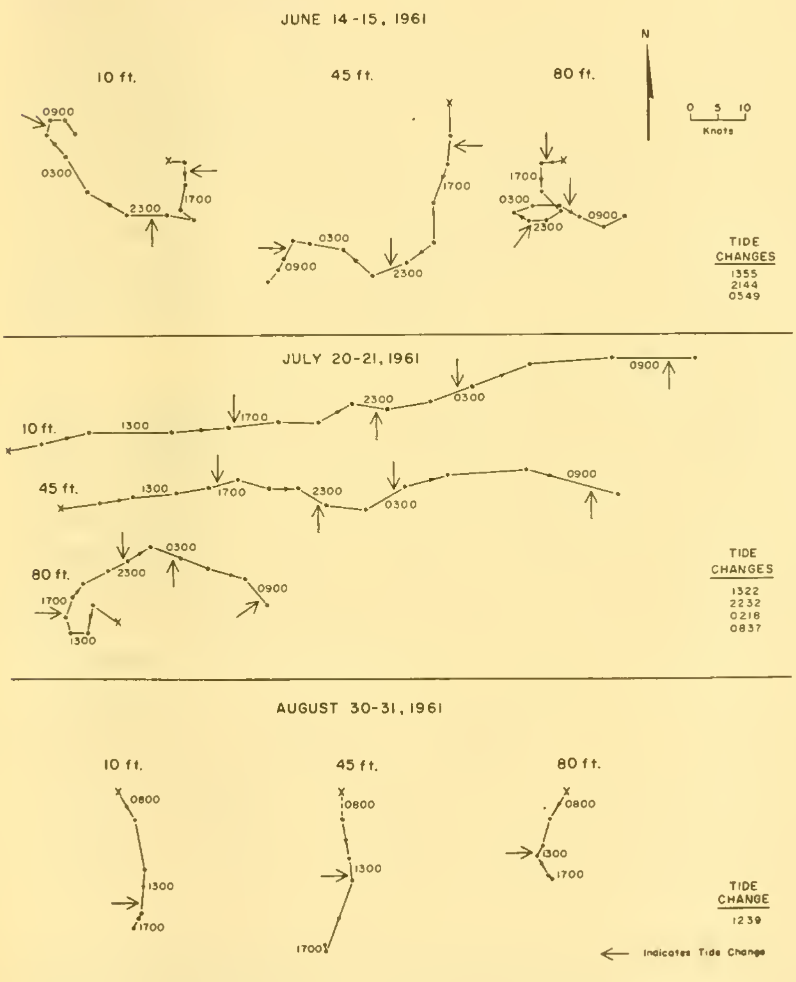
J. Bruce Kimsey and Robert F. Temple

The three commercially important species of shrimp, i. e., brown (Penaeus aztecus), white (P. setiferus), and pink (P. duorarum), all spawn offshore where the eggs hatch. This may occur at distances ranging from a few miles to as much as 150 miles offshore and at depths down to 60 fathoms. The larvae move shoreward while passing through a series of developmental stages, arriving at the passes into the bays and estuaries as postlarvae. It is not known whether the shoreward migration is aided by water currents or the larvae arrive under their own power with no outside aid.

A study to determine the role water currents play in the movement of larvae from offshore spawning grounds to the inshore nursery grounds has been a part of the Shrimp Fishery Program since 1961 when the Savonius rotor current meter was first used.

Analysis of current data collected with this current meter during April through October 1961 has been completed. The data were obtained by taking instantaneous readings every 3 weeks at 11 stations in waters adjacent to Galveston. Station depth ranged from $7\frac{1}{2}$ to 45 fathoms. At each station, current observations were made at 10 feet below the surface, mid-depth, and 10 feet from the bottom. To complement these data, three 24-hour current studies were undertaken at one 15-fathom station (Station "H").

In an attempt to obtain a generalized current pattern from the instantaneous monthly observations, current roses were constructed for each station and depth. Although the results are not conclusive, indications are



Progressive vector analysis of 24-hour current observations made at a 15-fathom station off Galveston, Tex.

that (1) currents decrease in velocity with an increase in depth, (2) the strongest longshore currents occur at the $7\frac{1}{2}$-fathom stations located off Galveston and San Luis Pass, and (3) although a few 2-knot currents were observed, the majority were less than 1 knot at all stations.

The purpose of the 24-hour current studies conducted in June, July, and August at Station H were twofold: (1) to check the validity of the instantaneous monthly readings and (2) to measure the residual current and determine, if possible, the influencing factors. Analysis of the first 24-hour current study substantiated the belief that instantaneous readings, although measuring the direction and speed of the current at that time, could conceivably result in an erroneous concept of the residual current.

Further analysis of the data indicated that if continuous monthly observations could be made at a permanent station, a residual monthly current pattern could be established. It should then be possible to relate existing residual currents directly to some physical factors, such as water density, winds, or tides.

Progressive vector analysis of the currents at three depths during the June study revealed a wide current variation between depths. The vector diagrams for the surface and bottom currents strongly suggest currents influenced by tidal action. Some discrepancies exist, however, between the noted changes at Station H and the tidal gauge at the Galveston Channel. The distance between these two points (48 nautical miles) probably accounts for these anomalies. Mid-depth currents (45 feet) appeared to be less subject to these tidal changes. The resultant currents at the three depths were variable. The current at 10 feet was moving 287° at 1.7 knots, the 45-foot current flowing 226° at 4.4 knots, and the 80-foot current flowing 133° at 1.5 knots. During this period, a 10-knot southeast wind prevailed.

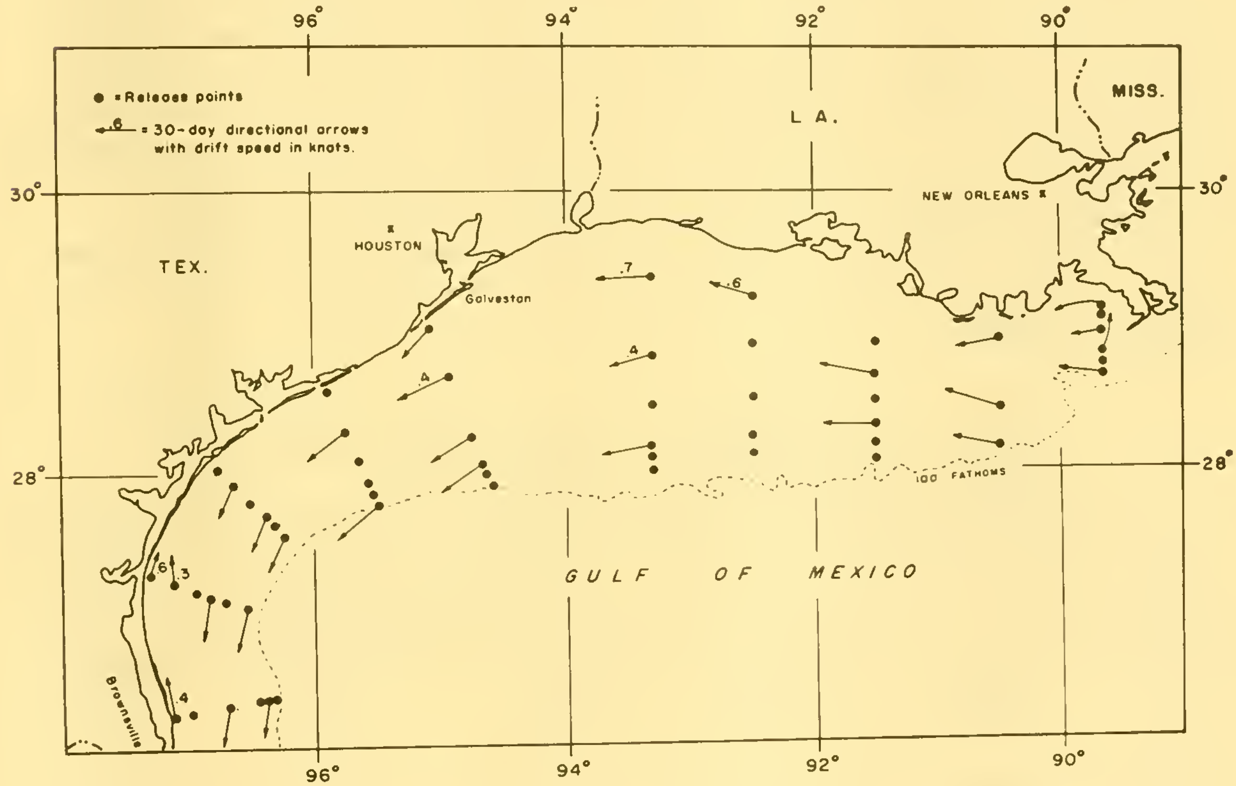
In the July and August studies, the variations noted in June were not evident. In July, all depths exhibited an easterly current with the velocity decreasing as depth increased. Prior to the July observations, a south to southeast wind averaging 11 knots had prevailed for 8 days. The water currents, moving to the right of this force, were probably a direct result of these winds.

The curtailed August observations revealed a similar picture. Currents at all three depths, flowing southerly, appear to be the result of a north to northeast wind averaging 10 knots which had prevailed for 6 days prior to the observations.

From these limited data, it is impossible to establish a monthly current pattern for either June, July, or August. Utilizing climatological data and Galveston Channel tide tables, however, we could detect relationship between observed currents during a 24-hour period, winds, and tides. Indications were that currents 48 nautical miles south of Galveston are influenced by tide and wind action.

In February 1962, the current study utilizing the Savonius rotor current meter was expanded by the addition of drift bottles and seabed drifters. Twelve drift bottles, six of which are ballasted with sand, and six seabed drifters are released at each of the 60 monthly stations.

Because they are more influenced by winds, the nonballasted bottles reach the shore more quickly than the ballasted bottles. The rate of drift is determined from the bottles with the shortest period of drift. Onshore winds tend to accelerate the rate, while offshore winds, which are more common in the winter, slow the shoreward movement. The rate of drift bottle return decreases during poor weather when few people frequent the beaches and markedly accelerates during the tourist season. The unusually large influx of Sargassum weed on the north Gulf coast in the spring of 1962 covered bottles and discouraged beach use. These factors, together with other more subtle influences, make the calculation of current velocities from drift bottles alone somewhat tentative. The instantaneous measurement of current velocity with the Savonius rotor current meter should strengthen the drift bottle data.



Surface drift on the continental shelf of the Gulf of Mexico in February 1962 as deduced from drift bottle releases.

In February 1962, the direction of surface drift over the continental shelf in the northwestern Gulf of Mexico was generally westerly, ranging in rate from 0.4 to 0.7 knots. An easterly drift of 0.3 to 0.6 knots was observed between Brownsville and St. Joseph Island, Tex. The higher rate is near the shore. There are indications of a large clockwise circulation developing in the vicinity of Port Aransas. Returns for the months of March through June tend to corroborate this impression, but its exact nature is not yet clear. A second smaller eddy apparently exists in the area off Grand Isle, La.

The seabed drifter previously described is a plastic umbrellalike device that barely maintains itself on the bottom, so that even very small water movements will cause it to drift along the bottom. It is largely dependent for its return, therefore, upon capture in shrimp trawls, although many liberated at inshore stations have been found on the beach. Their rate of return, except for the beach finds, is closely related to fishing effort, which varies extensively according to time and area, causing returns from this source to be slow and erratic. Shrimp trawlers in the Gulf of Mexico carry a minimum of navigation equipment, and the location of the return is often too vague to be of use. Despite these limitations, some useful information has been obtained. During February 1962, bottom drift, based on 16 returns, was generally easterly or opposite to surface drift except in the area off Grand Isle, La., where the bottom drift was northerly or westerly.

The direct measurement of water movements by drift bottles and seabed drifters is continuing; indirect measurement by analysis of density currents is planned.

Comparison of returns for ballasted and nonballasted drift bottles as of July 1, 1962

Month of release	Released	Returned	Composition of returns		Possible days out
			Ballasted	Nonballasted	
	Number	Number	Percent	Percent	Number
Feb.	720	108	40.6	59.4	123-132
Mar.	720	213	41.8	58.2	95-102
Apr.	720	135	29.6	70.4	65-73
May	720	62	25.8	74.2	39-43
June	720	16	18.9	81.1	7-12

Number of drift bottles returned as of July 1, 1962

Month of release	Released	Returned			
		Days out			
		0-30	31-60	61-90	91-129
	Number	Number	Number	Number	Number
Feb.	720	37	20	30	21
Mar.	720	78	59	65	11
Apr.	720	70	57	8	
May	720	38	24		
June	720	16			

Number of seabed drifters returned as of July 1, 1962

Month of release	Released	Returned			
		Days out			
		0-30	31-60	61-90	91-129
	Number	Number	Number	Number	Number
Feb.	360	6	6	3	1
Mar.	360	14	6	5	2
Apr.	360	25	14	6	
May	360	2	4		
June	360	1			

Identification of Shrimp Larvae

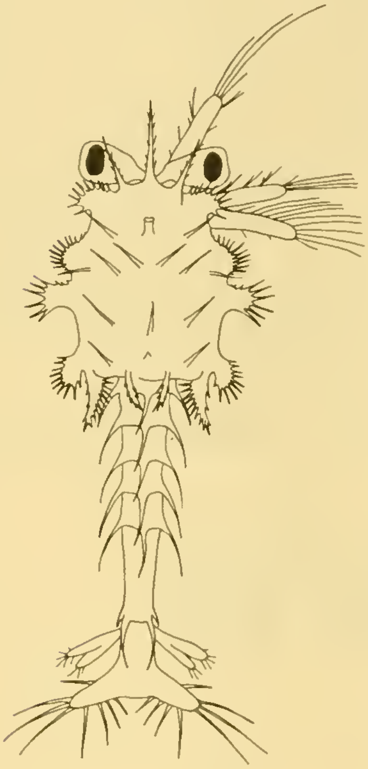
Harry L. Cook

An illustrated key to the genera of penaeid larvae found in the northwestern Gulf of Mexico was completed. We were able to assign to genera the reference specimens taken from plankton samples by comparing them with larvae obtained from rearing trials as well as with illustrations in the literature. Solenocera and Parapenaeus mysis and postlarval stages, missing from routine plankton samples, were obtained during a special cruise of the M/V SILVER BAY off the mouth of the Mississippi River.

The key is in two parts. The first, designed mainly for those unfamiliar with penaeid larvae, distinguishes penaeid larvae from the more prevalent forms of nonpenaeids found in the plankton samples. It also defines the stages of penaeid larvae. Five nauplial, three protozoeal, and three mysis stages were the general rule, except for Solenocera and Parapenaeus, which have more than three mysis stages.

The second part deals with the genus identification of the protozoeal, mysis, and postlarval stages of the littoral penaeidae of the northwestern Gulf of Mexico. The key includes illustrations of Parapenaeus, Penaeus, Sicyonia, Solenocera, Trachypeneus, and Xiphopeneus and is now being tested in the laboratory.

Considerable effort was spent to differentiate the species of larval Penaeus. As the most accurate way to do this is by examining larvae of known parentage, special short cruises were made to catch ripe females that would spawn in the laboratory. The efforts were successful, and from females that spawned in the recirculating sea-water system, larvae were reared through Protozoea I for Penaeus aztecus, Sicyonia brevirostris, and Trachypeneus similis. Most of the larvae preserved were in good condition, and sufficient material was obtained for detailed descriptions.



Protozoea III of Solenocera sp., dorsal view. (Left anterior appendages not shown.)

In conjunction with the rearing trials, experiments were made with temperature control, rearing media, and food. It appears that temperatures above 23° C. are required for optimum growth in the laboratory. Larvae reared at temperatures of 24° and 28° C. were very active and developed rapidly. Those reared below 23° C. grew slowly and showed little movement, all dying before reaching the first protozoeal stage. Brown shrimp (*P. aztecus*) eggs spawned at 22.5° C., hatched slowly, and even though the temperature was raised to 23.5° C. prior to hatching, the larvae were never as robust as larvae of *S. brevirostris* and *T. similis*, hatching at 24° C. Brown shrimp nauplii that were active at 23.5° C. ceased all movement when the temperature was lowered to 22.5° C. After the temperature was raised to 25.5° C., they again became active.

No optimum temperature was noted for brown shrimp larvae. Larvae of *S. brevirostris* did best at 24° C., and those of *T. similis* at 28° C.

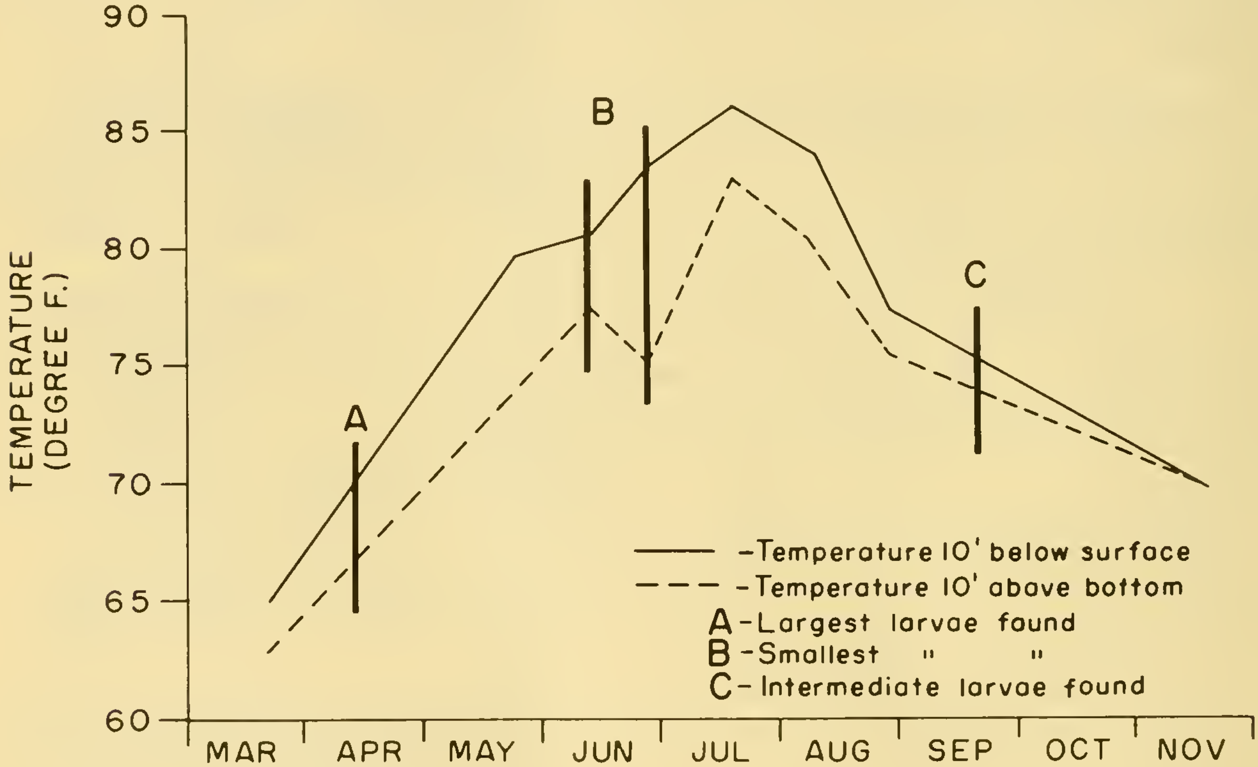
Temperatures that yielded the best results in the laboratory were higher than those in the area of the Gulf where the females were taken. Temperatures in the Gulf ranged from 20.5° C. at the bottom to 22.0° C. at the surface.

Miquel's sea water with soil extract added was found to be a more satisfactory rearing medium than natural sea water. Although, in some instances, the total number of larvae reaching Protozoea I was the same in the natural sea-water control, the larvae in the Miquel's were always more active with more setae. It appears that though nauplii do not actively feed, they do utilize some nutrients in the water.

Efforts to supply a suitable food for the larvae have been unsucessful. Protozoea I were introduced into cultures of unidentified diatoms and protozoans. Several of the larvae exhibited trails of fecal material, indicating feeding had occurred, but none molted to Protozoea II. A primary difficulty is the lack of live specimens to experiment with. In order to secure living protozoeal and mysis stages, live plankton was brought to the laboratory. The penaeid larvae obtained were alive and active. Other organisms in the plankton included carid, sergestid, and mysid larvae, some of which were isolated along with the penaeid larvae. While the nonpenaeid larvae fed and underwent several molts, the penaeid larvae did not appear to feed and died before molting to the next stage.

In an effort to find characteristics for separating *Sicyonia dorsalis* from *S. brevirostris*, we examined and measured 413 *Sicyonia* protozoeae and mysis stages from plankton samples. Slight morphological differences were noted in the protozoeal stages only. The protozoeae were separated into two groups by a difference in the pigmentation of the eyes and by the presence or absence of musculature in the rounded lobe, which is the anteriormost portion of the body. A size difference was also apparent between the two groups of larvae. Comparison with larvae reared in the laboratory proved one group to be *S. brevirostris*. The other group is assigned to *S. dorsalis*, the only other member of the genus which maintains a sizable adult population within the sampling area.

Larvae from five different cruises representing three major concentrations of larvae were examined. A seasonal variation in size was observed. Larvae taken in March and April were the largest, the June group smallest, and those in September were intermediate. The difference in size was not due to these groups being composed of different species, since the morphological differences noted previously were found in each group and compensated for. There seems to be, then, a seasonal variation in size, which can in turn be correlated to temperature. When the temperature is low, the larger larvae are encountered, and when the temperature is high, the smallest larvae are found.

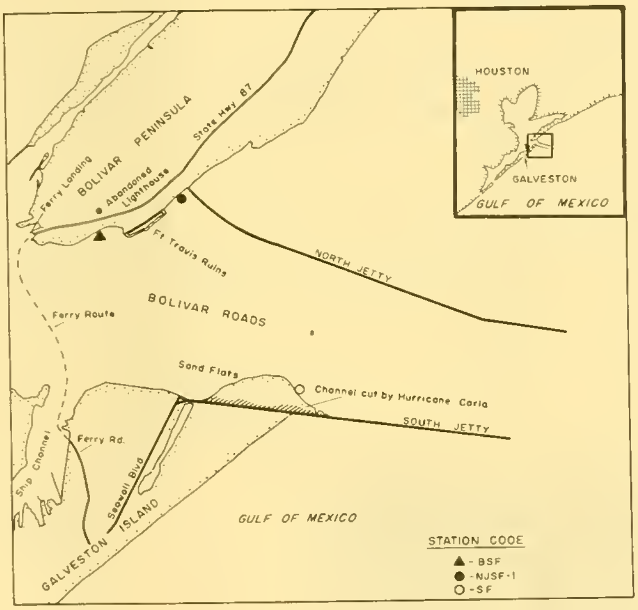


The relationship between larvae size and bottom temperatures.

Abundance of Juvenile Shrimp

Kenneth N. Baxter

To obtain a possible index of later abundance of adult shrimp, the monitoring of the passage of postlarval shrimp into Galveston Bay was begun November 1959. Samples are taken semiweekly using a hand-drawn, beam trawl fitted with a plankton net in the cod end. A station was established inside the entrance to Bolivar Roads near the south jetty on the sand flats (SF on figure). Samples were taken at this station from November 1959 to May 1961 and from August 11, 1961, until September 8, when flood waters from Hurricane Carla cut a channel 200 feet wide and 14 feet deep through the sand flats adjacent to the jetty, making the station site inaccessible. A new monitoring station was then located on Bolivar Peninsula in a cove off State Highway 87 opposite the abandoned lighthouse (BSF on figure). This station was occupied from September 25 to November 21 of 1961, when a third station site was selected on the beach, midway between the north jetty and the Fort Travis ruins on Bolivar Peninsula (NJSF-1 on figure), where twice weekly sampling is currently being carried on.



Postlarval sampling stations at the entrance to Galveston Bay.

The sample is taken in the following manner. A stake is driven into the ground at the shoreline. A 150-foot nylon cord is attached to the stake and stretched taut parallel to the waterline. Using the cord as a constant radius, the operator pulls the net assembly along the bottom in a half circle. The effective length of the tow is 426 feet, the volume of water sampled is 2,477 cubic feet, and the area of bottom traversed is 1,958 square feet. These are average measurements and vary according to the shoreline's configuration.

Through the winter months, great variations in numbers of postlarvae between sampling periods appeared to be related to fluctuations in temperature. Following rapid drops in temperature, very few postlarvae were collected, and on several occasions numbers of dead postlarval penaeids were noted. For instance, on March 1, 1962, about 75 dead postlarvae were found in the sample. This was after a drop in air temperature to below 35° F. the previous night. On March 12, 1962, nearly 500 dead postlarvae were found in the sample following a similar drop in temperature. Between January 1961 and June 1962, water temperatures ranged from -2.0° to 34.0° C. Although salinities ranged from 7.6‰ to 31.4‰ during the same period, there was no apparent correlation between salinities and the number of postlarvae present.

The bait shrimp industry of the Galveston Bay system is of considerable economic importance. This phase of the shrimp fishery has grown rapidly since the first survey was begun November 1956. Production has increased from 225,000 pounds reported by Chin for June 1957 to April 1958 to an estimated 943,400 pounds in 1960 and 731,200 pounds in 1961.

The number of active bait dealers decreased from 130 in May 1961 to 92 in May 1962. Many bait camps and bait boats were destroyed in September 1961 by Hurricane Carla. Approximately 20 percent have not been replaced.

In 1961, for the first time in 6 years, bait shrimp were available continuously through the winter. During the winter of 1962, however, very little bait shrimp was taken from the area. This is believed to be due primarily to unusually low temperatures during the first quarter of 1962. Most of the bait retailed in the Galveston area during this period was trucked in from Matagorda Bay and Sabine Lake.

The annual bait shrimp catch for 1961 consisted of approximately 60 percent white and 40 percent brown shrimp.

The occurrence of pink shrimp and *Trachypeneus* sp. was limited, neither accounting for more than 2 percent of the catch during any given month.

March and April	Tows	Postlarvae taken		May catch/effort for brown bait shrimp
		Total	Per tow	
	Number	Number	Number	Pounds per hour
1960	17	9,908	582.8	29.8
1961	15	429	28.6	18.3
1962	16	4,246	265.4	30.4

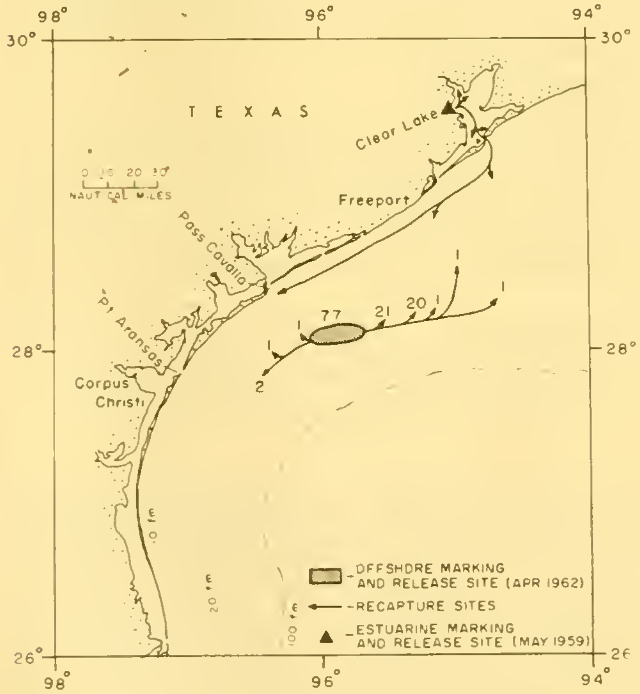
Sampling postlarvae with a small beam trawl.

Brown Shrimp Mortality Studies

Edward F. Klima

A mark-recapture experiment on brown shrimp, *Penaeus aztecus*, initiated during April 1962 is expected to yield preliminary estimates of fishing mortality and information on movement of the stocks of shrimp off the Texas coast. Over 2,400 shrimp were caught, stained with fast green FCF, and released in a 100-square-mile area ranging from 21 to 24 fathoms southeast of Pass Cavallo. Reports from the statistical branch of the Bureau of Commercial Fisheries indicate that this area was the most heavily fished section along the Texas coast in April 1962.

In addition, about 1,700 shrimp were tagged with Petersen disc tags, and released in the same depth range south of Port Aransas and southeast of Freeport. To obtain reliable estimates of fishing mortality, it is necessary to be able to roughly define the population. Since little is known concerning the movement and the population structure of brown shrimp in the northwestern Gulf, the stained shrimp were released in the area of the heaviest fishing concentration, and the tagged shrimp were released in adjacent areas. Any movement into or out of the staining area should be evident, and some idea of the population structure will be obtained.



Direction and distance of movement of brown shrimp marked in April 1962.

Because of the nonspecific stain mark and the large area of release, it is not possible to determine the exact distance traveled for any given recovered individual. To minimize this difficulty, the center of the staining area is considered to be the point of release for all of the stained shrimp. One hundred and twenty-five stained and eight tagged shrimp were recovered through June 6, 1962. Sixty-two percent of all of the recoveries were recaptured less than 15 miles from the release areas. These shrimp appeared to have moved randomly, because approximately equal numbers were recovered in all directions from the release position. Fifty marked shrimp traveled more than 15 miles. Of these, 46 moved in an easterly direction, while 4 moved in a westerly direction.

Thirty-three shrimp were recaptured in water shallower (16 to 19 fathoms) than in the release areas; no shrimp were recaptured in deeper water.

The information obtained from the return of marked shrimp indicates no immigration into and little long-distance movement out of the staining area. The stocks of shrimp off Pass Cavallo appear to have made a short-distance movement in an easterly direction. Since marked shrimp are still being returned, and the catch and effort data are not yet available, no attempt has been made to estimate fishing mortality.

Shrimp recovered			Distance moved from release area
General direction of movement			
Easterly	Westerly	Total	
Number	Number	Number	Nautical miles
38	45	83	15 or less
41	2	43	16 - 30
2	2	4	31 - 45
2	0	2	46 - 60
1	0	1	61 - 75
84	49	133	

Seabed drifters, which indicate the direction of bottom currents, were released along with marked shrimp. The return of these drifters indicates that there was a slow westerly current in the staining area.

At present, there are only two stains, Trypan blue and fast green FCF, that are suitable marking agents to use on shrimp for growth and mortality studies. To increase the versatility of the staining technique, laboratory experiments are being made to find additional stains.

Primary marks such as fast green FCF are now used exclusively. These stains are obvious and, with familiarization, are easily seen by fishermen. Secondary marks are not so obvious and are identified by visual, chemical, or fluorometric examination in the laboratory. The use of a series of secondary marks with primary marks increases the number of possible experiments that can be carried on at one time.

To date, 34 stains, dyes, and inks have been tested for use as either primary or secondary marks. Of these, only certain numbering machine inks, blue and green, show promise as primary marks for short-term experiments of no more than 50 days.

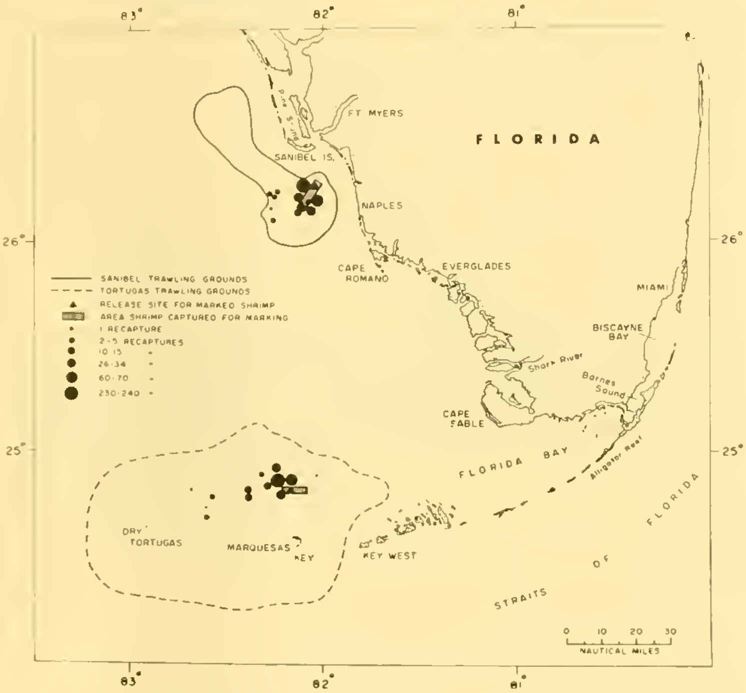
Preliminary results indicate that several fluorescent pigments might prove suitable as secondary marks when used with one of the biological stains. These fluorescent pigments do not fade, nor are they shed from the shrimp during molting and were easily detected under ultraviolet light 61 days after marking. Two other materials which might be useful as secondary marks are red and blue checkwriter inks. The inks were also visible at the site of injection 61 days after marking. A clear solvent which fluoresces white under ultraviolet light and mixes readily with fast green shows promise as a potentially good secondary mark.

Further experiments are presently being made to determine the suitability of these pigments and inks as secondary marks.

<u>Pink Shrimp Life History</u>

Thomas J. Costello

Projects designed to furnish information on the life history of the commercially important pink shrimp, <u>Penaeus duorarum</u>, have been undertaken by the Bureau of Commercial Fisheries in south Florida. Through research contracts with the Institute of Marine Science at Miami, extensive data on the identification and distribution of pink shrimp larvae have been accumulated. Primarily by use of mark-recapture experiments using biological dyes as marking agents, Bureau of Commercial Fisheries biologists have obtained information on the migration, growth, mortality rates, and geographical range of juvenile and adult pink shrimp stocks.



Release and recapture sites for pink shrimp marked on the Sanibel and Tortugas grounds in 1961 and 1962.

<u>Geographic Range</u> The geographical range of Tortugas pink shrimp is gradually being outlined. Nine mark-recapture experiments involving 106,779 pink shrimp have shown, through recoveries by commercial shrimping vessels, that shrimp inhabiting the Florida Bay and Shark River areas are part of the population fished on the Tortugas grounds. Evidence to date indicates that shrimp from Pine Island Sound on Florida's west coast and from Biscayne Bay and Barnes Sound, on the east coast, do not contribute to this fishery.

Migrations Juvenile pink shrimp make extensive movements in migrating from estuaries to offshore waters. Experiments during the past year reveal that adult pink shrimp have rather limited movements after reaching water depths of 7 to 13 fathoms. Of 2,091 pink shrimp marked with biological dyes and released near the center of the Tortugas grounds in September 1961, 443 (22%) were recovered by commercial fishing vessels during a period of 85 days. Movement of the marked animals was generally west and northwest. The greatest movement recorded for any marked shrimp of this group was about 27 statute miles.

In March 1962, 2,496 pink shrimp were captured, marked with biological dyes, and released at random on the Sanibel grounds west of Naples, Fla. By May 21, 1962, 453 (18%) had been recaptured by commercial shrimp trawlers. The greatest movement recorded for any of this group was 82 nautical miles. Two of the marked shrimp released on the Sanibel grounds were recovered near the northwest border of the Tortugas grounds after 115 days at liberty.

One marked shrimp released in lower Pine Island Sound in December 1960 was recovered in 9 fathoms on the Sanibel grounds in November 1961.

Growth Some useful pink shrimp growth data were obtained from the Tortugas experiment begun in September 1961. Shrimp (2,091) were individually measured prior to marking and release. These had a narrow size range of 83.0 to 93.5 mm. total length. Growth was calculated for 97 males and 82 females which had been at liberty from 29 to 36 days. Average growth for males having an initial mean total length of 89.3 mm. was 15.6 mm. per month. Average growth for females having an initial mean total length of 90.5 mm. was 18.0 mm. per month. Regression analysis of growth for the entire group of recoveries shows similar growth over the entire period during which recoveries were made.

This experiment depicts the surprisingly rapid rate at which these prerecruits grow as they enter the trawling grounds and are subjected to fishing.

Mortality Offshore mark-recapture experiments on the Tortugas and Sanibel grounds have demonstrated the feasibility of using this method in estimating the natural and fishing mortality rates of shrimp.

Survey of Species of *Penaeus* Shrimp in South Florida During the year, additional samples of shrimp were collected and examined to determine the distribution and seasonal occurrence of three species of the genus *Penaeus* occurring in south Florida waters. Since *P. duorarum*, *P. brasiliensis*, and *P. aztecus* are extremely difficult to separate unless mature, such information is necessary to evaluate the research on the more abundant *P. duorarum*. Monthly samples collected in Biscayne Bay, Fla., during 1960 and 1961 showed the following species composition:

Period	P. brasiliensis (balance P. duorarum)
	Percent
October	19
November-May	1 and less
June	30
July	41
August	11
September	14
October*	4

*Repeated in second year.

A sample of shrimp captured by the Bureau of Commercial Fisheries charter vessel M/V SILVER BAY in 40-60 fathoms southwest of Alligator Reef (in the Straits of Florida) was found to contain specimens of P. brasiliensis along with the P. duorarum and P. aztecus previously reported from that area.

INDUSTRIAL FISHERY PROGRAM

Joseph H. Kutkuhn, Program Leader

Gulf of Mexico fisheries for industrial-type fishes have developed rapidly in recent years and probably have not yet reached their full potential. Of the 1961 United States catch of nonfood fish, more than 40 percent was taken in the Gulf region. Practically all of this came from the 300-mile stretch of coastal waters off Mississippi and Louisiana. The question now being asked is whether or not extension of present fisheries to the east and west of this area would be feasible. It is anticipated that research by the Industrial Fishery Program will provide at least a partial answer.

Two well-defined fisheries produce the total volume of species harvested in Gulf waters for industrial purposes. The menhaden fishery operates with purse seines and large-capacity vessels in the nearshore shallows, its catch being reduced to oil and meal. The bottomfish fishery, which employs otter trawls and smaller vessels, ranges farther offshore and is supported by a wide variety of demersal fishes (mainly sciaenids) heretofore classified as "trash" species. Most of its production is used in the manufacture of petfood. Research on menhaden populations is currently conducted by the Bureau's laboratory at Beaufort, N. C., and that concerned with bottomfishes is directed from the Laboratory at Galveston and its Field Station in Pascagoula, Miss.

A project designed to survey the species and size composition of landings made by the "petfood" fleet at Pascagoula has functioned since 1958. Its principal objectives are to observe changes that may occur in the fish populations as a result of exploitation and to obtain life history information for the dominant species.

Work at the Galveston Laboratory is closely coordinated with the offshore studies by the Shrimp Fishery Program described elsewhere in this report. Monthly trawl samples of fish obtained systematically on the continental shelf between the Mississippi Delta and the Rio Grande River are providing information on patterns of seasonal and geographic distribution for the major demersal species. Since a few of these sampling sites are in the area fished by the existing industrial (bottomfish) fishery, comparative analysis of commercial and research statistics will enable us to make a realistic appraisal of the potential that the western Gulf holds for this fishery's expansion.

Industrial Bottomfish Fishery in the North Central Gulf of Mexico

Charles M. Roithmayr

The Fishery Gulf landings of demersal fishes processed for petfood mink-food, fish meal, and crab bait fell from about 81.0 million pounds in 1960 to 76.9 million pounds in 1961. The lower catch in 1961 was due not to a diminished resource but to a 40-percent decrease in the total number of fishing trips and, presumably, a comparable decrease in actual fishing effort. Despite the increased demand for fish meal, two reduction plants that processed fish during part of 1960 did not resume operations last year.

Reflecting changes in demand as well as changes in fleet composition and distribution, the overall average catch per vessel-trip increased in 1961 from 12 to 19 tons. Examination of catch records compiled for 6 percent of the industrial-fish fleet over the period 1960-61 revealed an average increase of 27 tons per trip for large vessels (50 or more tons capacity) fishing in 2 to 20 fathoms east of the Mississippi Delta. The same vessels fishing west of the Delta and in similar depths realized only a 12-ton increase. Smaller vessels (less than 50 tons capacity) fishing east of the Delta exhibited a 7-ton increase, whereas, a 10-ton decrease was indicated for trips made west of the Delta. In 1961, an estimated 30 percent more trips were made east of the Delta by the larger boats, this being primarily responsible for a proportional increase in the catch from that area. Greater activity and consequent

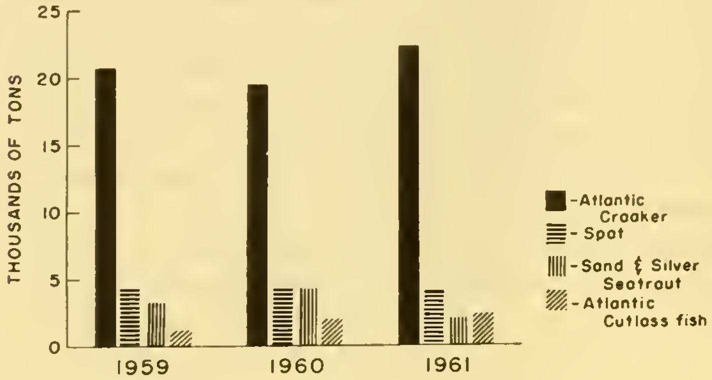
Typical industrial-fish trawler of the "Florida" design (right).

Typical industrial-fish trawler of the "Biloxi" design (left).

production east of the Delta occurred during September-December when successful trawling west of the Delta was precluded due to bad bottom and accumulations of debris resulting from Hurricane Carla.

A standard unit of effort was established to furnish a reasonable index of fish abundance and measure of fishing success on the grounds. Preliminary analysis of 1961 data shows that the average catch per 1-hour tow using a standard 65-foot, balloon-type otter trawl was 0.62 tons west of the Delta and 0.51 tons east of the Delta

Five species accounted for approximately 81 percent of the 1961 industrial bottomfish catch. Atlantic croaker, Micropogon undulatus, again topped all species by a wide margin. Comparative data for the period 1959-61 are shown in the accompanying graph. The year-to-year stability of catch



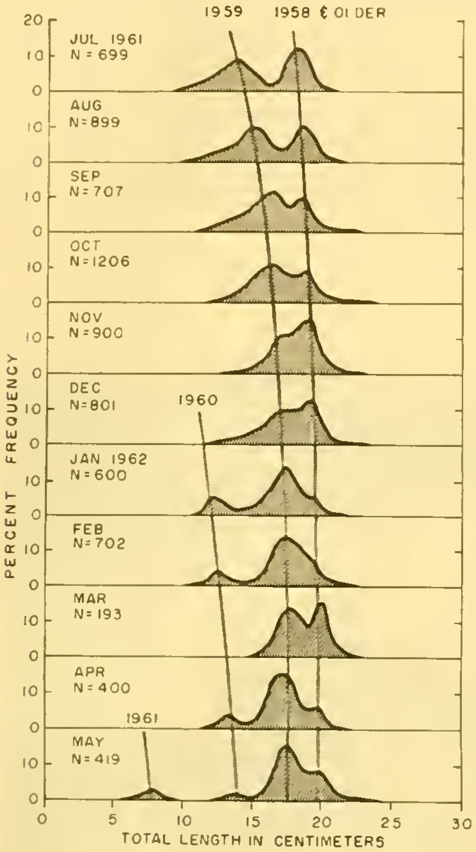
Comparative landings of dominant bottomfish species taken by industrial-fish fishery off north central Gulf coast, 1959-61.

composition (in terms of the major contributing species) is particularly noteworthy.

Life History Studies An intensive sampling project at the Galveston Laboratory's Field Station in Pascagoula, Miss., is furnishing basic information on the life history and general biology of Atlantic croaker; spot, Leiostomus xanthurus; sand seatrout, Cynoscion arenarius; and silver seatrout, C. nothus. A major portion of this project involves the study of variation in relative strengths of successive age groups ("year classes") of each species. Because attempts to validate the scale method of age determination are not yet complete, analysis of length distributions of the samples, despite its acknowledged subjectivity, has had to be relied upon for age assessment. Findings reported in the following discussion, which is restricted to the Atlantic croaker, must therefore be viewed as preliminary.

On a semiweekly schedule over the period July 1961 to May 1962, 7,500 croakers were examined for total length, weight, sex, and maturity from commercial catches made east of the Mississippi Delta (2-20 fm.) and landed at Pascagoula. Subsampling provided the scale samples being examined to decide on the feasibility of their use in determining age. After being compiled in 5-mm. classes and combined according to month of sampling, the plotted length measurements are shown in the accompanying figure.

Two distinct size groups contributed to catches of croaker in July 1961. Individuals in the smaller group were 9.5 to 16.0 cm. long, with the mode occurring at about 13.5 cm. They increased in average size throughout the summer and by October were 12.0 to 18.0 cm. long (mode at 16.0 cm.). Associated data on sexual maturity showed a preponderance of ripe fish in 4 to 17 fathoms between Sand Island Lighthouse, Ala., and Chandeleur Island Lighthouse, La., during September-November. Assuming this to be the principal spawning period and drawing also from earlier life history studies conducted in Texas and Louisiana estuaries, it is postulated that the 16-cm. modal group present in October 1961 was the result of spawning in the fall of 1959, and therefore may be identified as the 1959 year class. Modal positions for this year class remained relatively constant from January through May, varying only slightly between 16.5 and 17.5 cm. During this period it was the most important year class contributing to the industrial bottomfish fishery.



Length frequency distributions for Atlantic croaker taken east of the Mississippi Delta, July 1961 to May 1962.

The larger size group evident in July contained individuals ranging from 16.5 to 20.5 cm. with the mode at 18.0 cm. These grew at such a rate that by October they ranged in length from 18.0 to 22.0 cm., with the mode at 19.0 cm. This group, which included fish from the 1958 as well as earlier year classes, gradually decreased in density, exhibited little apparent growth, and was characterized in May by a mode of 20.0 cm.

In January 1962, a subdominant group of smaller fish with a modal length of 12.5 cm. entered the fishery and is assumed to have been a migrating (estuary to Gulf) as well as faster growing (and hence "selected") segment of the 1960 year class.

The 8-cm. modal group appearing in May 1962, can be attributed to the fall spawning in 1961, and henceforth identified as the 1961 year class.

Assuming that the major modes of the croaker's length frequency distribution indicated successive age groups, it is tentatively concluded that insofar as the croaker is concerned, the industrial bottomfish fishery of the northeastern Gulf depends largely on 1- and 2-year-old fish.

Western Gulf Bottomfish Survey

James G. Ragan

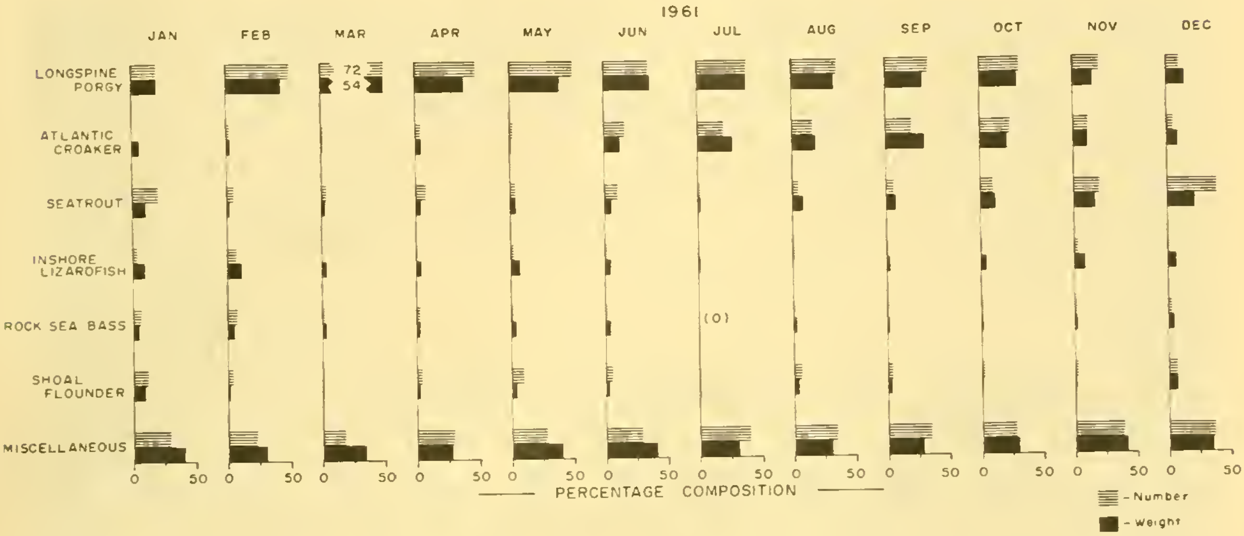
A full year's sampling of bottomfish populations in the Gulf between Cameron, La., and Freeport, Tex., has been completed. This was undertaken to determine the relative composition of bottomfish resources in the area and to provide biological and statistical data on the more common species.

Five-pound samples of fish were drawn from catches made with 45-foot, $2\frac{1}{2}$-inch mesh flat trawls, towed for 1 hour at each of 11 strategically located stations. These stations ranged in depth from $7\frac{1}{2}$ to 45 fathoms and were occupied every 3 weeks. After species identification, each fish was measured for length and weight, and examined for sexual maturity.

Weighing specimens of Atlantic croaker.

Combined over the entire year, the sample material revealed the presence of 111 species, of which the following 6 accounted for an estimated two-thirds (by weight and number) of the overall trawl catch.

Species	Percent by weight	Percent by number
Longspine porgy, *Stenotomus caprinus*	35	39
Atlantic croaker, *Micropogon undulatus*	11	8
Seatrout, *Cynoscion* sp.	7	8
Inshore lizardfish, *Synodus foetens*	6	2
Rock sea bass, *Centropristes philadelphicus*	4	3
Shoal flounder, *Syacium gunteri*	3	6



Composition of bottomfish resource in northwestern Gulf of Mexico.

The longspine porgy was the most common species encountered in all months except December when it was replaced by the seatrout (see graph). With the exception of the rock sea bass and lizardfish, habitats of the major species appear definable on the basis of depth. The longspine porgy, for example, was abundant only at depths greater than 20 fathoms. The croaker and seatrout dominated catches at the shallow-water stations, while the shoal flounder was taken almost exclusively at 15 fathoms.

The trawl-sample data (accompanying table) indicate that fish concentrations were greatest at the nearshore stations during the warm months and at the offshore stations during the cold months. Thus it appears that seasonal movements are largely governed by water temperature which fluctuates widely in the nearshore shallows.

Average weight of all species taken at indicated depths throughout 1961. Figures are based on trawl hauls standardized over a 3-mile towing distance.

Depth	Spring	Summer	Fall	Winter
Fathoms	Pounds	Pounds	Pounds	Pounds
$7\frac{1}{2}$	104	525	160	64
15	221	129	209	153
25	149	126	152	227
45	98	53	94	103

An expanded sampling program, comprising 60 stations arranged systematically on the continental shelf from the Rio Grande River to the Mississippi Delta, was begun in January of this year. In addition to supplying information on the fishes present in a previously unstudied area, this program should provide a comparison of fish concentrations on the grounds now being fished with those in the more westerly part of the Gulf, and thereby afford a means of assessing the potential of unexploited stocks.

ESTUARINE PROGRAM

George A. Rounsefell, Acting Program Leader

In the lower reaches of rivers and where they meet the sea, the environment is unlike either the typical river or sea. These marshes, lagoons, and partially enclosed bays between the fresh water of the river and the salt water of the sea are called estuaries. They furnish habitats in which many commercially important species of fish and crustaceans spend all or a particular portion of their life. Many of the more important Gulf species are quasi-catadromous, that is, the adults spawn at sea, but the young live in the lower salinity water of the estuaries.

Because of the necessity to understand the effects of an expanding number of manmade changes in the estuaries, a research program was begun in 1959 to explore basic ecology and the type and scope of research necessary to predict the effects of engineering projects upon fishery resources. Before

Bringing a sample trawl on board the TOMMY BOX in Galveston Bay.

1959, some data on estuaries in the Galveston area were obtained during the field operations of other Laboratory projects. The estuarine work is now divided into two basic projects:

1. The estuarine ecology project is intended to determine the types of habitats suitable for various species of fish and invertebrates, the effects of environmental factors, and their interrelationships.

2. The evaluation of estuarine data and of engineering projects has a twofold purpose: (a) to examine existing data for a clearer picture of the

present status of our knowledge in order to determine how to best plan future research without duplication of effort and (b) to evaluate the effects of engineering projects upon estuarine biota.

During the year, the outboard cruiser POGO was replaced with a 17-foot fiberglass "Boston Whaler," powered by a 75-hp. outboard motor. This acquisition increases the consistency of field sampling because of its speed and seaworthiness. The 40-foot diesel-powered vessel TOMMY BOX was acquired for work in the deeper and more distant inshore waters. Considerable remodeling and hull repairs were required before putting this vessel into service.

During the coming year, because of the limited staff, the tempo of field work will be reduced until the series of data already obtained can be adequately analyzed and reports written for publication. This will also prevent collection of data which analysis of existing data may show are not required.

Series of available hydrographic data and concomitant biological samples.

Month	1957	1958		1959	1960		1961			1962		
Jan.			C	C	C		C	O		C	O	T
Feb.			C	C			C	O	T	C	O	T
Mar.			C	C			C	O	T	C	O	T
Apr.		L	C	C			C	O	T	C	O	T
May	L	L	C		C	O	C	O	T			
June	L	L	C	C	C	O	C	O	T			
July	L		C	C	C	O	C	O	T			
Aug.	L		C	C	C	O	C	O	T			
Sept.	L		C	C	C	O	C	O	T			
Oct.	L		C	C	C	O	C	O	T			
Nov.	L		C	C	C	O	C	O	T			
Dec.	L		C	C	C	O	C	O	T			

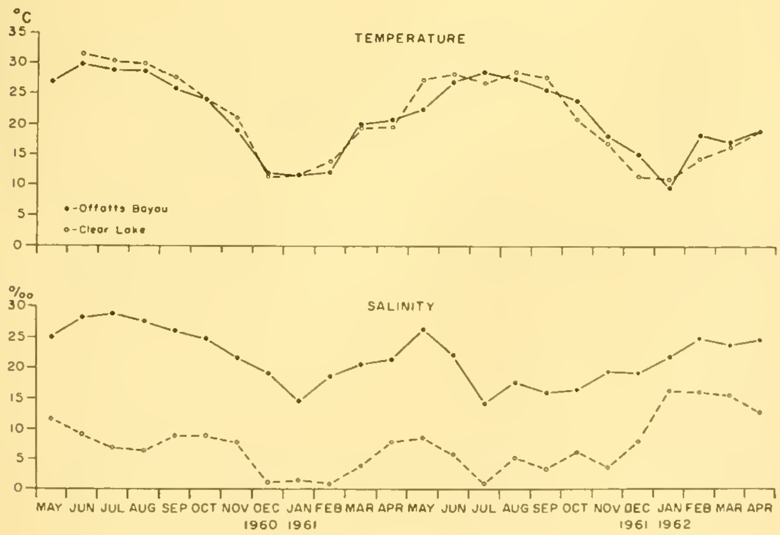
L = Lufkin Bayou on south side of West Bay
O = Offatts Bayou
C = Clear Lake
T = Trinity Bay

Ecology of Nursery Areas

Anthony Inglis

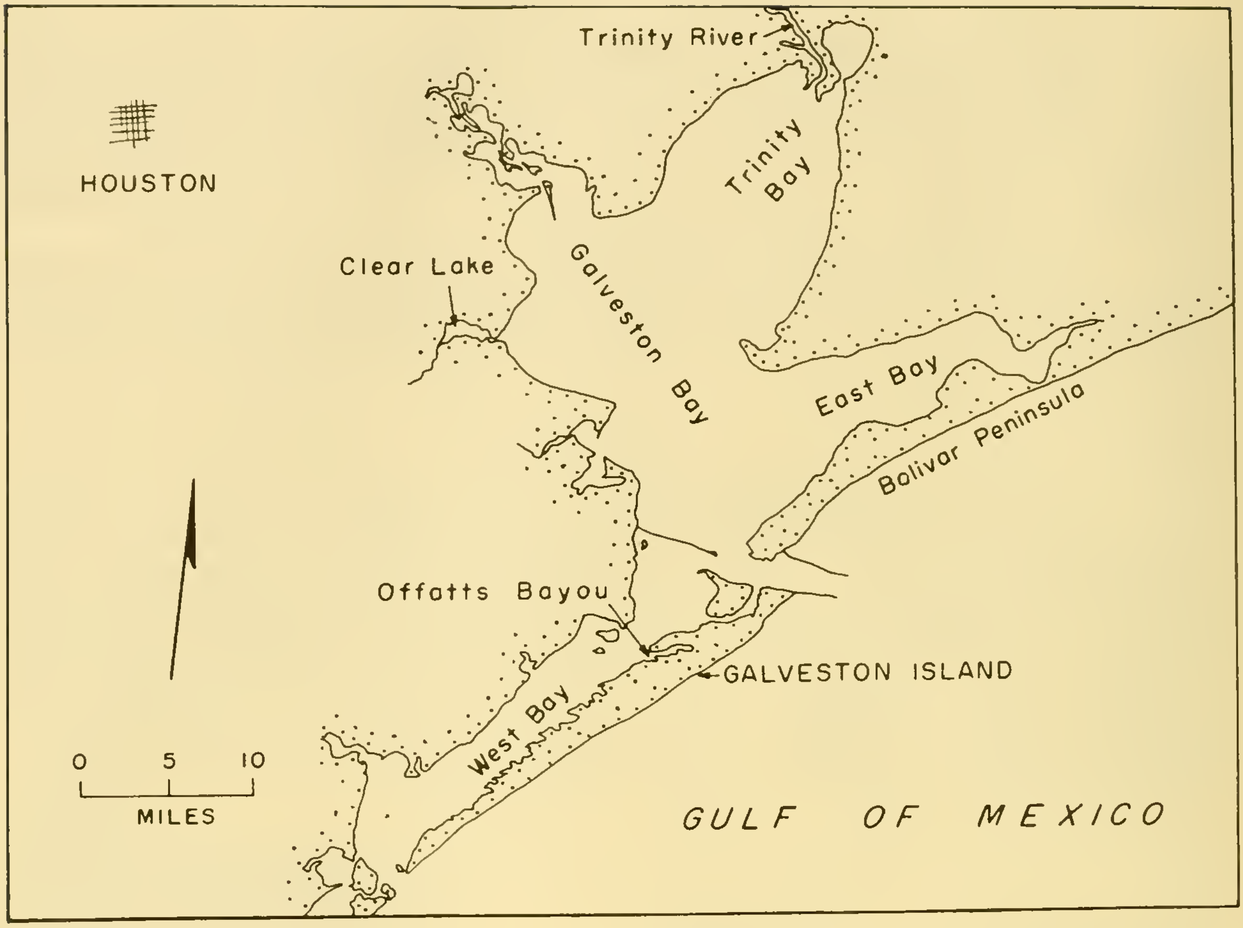
The role of the inshore waters in the economy of the seas requires clarification, but we know that many species of marine fishes and invertebrates spend at least part of their early life histories in these rich and shallow waters. The brackish streams, marshes, lagoons, and bayous, which are components of estuarine systems, have even been commonly referred to as "nursery areas" by both the scientist and the lay fisherman.

Since 1957, studies have been made on the ecology of nursery habitats in segments of the Galveston Bay system. Lufkin Bayou on the south shore of West Bay was first chosen for a study on the habitat differences of the three commercially important shrimps, the brown, white, and pink, but had to be abandoned a year later due to dredging in the area. In 1958, Clear Lake, a bay on the western shore of upper Galveston Bay, was selected because it supports a large and successful bait shrimp fishery. In 1960, the study was expanded to include Offatts Bayou, a deeper, more saline, and less turbid water body situated in the western part of the City of Galveston on Galveston Island. Offatts Bayou supports no major fishing with the exception of a winter sport fishery for the spotted seatrout, *Cynoscion nebulosus*. In the winter of 1961, the study of a fourth area, Trinity Bay, was undertaken to determine the probable effects on the estuarine fauna of reduced Trinity River discharge due to numerous engineering projects planned for the watershed. A report on the Trinity Bay studies appears elsewhere in this report.



Average monthly bottom salinities and temperatures for two Galveston Bay habitats.

For convenience this discussion is limited to the 24-month period May 1960 to April 1962, during which field investigations in Clear Lake paralleled those in Offatts Bayou. Biweekly sampling carried out at each location on alternating weeks included hydrological and meteorological observations as well as 5-minute trawl hauls for biological specimens. Both surface and bottom temperature as well as salinity were measured.



Galveston Bay system.

Monthly mean bottom temperatures for the two areas were similar, reaching peaks of about 30° C. in June 1960 and 28° C. during June-September 1961. (See accompanying graph.) Lows of about 12° C. were recorded during December 1960 to February 1961 and of 10° C. in January 1962. This latter measurement was recorded as a cold front passed during the period January 11-15. Sustained low temperature led to the formation of a 2-inch cover of ice on portions of Clear Lake and Offatts Bayou.

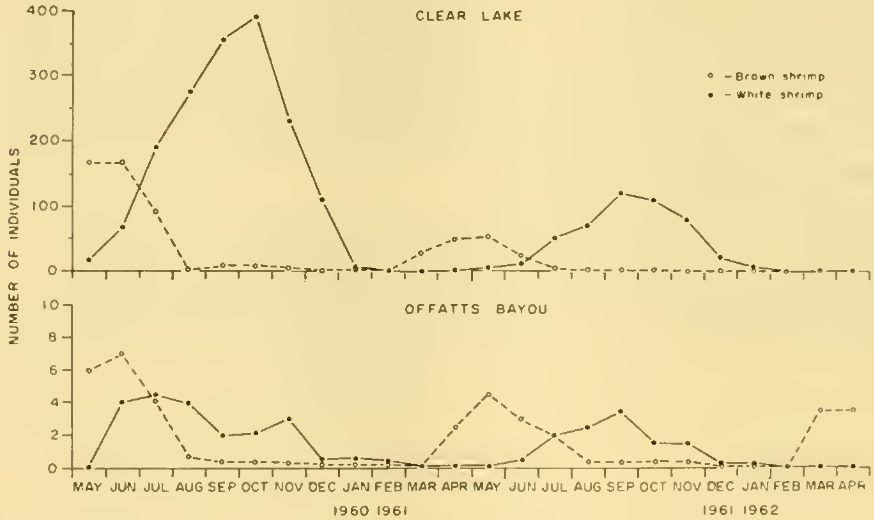
Monthly mean bottom salinity in Clear Lake, due to a direct source of fresh water through Clear Creek and a narrow elongated connection restricting the intrusion of more saline waters from Galveston Bay, was continually lower than that recorded for Offatts Bayou, which lacks any sizable source of fresh water and has a broad connection with West Bay. The difference ranged from about 7‰ to as much as 23‰ during the study period. Heavy rainfall during the months of June and July resulted in a generally lower midsummer salinity than was noted for a similar period in 1960, especially in Offatts Bayou where the bottom salinity, which averaged between 28‰ and 29‰ for July of 1960, averaged less than 15‰ in July 1961. The midsummer drop in salinity is usually more clearly defined in Clear Lake than in Offatts Bayou and seems to occur with predictable frequency. Thus the average spring and fall salinity in Clear Lake ranges from 6‰ to 8‰ while the summer salinity ranges from 3‰ to 5‰. From the last week of June through the second week of July in 1961, the bottom salinity averaged less than 1‰. In September 1961, the passage of Hurricane Carla caused a second drop in salinity.

Forty-five species of fish and invertebrates were taken by trawling in Clear Creek, and fifty-five in Offatts Bayou. The larger number of species taken in Offatts Bayou is characteristic of the more marine portions of Texas estuaries. However, the average number of organisms per trawl haul

Clear Lake (256 trawl hauls)		Offatts Bayou (433 trawl hauls)	
White shrimp	21,019	Spot	9,846
Atlantic croaker	15,558	Bay anchovy	4,448
Brown shrimp	10,082	Atlantic croaker	3,455
Largescale menhaden	2,934	White shrimp	2,074
Bay anchovy	2,781	Brown shrimp	2,056
Spot	2,202	Pinfish	1,346
Blue crab	1,817	Grass shrimp	226
Sand seatrout	1,628	Largescale menhaden	212
Grass shrimp	664	Blue crab	181
Striped mullet	434	Atlantic threadfin	120
Subtotal	59,119		23,964
35 other species	1,192	45 other species	662
Total	60,311		24,626

was more than four times greater in Clear Lake. This trend for greater numbers of individuals but fewer numbers of species in the lower saline waters as compared to the marine is characteristic. Unfortunately, these figures are in terms of numbers, not biomass. The accompanying data show the total catch of each of the 10 most abundant species in the trawl samples from Clear Lake and Offatts Bayou during the period May 1960 to April 1962.

Both brown and white shrimp were considerably more abundant in Clear Lake than in Offatts Bayou though their periods of abundance in the two locations coincided closely. White shrimp show peaks in abundance in both estuarine habitats during the month of September and low points during March. Brown shrimp reach their greatest abundance in May and June and the least in the month of January. Analysis of the accompanying figure reveals that both species show a sharp decline in catch per unit of effort for 1961. This agrees with Fish and Wildlife Service statistics and reports for both the bait shrimp fishery and the regular commercial fishery. Sizes of the two species were comparable in both areas, ranging in the case of brown shrimp from tiny postlarvae to large juveniles (12.5 g., 115 mm.) and, in the case of white



Monthly catch per unit of effort for brown and white shrimp between May 1960 and April 1962 in two Galveston Bay habitats.

shrimp, from postlarvae to subadults (16.5 g., 130 mm.). The smaller sizes were relatively more abundant in Clear Lake, while Offatts Bayou samples contained proportionally higher numbers of the larger sizes.

The number of blue crabs taken in Offatts Bayou during the 24 months of study was considerably less than that in Clear Lake. Immature or juvenile crabs of both sexes made up the bulk of the Clear Lake catch. Mature individuals, mostly males, made up the greater part of the Offatts Bayou catch.

Finfish catches, with several exceptions, followed the same picture of lower catches per unit of effort in Offatts Bayou than in Clear Lake. The spot was the most abundant single species taken in Offatts Bayou, contrasting with its rank of the fourth most common fish in Clear Lake. Catch-per-unit-of-effort data compare fairly well in the two areas, but the peak of abundance of this species is reached 1 or 2 months earlier in Offatts Bayou than in Clear Lake. The secondary peak of abundance which normally occurs in October or November in Clear Lake was only slightly evident in Offatts Bayou. This secondary peak of abundance is closely associated with the normal rise in salinity in Clear Lake during these months. The greatest abundance of this species is associated with areas of higher salinity in the Galveston Bay area.

The bay anchovy was the second most abundant fish in Offatts Bayou samples and the third most abundant in Clear Lake samples. This species, which is considered to be the most important forage fish in Texas estuaries, probably occurs in far greater abundance than indicated by trawl samples. The catch per unit effort of this species, however, was roughly comparable in the two areas. Peaks were reached in Clear Lake in October 1960 and August 1961, whereas, lows were recorded for December 1960 and January 1962 in Offatts Bayou.

The above studies are being modified toward a broader program to investigate the entire Galveston Bay system. The detailed work of the last 5 years is scheduled to be published as quickly as the data can be analyzed.

Sampling fish and crustaceans in Offatts Bayou
with a small bottom trawl.

Effects of Engineering Projects on Estuaries

Richard A. Diener

The value of estuaries as nursery and feeding grounds for many commercially important species of fish and crustaceans is reflected in Texas landings, of which approximately 98 percent by weight are of species in some way dependent on estuaries. The cumulative effects of water development practices upon these estuaries and upon the allied commercial fish production will likely be extensive. Our present knowledge does not permit us, however, to make accurate predictions of these effects upon marine fishery resources.

Although the effects of development projects cannot yet be evaluated accurately, several types of changes may be foreseen. The most obvious alteration of existing conditions would be reduction of fresh-water discharge through greater consumptive water use and increased total evaporation due to more exposed surface area in reservoirs. A reduced discharge of fresh water may alter the suitability of estuarine areas by raising their salinity; by varying salinity, circulation, and water interchange patterns; by draining surrounding marsh areas through the lowering of river levels; by reducing silt load and thus altering deposition rates; and by reducing inflow of terrigenous nutrient materials required for primary productivity.

Typical spoil retention dike used to keep spoil from filling in and thus destroying valuable marsh habitat.

As human population increases with accompanying expansion of agricultural and industrial interests, it is logical to expect an increase of pesticides and other pollutants entering the estuaries with the waste waters and runoffs. Influence of inshore waters upon the hydrology and food cycles of offshore waters has not been clearly defined, but is another factor which must be considered when assessing the effects of drastic modifications of river systems and their associated estuaries.

The Nueces River of Texas affords an excellent example of the many extensive water development programs proposed for the various watersheds draining into the Gulf of Mexico, either directly or indirectly through the estuaries. From its headwaters in Edwards County in south central Texas, the Nueces flows southeasterly for some 315 miles terminating in Nueces Bay, a segment of the Corpus Christi Bay system. As the Nueces River is the largest tributary of the Corpus Christi estuarine system, it is one of the chief factors determining hydrological conditions therein.

Traversing one of the population centers of south Texas, the Nueces' waters are considerably exploited by industrial, agricultural, and municipal interests. A single large impoundment above Corpus Christi supplies the major portion of irrigation in the semiarid counties of the Nueces valley. Municipal and industrial uses, particularly in the vicinity of Corpus Christi, place a further drain on flows in the lower reaches. Expanding populations and the resulting agricultural and industrial needs will place additional demands upon river flows. These new demands will be met by the construction of approximately seven more reservoirs along various reaches of the river system and by increasing the capacity of the existing reservoir.

Various federal agencies, including the Bureau of Reclamation, the Soil Conservation Service, and the Corps of Engineers, are considering means of utilizing flows of other Texas streams in addition to that of the Nueces. The United States Study Commission recently submitted a report proposing a water supply and control program for the entire state of Texas. Large variations of climate exist in the state, and consequently, fresh-water supply is most critical in the arid and semiarid southern and western regions. The proposed method of alleviating this imbalance is to divert the "surplus" runoff from the major streams and transport this water to the semiarid lands by means of a system of canals and pumping stations. Surplus runoff is considered as all nonexploited flows entering the estuarine systems.

A further indication of an expanding economy along the Texas coast is the increased number of navigation channels, mineral developments, and general construction projects which alter in varying degrees the estuaries and their suitability as marine habitats. Projects for realignment, maintenance, and addition of navigation channels - chiefly those associated with the Intracoastal Waterway - are frequently submitted for an evaluation of their effects upon marine fishery resources. General construction projects, a term embracing such items as small fills, mineral drilling facilities, wharf construction, pipeline crossings, and others, generally have minimum effects upon marine fishes.

Severe alteration of water circulation and interchange through "canalization" and segmentation of the estuaries by channels and the resulting spoil banks, is the principal danger from navigation projects, aside from the actual physical loss of habitat. This is a major problem in Louisiana where canalization is changing marshland ecology through increased salt-water intrusion. Navigation projects often can be modified so that spoil disposal results in a minimum loss of habitat.

Individual construction projects of a general nature are usually not sufficiently extensive to be considered detrimental. In large numbers, however, they may produce serious cumulative encroachment upon available and irreplaceable estuarine habitats.

Lacking sufficient knowledge in specific areas concerning species utilization or hydrological effects, we can usually only recommend the maintenance of existing conditions.

Recognizing the above problems, program personnel during the past year and under the present system of coordination with the Branch of River Basin Studies made 180 appraisals of engineering projects potentially affecting estuarine fishery resources. Of this number, all but six involved Texas waters. The majority of these resulted from more than 325 Corps of Engineers public notices and letters received during the year and screened to determine which projects could materially affect estuarine and marine fishery resources. Sections pertaining to these fishery resources in 40 Bureau of Sport Fisheries and Wildlife draft reports were also reviewed.

Evaporation losses from irrigation ditches may reduce necessary fresh-water inflow to estuaries.

PHYSIOLOGY AND BEHAVIOR PROGRAM

David V. Aldrich, Program Leader

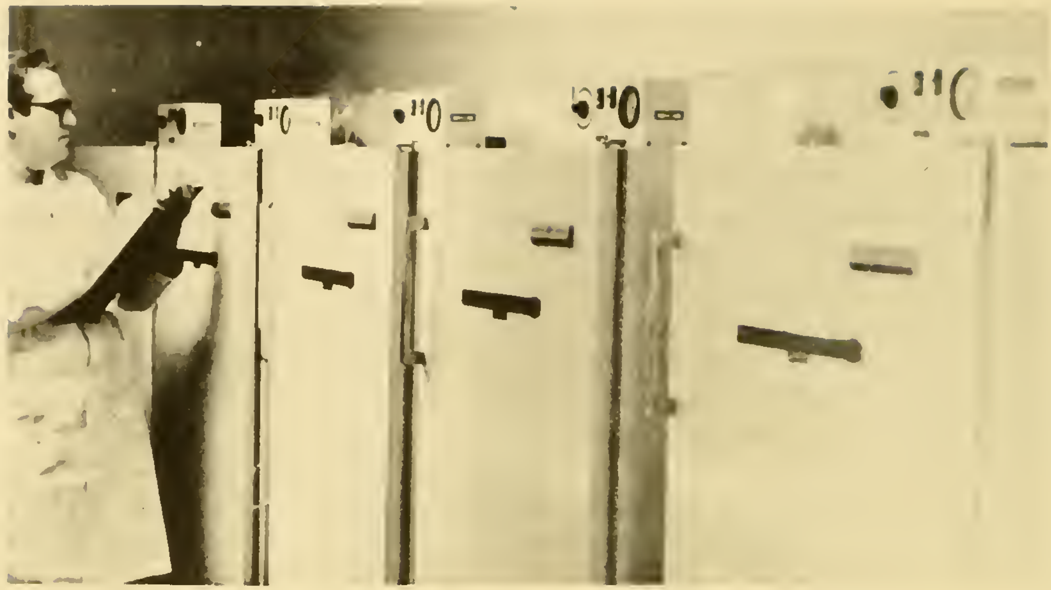
Since midyear, this program has been specifically directed toward laboratory experiments dealing with the environmental requirements of commercial shrimps, primarily in postlarval and juvenile stages of development. One goal - to determine limiting and optimal levels of salinity and temperature - is being approached in three ways: (1) observing survival of shrimp exposed to known salinity and temperature combinations, (2) observing the selection of a temperature or salinity range by shrimp placed within a continuous linear gradient, and (3) comparing the growth rates of shrimp held at known salinity and temperature conditions.

Much of our progress has been made possible by adapting available equipment and developing new devices. Examples of this type of activity are the successful modification of laboratory incubators for survival studies, completion of vertical water columns with salinity and temperature gradients for behavior experiments, development of a method for preventing postlarval shrimp from jumping above the water's surface in aquaria (reducing "false mortality" during growth and survival studies), and finding a practical laboratory diet for small shrimp.

Laboratory results obtained using brown shrimp, Penaeus aztecus, indicate that postlarval as well as juvenile stages can tolerate a wide range of salinity levels (5‰-35‰). It is particularly noteworthy that this conclusion is based not only on the results of short-run survival experiments but also on the more sensitive indices of environmental suitability provided by behavior and growth studies. The survival work further showed that the range of tolerance to salinity narrowed considerably at the lowest temperature level tested (7° C.).

Preliminary results of comparative survival experiments suggest that juvenile shrimp tolerate a wider range of temperatures than do postlarvae. Such physiological changes during development within a species may have an important bearing on the patterns of distribution and movement characteristic of young shrimp. It may be that the relatively stable temperature of offshore spawning grounds is more conducive to the survival of larvae and early postlarvae, whereas the larger and hardier forms can tolerate the less static conditions encountered in the more fertile nursery areas of the bays.

We hope that another sensitive physiological index - oxygen consumption - can also be used to measure influences of environmental factors on shrimp. To this end, potential anesthetics are being tested in an effort to stabilize physical activity and thus permit accurate assessment of basal metabolic activity through measurement of oxygen consumption.



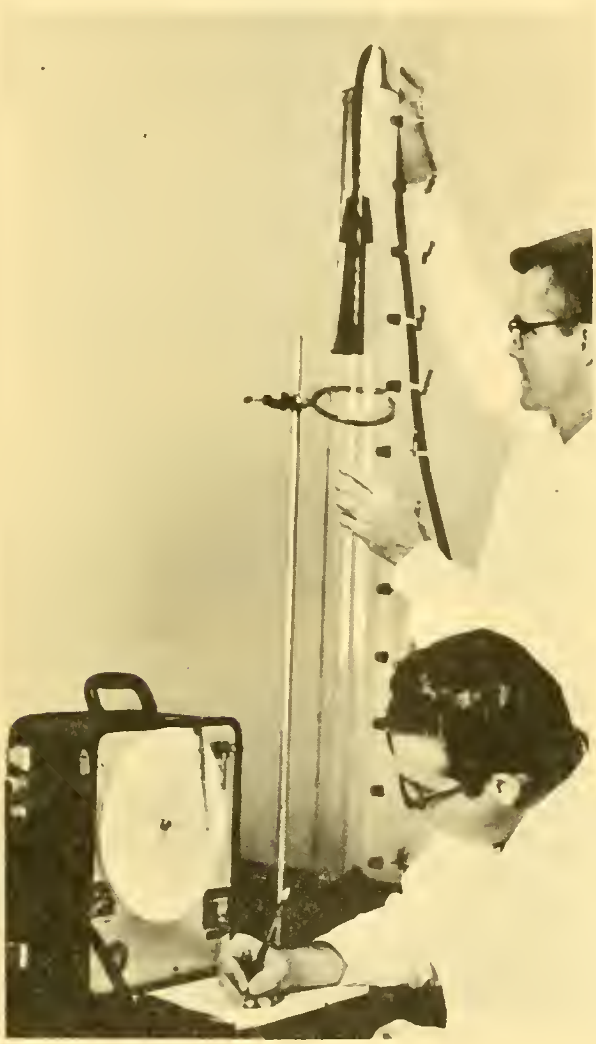
Checking incubator temperatures during a survival study.

One phase of future work will investigate the combined influences of salinity and temperature on growth of shrimp in experiments which will be made feasible with the completion of four controlled-temperature rooms now under construction.

Tolerances to Environmental Factors

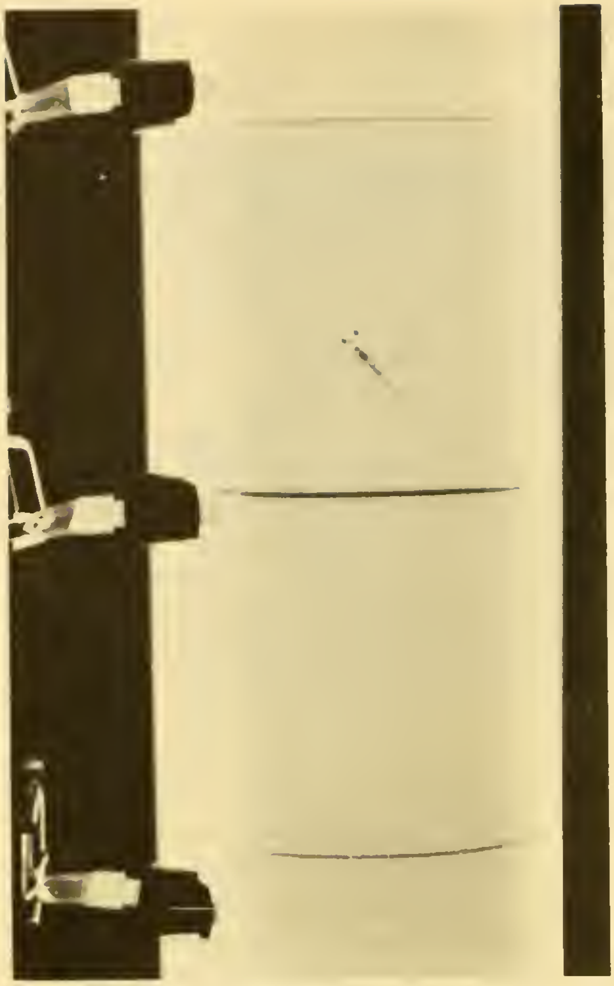
David V. Aldrich

The behavioral phase of this project started with the exposure of small (13-28 mm. total length) brown shrimp to continuous linear salinity gradients. These gradients are of the vertical type, in which density differences associated with differences in salinity tend to maintain stratification within the water column. Using evaporation-concentrated sea water and distilled water, continuous gradients ranging from 1‰ to 70‰ are established in a 7-liter column 4 feet high. (See photo.) After a shrimp is introduced into the column at a salinity level equivalent to that of the medium from which it came, the animal's movements up and down the gradient are observed. To minimize observer bias in this operation, 100 determinations of a shrimp's level in the gradient are taken regularly at preestablished 15-second intervals. Preliminary tests showed that (1) such salinity gradients are extremely stable and (2) the shrimp, although usually found on the bottom of experimental tanks, are quite capable of swimming continuously at levels above the bottom for 12 hours or longer. In providing no resting place for the animal within each salinity range, this type of apparatus continually forces the shrimp to swim to remain within a salinity range of its choice, frequently encountering and avoiding the levels which lie above and below this range. Thus, results should suggest avoidance limits, which may be significant in regard to the natural distribution of these animals.



Determining salinity gradient with conductivity meter.

The grouped results of 13 such experiments using juvenile brown shrimp acclimated in a salinity of about 27‰ clearly show that the shrimp occupied low salinity ranges within the gradient column



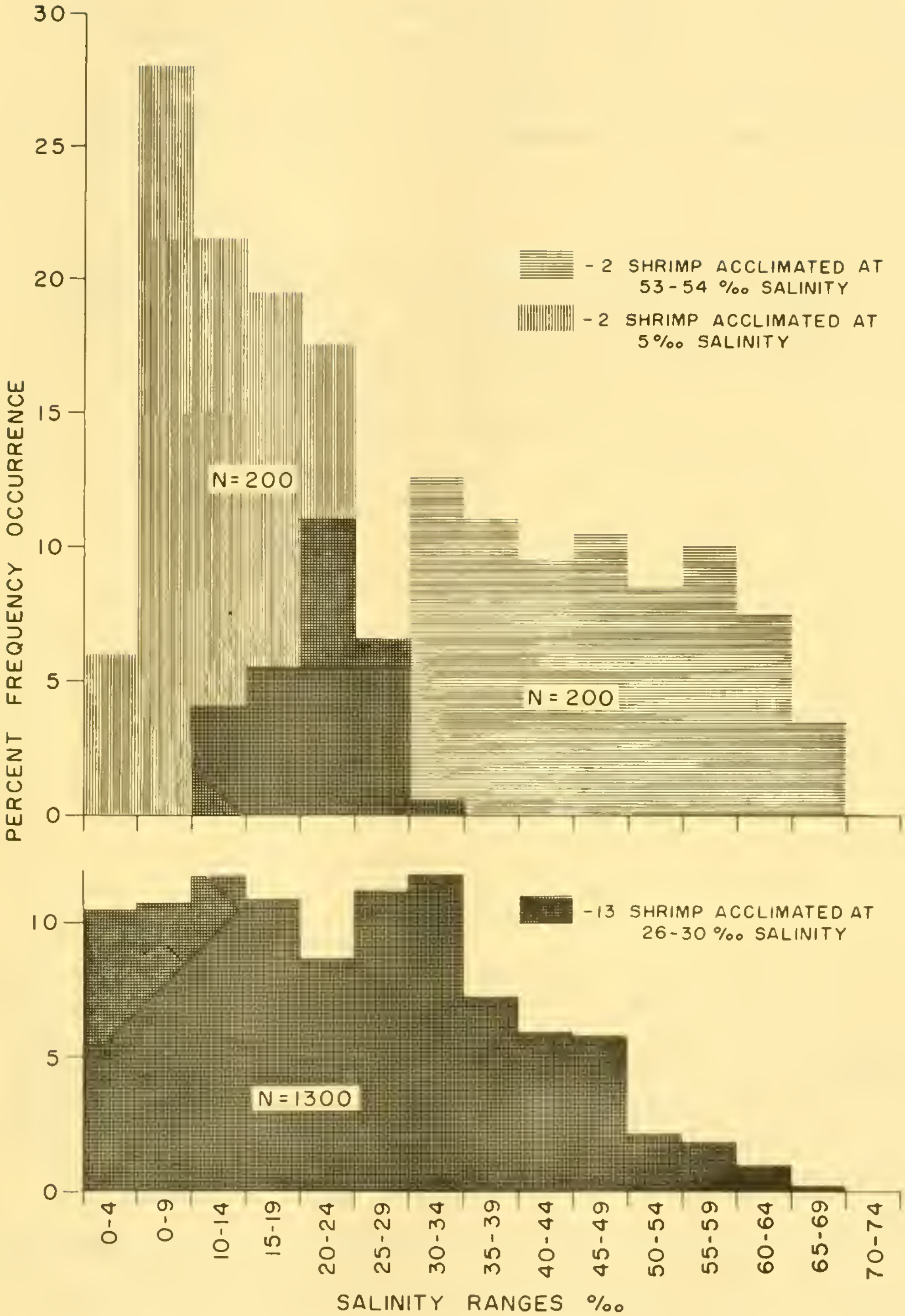
just as frequently as they chose more saline levels, up to and including the 30‰-34‰ range. (See figure next page.) Maximum concentrations occupied by individual shrimp varied from 49‰ to 70‰, and minimum concentrations from 1‰ to 10‰, again indicating widely separated avoidance limits for this species.

Small (1-in.) brown shrimp swimming in experimental salinity gradient. The horizontal reference line just below the shrimp indicates the 21‰ level; the next line above marks the 13‰ level.

The influence of acclimation to high or low salinities is suggested by the results of similar experiments which tested two shrimp grown at 5‰ and two held for 3 days at 53‰-54‰. The obvious differences between frequency distributions of these two groups seem to reflect the salinity history of the experimental animals. Moreover, data for the low-salinity group are much less widely distributed than are those for the high-salinity group. The small number of shrimp tested to date, however, limits the confidence with which these differences can be associated with salinity acclimation.

Present plans are to repeat this type of work in order to determine the extent of behavior variability within and between individuals. Future work will also extend this approach to other species, beginning with white shrimp, and to another important environmental factor - temperature.

A study of the effect of salinity and temperature on survival of small brown shrimp has also been undertaken. Using five incubators, 24-hour survival tests involving a two-factor, five-level experimental design were conducted with postlarvae and juveniles. Within each experiment, initial salinity and temperature conditions (25‰-27‰ and 22°-25° C., respectively) were the same for all shrimp. Changes to final experimental conditions were made over a 12-hour period for each group by making periodic changes until the desired conditions were obtained.



Frequency distribution of times that small brown shrimp selected certain salinity ranges.

Here again, results show a broad range of salinity tolerance for postlarvae at 25° or 30° C. (See accompanying table.) As temperature was lowered, however, the tolerance range was progressively reduced. At 35°, some mortality occurred at all five salinity levels, suggesting that this temperature is very near the upper absolute limiting level for postlarvae of this species.

Number of postlarval brown shrimp surviving various temperature-salinity conditions. Pooled results of two experiments. (10 = 100 percent survival.)

	Temperature (° C.)				
Salinity (‰)	7	15	25	30	35
37	7	10	10	10	7
34	7	10	10	10	7
25	10	10	10	10	4
10	2	7	10	9	7
5	0	1	10	10	1

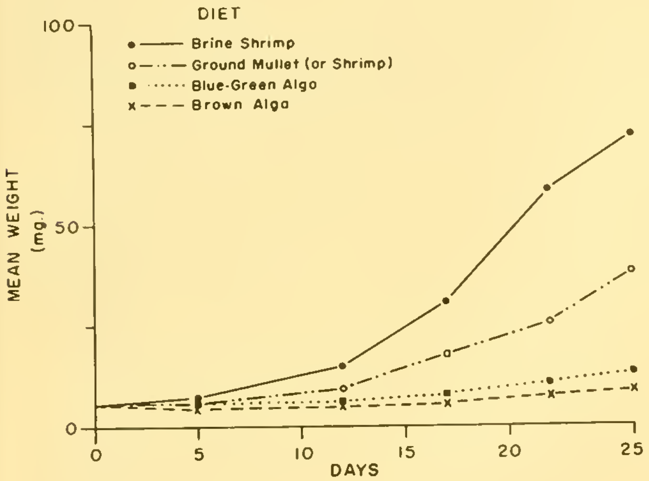
A similar experiment on juvenile brown shrimp showed only 4 percent mortality at 13° C. (including all salinity levels) and 8 percent mortality at 35°. Comparison of these figures with those for postlarvae (24 percent at 15° and 48 percent at 35°) suggests that juveniles tolerate a broader range of temperature. Increased tolerance to temperature changes might have considerable adaptive significance for shrimp of this size, since they are naturally exposed to the changeable conditions characteristic of estuarine environments.

Much additional work of this type is needed, e.g., (1) repetition of above experiments, (2) testing of salinity and temperature levels which will more closely define limiting levels, (3) tolerance comparisons between species, and (4) testing for acclimation effects.

Experimental Growth Studies With Postlarval Brown Shrimp

Zoula P. Zein-Eldin

Studies of shrimp growth rate as an index of the suitability of simulated environmental conditions were begun this year. In the first series of experiments to determine a practical diet capable of supporting growth in the laboratory, we compared the growth and survival of postlarval brown shrimp fed various foods. These diets included: live brine shrimp (nauplii); brine shrimp plus a species of filamentous brown alga; the brown alga alone; ground mullet; ground shrimp; and a species of filamentous blue-green alga. Salinity in test aquaria was maintained at 25‰ with room temperature ranging from 23° to 27° C. The experiment began with 150 postlarvae per aquarium. At intervals of 5 to 7 days, 10 shrimp were removed from each test aquarium, weighed, their length measured, and preserved. The mean weight of shrimp in each test group is indicated in the accompanying figure. Data for both

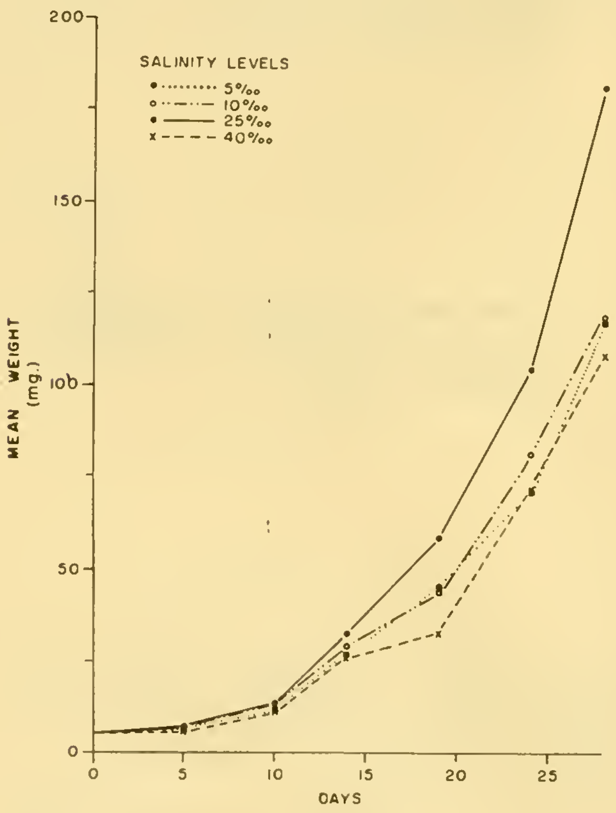


Laboratory growth of postlarval brown shrimp fed various diets. (Salinity: 25‰)

diets containing brine shrimp were combined, since the addition of the brown alga increased neither the growth nor the survival rate but merely afforded a hiding place during periods of molt. Growth data from the groups fed ground mullet and ground shrimp were similarly combined.

It is quite apparent that a diet of live brine shrimp, yielding a mean growth of 2.8 mg. per day and a maximum rate of 7.8 mg. per day, gave far better results than any of the other diets. Neither of the algal diets produced good growth, and, in addition, the rate of survival for animals fed the brown alga alone was less than half that of the animals fed brine shrimp (33 percent as against 80 percent). The ground-meat diets tended to foul the experimental aquaria, making them impractical food items. It was concluded that live-animal foods are by far the most satisfactory, not only in terms of growth but also in terms of application and degree of utilization by the experimental animals. Food supply seemed to be a limiting factor regardless of whether or not brine shrimp were included in the diet. With the brine shrimp diet, the growth rate dropped noticeably in the experiment's later stages, during which the amount of food supplied was obviously inadequate for the number of animals present.

With brine shrimp as the only food involved, a second experiment was undertaken to determine the effects of salinity on the growth of postlarval brown shrimp. Four levels of salinity were established, viz., 5‰, 10‰, 25‰, and 40‰. These were adjusted over 48-hour periods by adding distilled or concentrated sea water to the "control" sea water (25‰) to obtain the desired level. As in the preceding experiment, 10 animals were removed at 4- or 5-day intervals for weight and length measurements. The accompanying figure shows that consistently better growth was obtained in all salinity groups than in the previous experiment with the diet group fed live brine shrimp. (cf. figure for experiment described in previous section.) This may have been partly due to the use of fewer animals in the salinity test aquaria (100 as against 150 animals in the diet experiments). There was, however, significantly greater growth at 25‰ than at any of the other salinity levels, this being noted at all stages of the experiment. No significant differences in growth could be detected among the other salinity groups. The mean rate of increase was 3.8 mg. per day (0.6 mm. per day) with a maximum in 25‰ of 9.8 mg. and 0.8 mm. per day. The greater growth at 25‰ may be related to a decreased survival rate (more food per animal), since only 36 percent of the animals survived, as against 68 percent in each of the other salinity groups.



Laboratory growth of postlarval brown shrimp at four levels of salinity. (Diet: Live brine shrimp nauplii.)

These findings suggest that for immature brown shrimp good growth and survival are possible over wide salinity ranges, provided an adequate food supply is available. This should stimulate reexamination of the hypothesis that young shrimp require low salinity levels for adequate growth.

Use of Anesthetics in Metabolism Studies With Penaeid Shrimps

Zoula P. Zein-Eldin

During the past 3 years, studies of oxygen consumption in two species of Penaeus have enabled us to determine a standard rate of metabolism for each. Since differential physical activity in experimental animals may be a major source of variability in the measurement of oxygen uptake, the possibility that it might be eliminated by general anesthesis is being examined. For this purpose, the anesthetic should act rapidly, have an effective period of at least 1 hour (to permit accurate respirometry), and be nontoxic. Of the seven compounds tested (sodium pentabarbital, ethclorovynol, methylparafynol, tribromoethanol, chlorobutanol, menthol, and M.S. 222), none seem to meet all the above requirements at any given concentration. The effective anesthetic dose for postlarval shrimp was found in all cases to be at least 10 times greater than that for fish of comparable weight. Moreover, there is a very narrow concentration range in which rapid sedation can be obtained and maintained without fatality. Present tests are investigating the feasibility of using a high initial concentration to induce sedation, followed by a reduced maintenance dosage.

SPECIAL REPORTS

Chemicals Toxic to the Red-Tide Organism

Kenneth T. Marvin and Raphael R. Proctor

The current project was started in March 1959 to find a chemical means of controlling intense plankton blooms and thus preventing the damaging effects of the red-tide organism, Gymnodinium breve. Previous control attempts have been made by applying copper in both solution and powdered form (copper sulfate) to affected areas. Large-scale experiments employing tons of material demonstrated, however, that although copper can give temporary relief in localized situations, it is neither economically nor chemically feasible for large-scale control. Present research involves the screening of nearly 5,000 primarily organic chemicals in a search for a material with which the desired degree of control would be feasible.

Preliminary tests evaluated all chemicals as toxicants for G.breve. These tests, which were covered in last year's laboratory report, permitted separation of those materials toxic at concentration levels of 0.04 p.p.m. (parts per million) or less from those that were not. The latter group was discarded.

This year we decided that to be economically suitable, a potential control material must be toxic to G. breve at a concentration of 0.01 p.p.m. or less. We therefore separated the ".01" chemicals from the ".04" group. The procedure involved was similar to that covered in the previous report. Each chemical in the ".04" group was retested three times at five concentrations ranging from 0.04 to 0.0004 p.p.m. Two that were toxic at 0.0004 p.p.m. were further tested at 0.0001 p.p.m. In this manner, 32 compounds toxic at 0.01 p.p.m. or less were separated from the ".04" group.

Current activity centers on determining the selectivity of the ".01" group. The material being sought must be toxic to G. breve, but at the same time have no harmful effect, either directly or indirectly, on commercially important species. Our approach to the problem considers short-term effects only. Any control material recommended as a result of this study should therefore be used cautiously until long-term effects are ascertained.

The study consists of observing the effects of chemicals in the ".01" group on the young of various species of marine life found in Galveston Bay and Gulf coast waters. Each chemical is tested at five concentrations ranging from 0.01 to 1.0 p.p.m. Tests are conducted in 10-liter, all-glass aquaria, each of which contains 10 specimens of the organism being tested in 8 liters of treated water from our recirculating sea-water system. All chemicals are initially prepared in an alcohol solution, hence alcohol as well as untreated-sea-water controls are included with every trial run.

One-tenth (0.10) p.p.m. was arbitrarily selected as the threshold level. Any chemical that kills 50 percent or more of any test organism at or below this level within the 24-hour test period is rejected. Thus far, all but

Each chemical is tested for its effect on the young of various species of marine life.

eight chemicals have been eliminated. (See accompanying table; blank spaces indicate temporary nonavailability of test organisms.)

A source of variation over which we have no control and one that could have a profound effect on the results of this project is differential toxicity of some chemicals with respect to source of supply. For example, we had to replenish our supply of 3-5-hexadienoic acid, 2-oxo-6 phenyl which, as shown in the accompanying table, is one of the two most toxic materials tested. The new compound, which is supposedly the same as the original, has not proved toxic to G. breve at any of the levels tested.

Difficulty in finding new sources of supply for some of our materials is also causing concern. For example, our supply of mercury acetate, (2, 3-dimethoxy tetramethylene) bis-, one of the two most toxic materials tested, is exhausted. The original supplier no longer exists, and to date we have been unable to find a new one.

Now being planned is a second series of tests through which the chemicals that have passed the selectivity tests will be rechecked to determine their minimum toxic level for G. breve in relatively large volumes of culture. Each compound will be checked at five concentrations, viz., .01, .003, .001, .0003, and .0001 p.p.m. in 5 liters of G. breve culture. This will be a 500-fold increase in volume over previous tests and should give an indication, among other things, of the surface-volume effect.

Mortality estimates will be made after 24, 48, and 72 hours, following which selectivity tests will be made on important marine species. To minimize water-quality variables, tests will be made in G. breve media instead of water from the recirculating sea-water system. Potential control chemicals will also be tested in synthetic sea-water medium containing both commercially important species and a sublethal population level of G. breve.

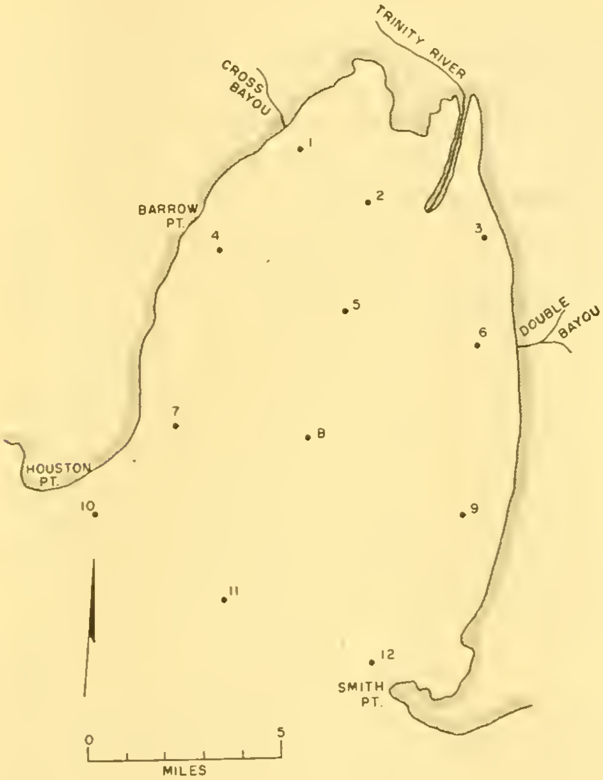
Results of chemical screening experiments with species other than *Gymnodinium breve*

Chemical name	Maximum test concentration tolerated by more than 50 percent of the test organisms										Minimum concentration toxic to *G. breve*
	Brown shrimp	Grass shrimp	Hermit crab	Blue crab (megalops)	Marsh periwinkle	Sheepshead minnow	Sailfin molly	Striped mullet	Pinfish	Atlantic croaker	
	(p.p.m.)										(p.p.m.)
Mercury acetate, (2, 3-dimethoxytetra-methylene) bis-	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	-	-	0.0004
3,5-Hexadienoic acid, 2-oxo-6-phenyl-	1.0	1.0	1.0	1.0	0.3	1.0	1.0	1.0	1.0	-	0.0004
Tetraethylthiuram disulfide	1.0	-	1.0	1.0	1.0	1.0	0.3	0.3	0.3	0.1	0.004
Ferric dimethyl-dithio carbamate	1.0	-	1.0	1.0	1.0	1.0	1.0	0.1	-	0.1	0.004
Dimethyldithio carbamic acid and 2-Mercaptobenzothia-zole; sodium salts	1.0	-	1.0	1.0	1.0	1.0	0.3	1.0	-	1.0	0.01
Sulfide, bis(2-hydroxy-3-bromo-5-chlorophenyl)-; cyclohexylamine mono salt	1.0	-	1.0	1.0	0.1	0.3	0.3	0.1	1.0	0.1	0.01
Sulfide, bis(2-hydroxy-3-bromo-5-chlorophenyl) bis-dimethylamino butyne mono salt	1.0	-	1.0	1.0	0.1	0.1	0.3	0.1	0.1	0.1	0.01
Tellurium diethyl-dithio carbamate	1.0	-	1.0	1.0	1.0	1.0	0.3	0.1	-	0.1	0.01

Results of the Trinity Bay Study

Richard A. Diener

The Trinity River watershed covers about 17,635 square miles in the eastern half of Texas. The watershed, about 350 miles long and 70 miles wide, empties into Trinity Bay east of Houston. Trinity Bay, a part of the Galveston Bay system, covers about 89,000 acres, and is a valuable estuarine habitat utilized by numerous commercially important species of fish and crustaceans. This importance is reflected in Texas landings, of which approximately 98 percent by weight is composed of species that are in some way dependent on estuaries.

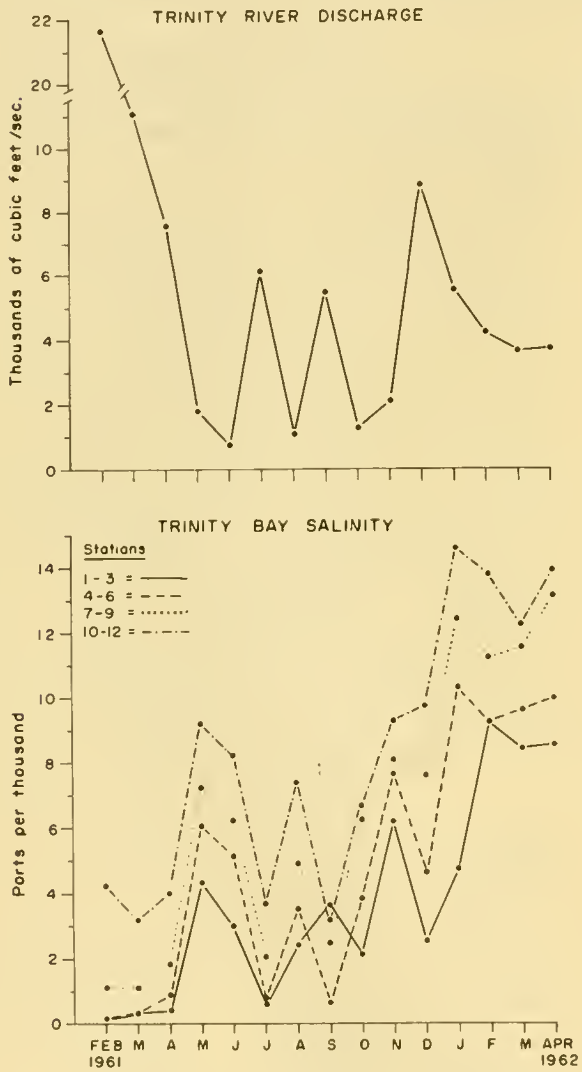


Trinity Bay sampling stations

Water development plans in the Trinity River watershed by various private, State, and Federal agencies have not yet been completely formulated, but these will include projects for flood control, navigation, and conservation storage for municipal, industrial, and irrigation uses. When considered on an individual basis, each project will reduce the fresh-water discharge into Trinity Bay by only a fraction, but when the effects of all are compounded, the reduction of fresh-water discharge will be considerable. A large share of the runoff would be returned to upper Galveston Bay (near Trinity Bay) by way of the Houston Ship Channel and the San Jacinto River.

The effects of the reduced fresh-water discharge upon the fauna and the existing water conditions of Trinity Bay are of vital concern to the welfare of commercial and sport fishing interests in Trinity, Galveston, East, and West Bays, and to offshore species dependent upon these brackish waters for nursery areas. The Trinity Bay field study by this laboratory (supported by funds supplied through the Branch of River Basins, Bureau of Sport Fisheries and Wildlife, Region 2) was conducted to determine what effects the projects would have upon the Trinity Bay estuarine habitat and to formulate recommendations which would minimize any detrimental effects.

In January 1961, 12 stations were established in Trinity Bay, these being located along three gridlines (four per line) oriented with the long axis of the bay, which runs from the Trinity River delta to a line extending from Houston Point to Smith Point. Operations at each station included a Secchi disc reading for turbidity, surface and bottom measurements for temperature and salinity, and a 5-minute trawl haul for biological specimens. Considerable bias is created in Secchi disc readings due to variations in cloud cover, position of the sun, and recording methods utilized by different individuals. Bias is also possible in the trawl samples due to the alternate use of several different vessels. This sampling continued through April 1962 on a biweekly basis when weather permitted.



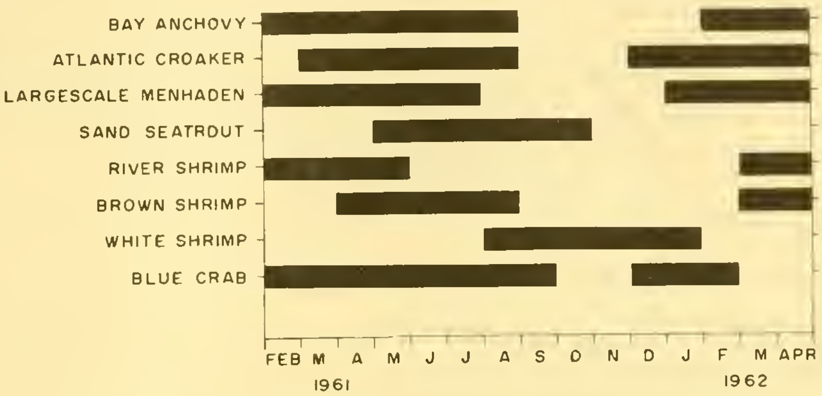
Monthly mean salinity for four tiers of sampling stations in Trinity Bay, February 1961 to April 1962.

With only two exceptions, the monthly mean bottom salinity for each tier of three sampling stations increased with increasing distance from the mouth of the Trinity River. (See accompanying figure.) The high salinity recorded in September for Stations 1-3 may be in part due to pockets of high saline waters deposited in upper Trinity Bay by Hurricane Carla, which passed through the area on September 9-12, 1961. A study of river discharges into, and salinity levels within, Trinity Bay indicates that increased discharges of fresh water are generally associated with a lowering of salinity, and vice versa. (See figure.) Lags between varying discharge and the associated rising or lowering of salinity are commonplace phenomena in the study area.

Light penetration recordings by means of Secchi discs range from a minimum of 7 cm. to a maximum of 90 cm. The greatest turbidity was observed in a belt from the mouth of Trinity River to Smith Point, while the northwest half of the bay was slightly clearer.

Water temperatures ranged from 3.5° to 29.8° C. at the bottom, whereas the surface temperatures ranged from 1.0° to 29.9° C. These low temperatures, both bottom and surface, were generally higher at the northwest and southeast margins of the study area, and cooler in a central belt running from the mouth of Trinity River to a point midway between Smith and Houston Points.

Approximately 60 species of vertebrates were taken throughout the course of the study, and these were dominated by such typical estuarine forms as the Atlantic croaker, Micropogon undulatus, and the bay anchovy, Anchoa mitchilli. (See figure.) The fresh-water catfishes, Ictalurus punctatus, and I. furcatus, were found near the center of the bay during February and March 1961.



Months of greatest relative seasonal occurrence of principal fish and shellfish.

The fresh-water shrimp, Macrobrachium ohione, and the blue crab dominate the motile invertebrate fauna during the early spring but are gradually replaced in late spring by the brown shrimp. This species is in turn replaced by the white shrimp in midsummer (August).

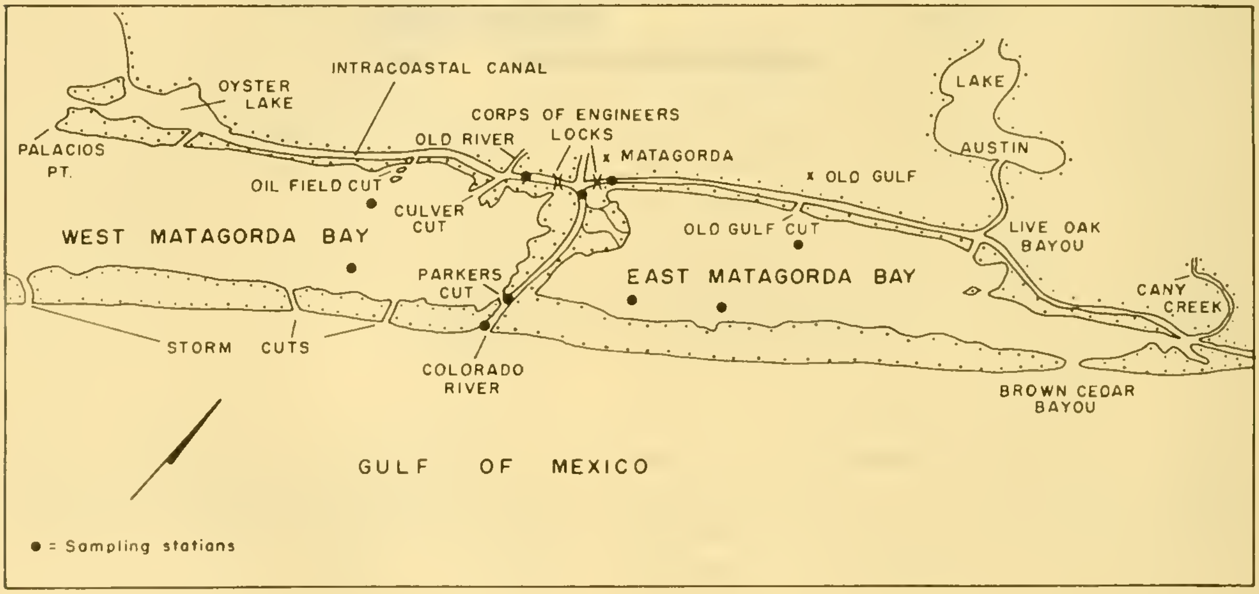
From the above data coupled with those found in the literature, it appears that optimum salinity for the Trinity Bay estuarine habitat lies between 10‰ and 17‰ with the lower and higher extremes appearing near to and away from the mouth of the river, respectively. To maintain this habitat, it was recommended that a mean monthly discharge of 2,000 c.f.s. be maintained during the critical months of March through October when the bays are utilized by important estuarine species.

The Colorado River-Matagorda Bay Study

Charles H. Koski

The purpose of this project is to ascertain the probable effects on estuarine fauna of reduced fresh-water discharge into the lower basin and adjacent bays caused by proposed impoundments in the Colorado River watershed. This project is supported by funds supplied through the Branch of River Basins, Bureau of Sport Fisheries and Wildlife, Region 2.

Field operations were initiated in February 1962 to determine the distribution and abundance of the estuarine fauna. With each being occupied once every 2 months, three stations were established in the Colorado River below the town of Matagorda, two in West Matagorda Bay (west of the river), three in East Matagorda Bay, and two in the Gulf Intracoastal Waterway. (See figure.) Salinity and temperature measurements (surface and bottom) and a 5-minute trawl tow for biological samples were made at each of these stations. An additional station was established at Parkers Cut, between the river and West Matagorda Bay, to measure salinity, temperatures, and approximate current. Irregular bottom and swift currents prohibit trawling at this station. Meteorological conditions are noted during each trip.



Colorado River-Matagorda Bay sampling stations.

In one West Matagorda Bay station, a 1/8-inch mesh nylon cover was used over the cod end of the trawl net to obtain postlarval shrimp and other small forms, which would normally pass through the larger mesh of the net.

Water temperatures during the study ranged from 11° to 29° C. with the salinity ranging from 1.7‰ at the station in the upper river to 30.3‰ at the mouth. During calm weather, surface turbulence at the seaward edge of the salt-water wedge in the river was readily observed. Salinity readings on the bottom indicate that the leading edge of the wedge was often several thousand feet upstream of the surface manifestation. Parkers Cut provides a connection between West Matagorda Bay and the Colorado River, and currents induced by ebb and flood tides are sometimes very swift in this area. Parkers Cut, however, does not seem to appreciably affect the salinity in West Matagorda Bay. At present, the salinity seems to be relatively stable, probably due to passes opened on the Gulf side by Hurricane Carla. These passes will probably be closed eventually by the surf and subsequent silting action, eliminating the exchange of water between the Gulf and bay. (See figure.)

The average salinity in both West Matagorda and East Matagorda Bays was identical (25‰), but the range was greater in the former (17.3‰ to 31.2‰) than in the latter (17.5‰ to 28.1‰). There are two cuts between the Gulf Intracoastal Waterway and West Matagorda Bay. These cuts are a source of lower salinity water (average, 20‰) flowing into West Matagorda Bay from the waterway. In East Matagorda Bay, there are three cuts between the waterway and bay. Live Oak Bayou and Caney Creek flow into the waterway and through their respective cuts into East Matagorda Bay. These two cuts are at the extreme eastern end of the bay and opposite Brown Cedar Cut. It is possible that these waters flow through Brown Cedar Cut and into the Gulf. The third cut, Old Gulf Cut, is located about midway, opening from the waterway into the bay. The source of fresh water in these bays is very limited, the main source coming through precipitation and mixing of the Colorado River water with the water in the canal. During June, at the close of the study and the beginning of the warm weather, the salinity in these bays approached 30‰. Probably as the weather became milder and evaporation increased, it rose even higher. If the flow of fresh water in the Colorado River is reduced, the salt-water wedge will move farther up the river and into the Gulf Intracoastal Waterway. This would bring the bays to yearlong sea-water conditions and decrease their value as nursery areas for many of our marine forms. Tentatively, it would appear that regulation of the fresh-water discharge from any impoundment upstream would be desirable, especially during periods of low rainfall and high salinity and during the months when the bays serve to rear juvenile forms. A diversion channel from the river into the bays might be helpful in maintaining suitable bay habitat and would prevent loss of fresh water into the Gulf.

Preliminary analysis of the data indicates that the three most abundant finfish taken in the trawl samples were the Atlantic croaker, the spot, and the bay anchovy. The croaker was the most abundant fish taken, averaging 58 fish per tow with modal length increasing from 20 to 60 mm. by late June. The spot was second in abundance with an average catch of 15 fish per tow and modal length increasing from 35 to 60 mm.

The bay anchovy, the least abundant of the three species mentioned, averaged only three fish per tow. This contrasts with Galveston Bay, where at this time of year the anchovy usually occupies second place in abundance, with the spot in third place. The modal length of the bay anchovy was between 40 and 50 mm.

Thirty-three other less abundant species of finfish were caught. As a whole, the biological samples are typical of brackish estuaries and bays in this area for this time of year, with a few exceptions. Near the mouth of the river and along the Gulf side of West Matagorda Bay, the stations occasionally yielded a few marine forms not normally associated with the estuaries.

Among the motile invertebrates taken, 3 species of the 10 recorded have been classed as the most important commercially. The other seven forms are of little commercial value.

The blue crab has been relatively abundant with an average catch of six crabs per tow. During April, a large number of mature ripe females moved into the river and West Matagorda Bay.

Large white shrimp occurred sporadically from February to May. The largest of these shrimp reached 32 g. During June, smaller white shrimp (average, 0.50 g.) were taken in increasing numbers, indicating that the summer run was beginning. The average catch of large white shrimp from February to May was 0.5 per tow; in June, the smaller shrimp averaged 12.5 per tow. Postlarval shrimp, probably brown shrimp, were first taken in the trawl cover during early April. Subsequent samples indicated an increase in the size and numbers of individuals as well as a continuing influx of postlarval shrimp. By the latter part of April, the earlier arrivals had attained a size large enough to be retained in the larger mesh net, and thus began appearing in increasing abundance at the other nine trawl stations. In May and June, the modal weight was between 1.0 and 2.5 g. with a few as large as 21 g. The average catch per 5-minute tow during April, May, and June was 60.

Oysters are abundant in East Matagorda and West Matagorda Bays, in both shallow and deep waters. A sizable commercial fishery is dependent upon these shellfish. No attempt has been made to study oyster ecology in relation to this project.

Several boats operate trammel nets commercially, chiefly in the shallow waters of West Matagorda Bay. They take principally redfish, *Sciaenops ocellatus*, and speckled trout, *Cynoscion nebulosus*.

Families of finfish and numbers of species represented in the trawl samples.

Species	Number of species
Dasyatidae -- Stingrays	1
Clupeidae -- Herrings	2
Engraulidae -- Anchovies	1
Ariidae -- Sea catfishes	2
Anguillidae -- Freshwater eels	1
Gadidae -- Codfishes and hakes	1
Mugilidae -- Mullets	2
Polynemidae -- Threadfins	1
Haemulidae -- Grunts	1
Scianidae -- Croakers	8
Sparidae -- Porgies	2
Ephippidae -- Spadefishes	1
Uranoscopidae -- Electric stargazers	1
Blenniidae -- Blennies	2
Gobiidae -- Gobies	4
Triglidae -- Searobins	1
Bothidae -- Lefteye flounders	4
Soleidae -- Soles	1
Cynoglossidae -- Tonguefish	1
Monacanthidae -- Filefishes	1
Tetraodontidae -- Puffers	1
Gobiesocidae -- Clingfishes	1
Batrachoididae -- Toadfishes	1

Number of animals taken in trawl samples, 1962. Number of tows in parentheses.

Major species	February (6)	March (20)	April (20)	May (30)	June (20)
Atlantic croaker	58	1,067	1,895	2,116	435
Spot	2	191	319	681	281
Bay anchovy	8	33	68	91	125
Blue crab	5	83	224	238	45
White shrimp	1	4	21	12	253
Brown shrimp	0	0	212	2,565	1,418

The areas adjacent to the lower Colorado River are the east end of West Matagorda Bay and the west end of East Matagorda Bay. These areas were the primary concern of the project and shall be termed "bay heads."

The average depth of these bay heads within 3 miles of the Colorado River is $2\frac{1}{2}$ feet. Due to their shallowness, they are subject to high temperature and salinity during seasons of warm weather. Heavy downpours seem to have little effect on the salinity regime because they are usually too abrupt and of too short a duration. At present, the biota of these bay heads seem to be comparable to that of other coastal bays of East Texas. This is probably due to the present low salinity and temperature levels. During drought years, usually coupled with low river discharge, high salinities can be expected in these bay heads, which might cause a drastic reduction in desirable biota. Although there is little direct evidence that moderately high salinities in themselves have a detrimental effect on the biota, there may be associated factors that depend largely on salinity or temperature or both to maintain suitable estuarine habitat.

At the present state of our knowledge, indications are that if these bay heads are to maintain a suitable habitat for estuarine biota, it would be advisable to regulate river discharge so that salinities will be maintained between 10‰ and 30‰. This is especially important during the two seasons of greatest influx of the immature forms, i.e., early spring, and late summer through early fall. During the remainder of the year, precipitation and low temperatures will probably suffice to maintain the habitat if river discharge is not either completely shut off or allowed to flow too freely.

If a water control gate were installed approximately a mile and a half below the point at which the river intersects the Intracoastal Waterway, and canals were cut through the riverbanks into the adjacent bayous, fresh water could flow directly into the bay heads under controlled conditions. During periods of low rainfall and runoff, this would provide maximum use of the fresh-water discharge. This would in no way affect the lower part of the river as far as sport or bait fisheries are concerned, and it would allow easier access to the bay heads by boat, thus permitting greater utilization of these areas.

Salinity check stations could be set up in the bays so that riverflow may be regulated with maximum benefit to all interests. The lower Colorado River itself, below its intersection with the Gulf Intracoastal Waterway, fluctuates in salinity with the tides and winds, this varying from day to day as much as 20‰. At Station "A" the surface water is sometimes as low as 1‰ and as high as 22‰. The bottom salinity is usually high, ranging from 16‰ to 29‰. Anything that would reduce this tremendous fluctuation in river salinity would be beneficial to the biota. Every effort should be made to maintain the present status of these bay heads and possibly to reduce the salinity fluctuations in the river itself.

Movement of Water Masses in Galveston Harbor

Cornelius R. Mock

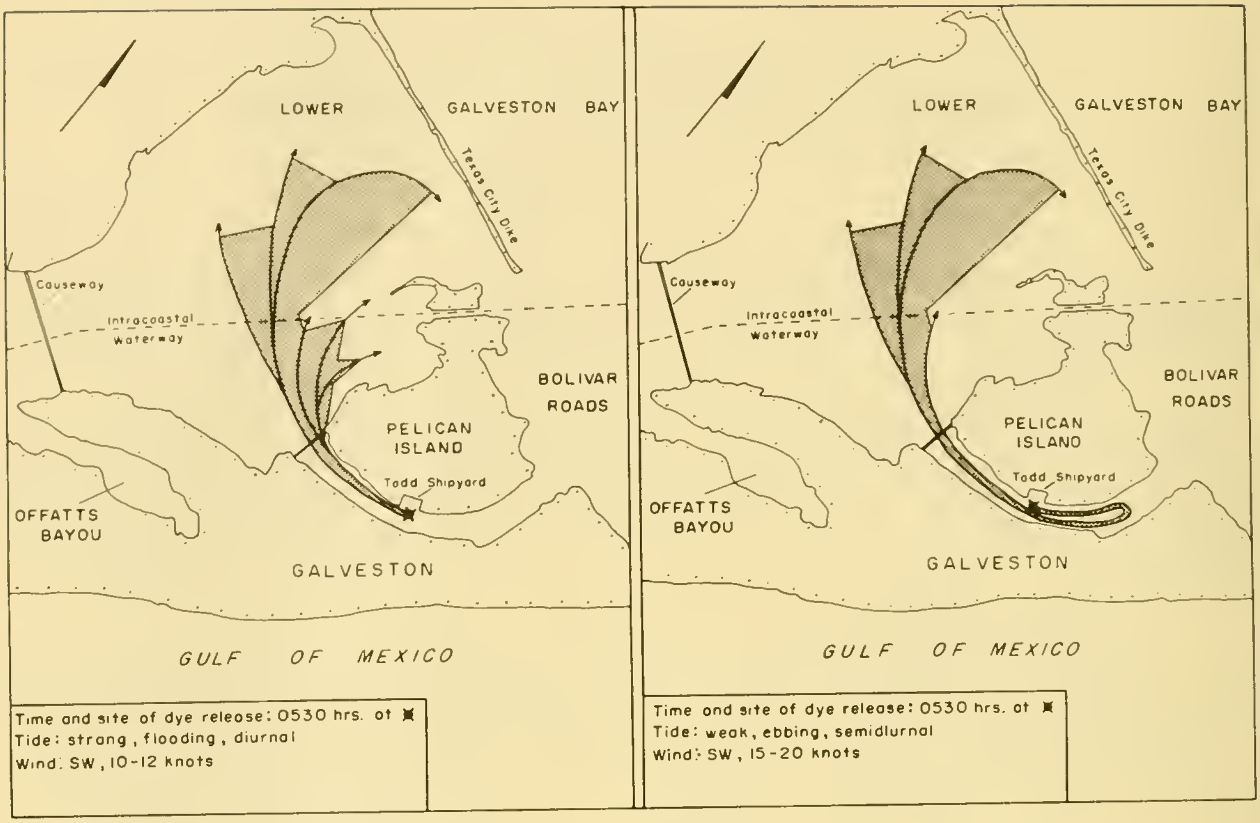
Todd Shipyard located on Pelican Island in the port of Galveston has been chosen as a docking and servicing facility for the nuclear powered ship SAVANNAH.

Although refueling of the vessel is a relatively safe process, it is likely that if an accident should occur during the handling, the general area would become contaminated. With this in mind, the Navy Hydrographic Office in Washington, D. C., the U. S. Army Corps of Engineers (Galveston District), and the Bureau of Commercial Fisheries Biological Laboratory cooperated in an investigation of the movement of water masses through the Galveston Harbor area.

The investigation was begun on May 4, 1962, with the first few days being spent surveying the area and adapting equipment and methods for the study. Background fluorescence was monitored with a fluorometer. This instrument was adapted for operation while underway by securing a hollow tube to the side of the boat. A sample of water from a constant depth of 6 feet was drawn directly, by way of the tube, to a receiving tank aboard the vessel. A bypass was installed to monitor a constant volume of the water. An induction conductivity salinometer was used to obtain depth profiles of salinity and temperature.

Rhodamine B, a red fluorescent dye in a liquid form, was used to trace the flow pattern from the vicinity of Todd Shipyard. Fifty gallons of this dye were introduced into the water May 7, 1962, at 0530 hours, which marked the beginning of a strong flooding diurnal tide. The patch of stained water began to drift westward along the Galveston Channel. Upon reaching the area west of Pelican Island Bridge, the patch immediately took on a northwesterly to northerly route. The dye then began to spread out in the pocket between the Texas City Dike, Galveston Intracoastal Waterway, and the mainland. After the dye became too diluted for visual recognition, the fluorometer continued to make contact at the northern tip of Pelican Island and southwest of the Texas City Dike.

In a second test initiated on May 15 at 0530 hours, dye was released at the beginning of a weak, ebbing, semidiurnal tide. It moved very slowly for about a mile in an eastwardly direction. With the combination of a 15- to 20-mile southwesterly wind and the onset of the flooding tide, the movement of the dye patch reversed toward Todd Shipyard and along the



The distribution of rhodamine B dye in Galveston Bay ship channel on May 7, 1962 (left), and May 15, 1962 (right).

Galveston Channel to the Pelican Island Bridge. The patch then passed under the bridge and began to disperse in a generally northwest to northerly course, as it had on the first dye release. A northeasterly shift was noted, and the dye proceeded to diffuse into Galveston Bay. Samples taken for 3 days after the drop indicated that the dye remained in the same general area between Pelican Island and the Texas City Dike.

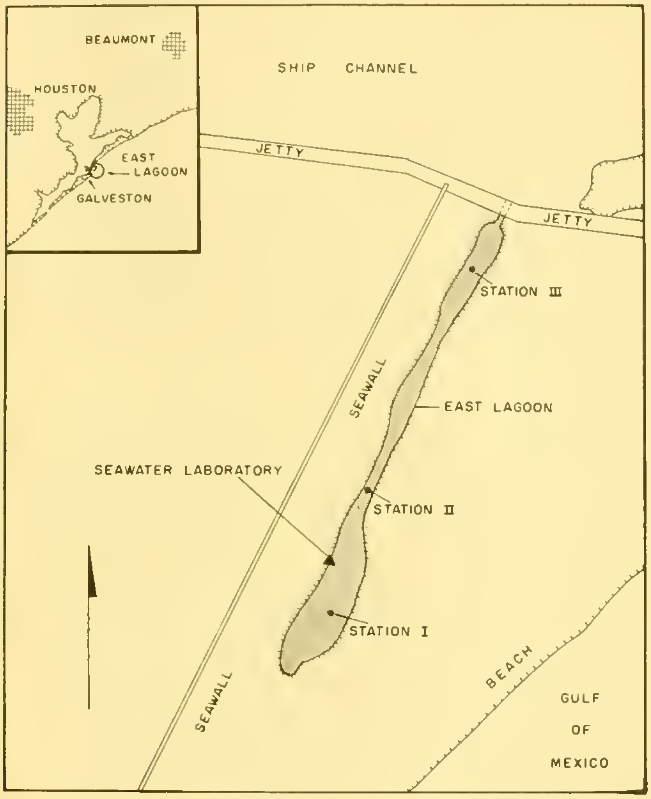
Factors which had a direct effect on the direction of the currents were: (1) wind direction, (2) wind duration, (3) wind velocity, (4) shape of shoreline, and (5) amount of deep and shallow water.

Estuarine Water Observations During a 24-Hour Cycle

Ray S. Wheeler

A study of some of the continuous physical and chemical changes during a 24-hour period in a 1 1/10-mile lagoon at the northeast end of Galveston Island was made on July 2 and 3, 1958. This particular body of water was selected for study because of its accessibility and its similarity to other estuarine waters in the area. The East Lagoon sea-water laboratory was later constructed on this lagoon.

Samples were collected for oxygen, carbon dioxide, total phosphate, inorganic phosphate, nitrate-nitrite, nitrite, ammonia, carbohydrate, salinity, and chlorophyll "a" determinations. In addition to chemical samples, observations were made of water and air temperatures and tidal fluctuations.



Sampling stations on East Lagoon, Galveston Island.

Samples and observations were taken concurrently at 2-hour intervals at each of three stations. These intervals are referred to as periods 1, 2, 3, etc. Period 1 started at 0630 hours. Station I was located at a point farthest from the inlet, Station III at the inlet, and Station II halfway between.

There was a general rise in oxygen values at each of the three stations for the first six periods, i.e., during the hours in which photosynthetic processes took place. From period 7 to period 9, there was a steady decline in dissolved oxygen, after which an abrupt increase was evidenced between periods 9 and 10. If oxygen alone is used as a measure of productivity, these data seem to indicate considerable phytoplankton production within the lagoon. The chlorophyll "a" values also support this conclusion, especially as an ebb tide was concurrent with the diurnal phase of this study.

During sampling period 1, we noted that oxygen values were greatest at Station III and gradually declined in value toward Station I. Two reasons for this are suggested. First, the lower values obtained at Station I could have been due to the respiratory demands of the dense floral and faunal populations during the hours of darkness immediately preceding the sampling period. Secondly, greater aeration of the water might have occurred at the mouth of the lagoon due to wave action and mixing of the water at the restricted inlet. Any change in oxygen concentration due to the tide reversal which occurred between periods 10 and 11 was either masked or wholly lacking, for the sharp increase in oxygen concentration was noted throughout the lagoon 2 hours before the flood tide commenced (between periods 9 and 10).

No explanation is offered for the erratic pattern of carbon dioxide values.

Samples for total phosphate were frozen after being collected and remained so until analyzed. Each sample was divided, half being filtered and half remaining unfiltered. An appreciable difference in concentration of phosphates exists between filtered and unfiltered samples. The difference in concentration between the filtered and unfiltered samples is indicative of the amounts of phosphates contained in the particulate matter.

Values were such that no distinction could be made between samples taken during the hours of daylight and those taken during the hours of darkness. Some fluctuations in concentrations of total phosphates were evident, the most striking being at Station III, period 12, where the unfiltered sample contained more than five times as much phosphate as the filtered sample. This particular sample was collected after the turn of the tide and at a time when a strong prevailing current resulted in particulate matter being maintained in suspension.

Inorganic phosphate samples were left unfiltered. The average values for each station during the daylight hours indicate that an inorganic phosphate gradient exists between the two extremities of the lagoon with the greatest concentration in the Station I area. Values for each station display considerable variation, and it is doubtful whether or not this gradient display is of real significance since there is a relatively small difference in average values between stations. Values during the hours of darkness, although still variable, are not quite as erratic as those during the daylight hours. Average nighttime values were of the same magnitude as those of daylight hours at Stations I and II, but slightly higher at Station III with no gradient existing between stations. With the change of the tide, an abrupt drop was noted in the inorganic phosphate content at Station III during period 11.

When the values for both total and inorganic phosphate at each station were compared, we noted that the concentration of phosphorus in the unfiltered total phosphate sample was consistently higher than that in the unfiltered inorganic phosphate sample. The difference represented an estimate of the total organic phosphate. The phosphorus contained in the unfiltered inorganic phosphate samples was consistently greater than the amount of phosphorus contained in the filtered total phosphate samples, indicating more particulate inorganic phosphate than dissolved organic phosphate.

The nitrate-nitrite values point up the difference in concentrations that exists between Stations I and III. The lower values at Station I are attributed to the utilization of nitrogen by denser growths of phytoplankton at that station. Nitrite concentrations were considerably lower than nitrate-nitrite values and varied between stations and periods.

Ammonia was found in only 11 of the 36 samples analyzed. Considerable variation in concentrations existed between those samples in which ammonia was found. No explanation can be offered for this patchy distribution other than perhaps streaks of ammonia originating from some organic decomposition.

Measurement of the arabinose equivalent from the unfiltered samples shows that the production of carbohydratelike material occurred during the daylight hours. A gradual increase in the concentration of this material was evident during the hours in which photosynthetic processes were taking place. No carbohydrate breakdown was apparent until just before dark. The production of carbohydrates was greatest at Station I and least at Station III.

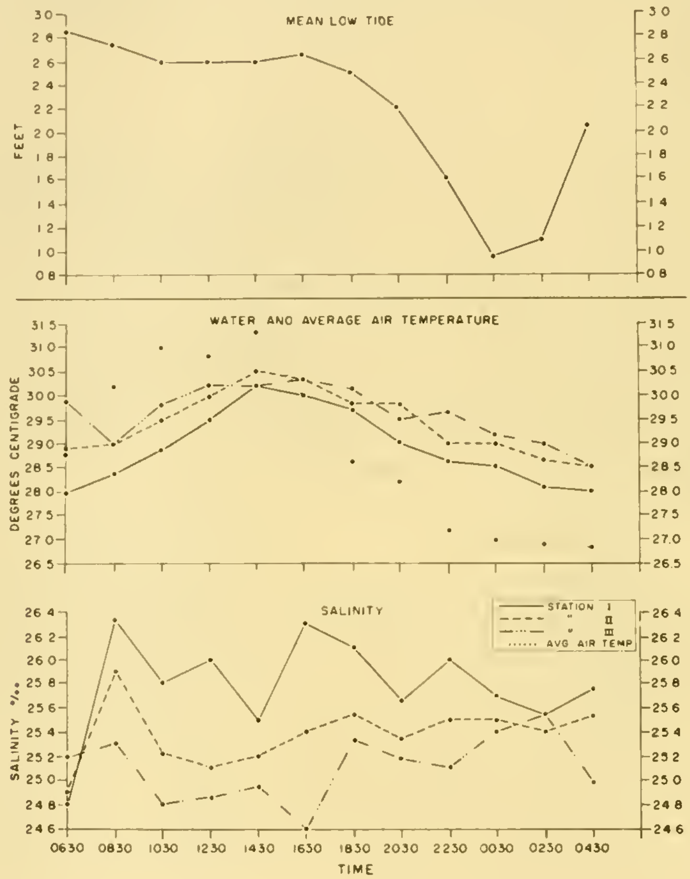
Salinities were obtained from density and temperature data. These values were quite variable, the greatest differences being noted at Station I. Increasing salinity from Station III toward Station I was probably caused by a poor water exchange coupled with excessive evaporation in the upper extremities of the lagoon.

Samples were quantitatively analyzed for chlorophyll "a", which had its highest concentration in the upper extremities of the lagoon, becoming progressively lower at Stations II and III. The values obtained for Stations II and III remained fairly constant. When the bihourly chlorophyll "a" values during daylight hours (periods 1-7) were averaged and compared with those of the hours of darkness (periods 8-12), a significant difference was noted only at Station I where production was markedly greater during the daylight hours. These averages further indicate that chlorophyll "a" concentrations differ significantly from station to station. Station II averaged 74 percent of that of Station I for the 12 periods; Station III averaged 58 percent of that of Station I for the 12 periods.

Water temperatures followed the normal diurnal rise and nocturnal fall. However, there was relatively little difference in temperature between stations and between collecting periods during the study. The total difference amounted to only 2.3° C. It is doubtful that this slight fluctuation would have a significant effect upon any of the values obtained.

Air temperatures for each period were obtained by averaging the temperatures recorded at each of the three stations. They followed the same trend as those of the water, reaching a maximum of 31.3° C. and a minimum of 26.9° C.

The tide level fluctuated between 2.81 feet and 0.95 feet above mean low tide. A flooding tide immediately preceded the study; the crest of this tide coincided with the first sample collected during period 1. Except for those collected during periods 11 and 12, the remaining samples were taken on the ebb tide. Because of the length of the lagoon and the comparatively small difference in tide levels, it is believed that only a very limited tidal exchange takes place.



Observations made on East Lagoon, Galveston Island, during a 24-hour cycle.

Water analysis at three stations during a 24-hour period.

	Period	Station I					Station II					Station III				
		* Nitrite	** Dissolved oxygen	*** Nitrate-nitrite	+ Carbon dioxide	++ Ammonia	Nitrite	Dissolved oxygen	Nitrate-nitrite	Carbon dioxide	Ammonia	Nitrite	Dissolved oxygen	Nitrate-nitrite	Carbon dioxide	Ammonia
Daylight	1	0.22	5.01	1.0	31.43	4.2	0.24	5.30	1.1	29.74	0.3	0.19	6.25	1.0	30.02	0.0
	2	.22	5.37	1.0	19.50	1.1	.35	5.04	0.8	21.31	.1	.21	5.16	0.8	33.92	.0
	3	.24	5.79	1.0	28.88	.0	.24	7.08	0.6	20.33	.4	.24	6.89	1.3	29.80	.0
	4	.24	7.58	1.0	26.46	.0	.32	7.64	1.0	32.03	.5	.22	7.36	1.8	28.63	.0
	5	.22	8.39	1.0	26.04	.0	.26	7.87	1.1	5.90	.3	.37	7.48	1.2	16.15	3.5
	6	.22	8.43	1.0	30.64	.0	.19	8.22	1.0	34.66	.0	.26	7.60	1.1	27.71	1.0
	7	.22	7.57	1.0	36.91	.0	.21	7.68	1.2	27.75	1.4	.26	7.43	1.2	31.45	.0
Dark	8	.46	7.19	0.7	29.44	.0	.24	6.92	1.3	21.68	.0	.26	5.83	1.1	35.04	.0
	9	.24	5.03	1.0	37.34	.0	.16	5.31	1.2	34.80	.0	.41	4.12	1.2	27.20	.0
	10	.29	5.92	1.0	20.46	.0	.19	6.73	1.2	22.05	.0	.40	6.68	1.3	20.34	.3
	11	.19	6.57	0.8	+++	.0	.14	5.03	1.0	+++	.0	.35	6.57	1.0	+++	.0
	12	.21	6.81	.0	+++	.0	.22	6.74	1.0	+++	.0	.35	6.67	1.5	+++	.0

* µg. at. NO_2-N/l.
** cc. /l.
*** µg. at. NO_3-NO_2 N/l.
\+ ml. /l.
++ p.p.m. NH_3/l.
+++ Sample lost

Water analysis at three stations during a 24-hour period.

	Period	Station I					Station II					Station III				
		* Arabinose equivalent	** Chloro- phyll "a"	*** Inorganic phosphate	*** Total phosphate filtered	*** Total phosphate unfiltered	Arabinose equivalent	Chloro- phyll "a"	Inorganic phosphate	Total phosphate filtered	Total phosphate unfiltered	Arabinose equivalent	Chloro- phyll "a"	Inorganic phosphate	Total phosphate filtered	Total phosphate unfiltered
Daylight	1	2.0	2.15	2.6	* +	* +	1.7	1.66	2.5	2.5	2.8	0.7	2.38	2.6	* +	2.5
	2	1.7	2.20	2.5	2.1	2.4	1.9	2.12	2.5	2.9	3.1	0.6	1.37	2.2	2.3	2.4
	3	1.8	4.31	3.0	2.3	3.0	2.3	1.90	2.5	2.6	2.9	0.5	1.31	2.0	1.7	2.1
	4	2.6	4.31	2.4	2.5	2.5	3.1	2.20	2.8	2.1	2.4	1.6	1.60	2.6	1.9	2.4
	5	3.4	3.28	2.6	2.6	3.2	3.0	2.22	2.3	2.1	3.8	1.6	1.63	2.4	2.3	4.5
	6	3.1	2.35	3.0	* +	3.2	3.6	2.04	2.7	2.3	2.7	2.2	1.46	2.6	2.0	2.5
	7	3.6	2.50	2.5	* +	3.3	1.4	2.07	2.8	2.3	2.6	2.1	1.40	2.0	1.9	2.5
	Avg.	2.6	3.01	2.7	2.37	2.93	2.43	2.03	2.6	2.4	2.9	1.33	1.59	2.3	2.0	2.7
Dark	8	2.6	2.60	2.5	* +	* +	1.3	2.06	2.4	2.8	3.1	2.0	1.60	2.6	1.9	2.9
	9	1.9	2.65	2.6	2.1	2.5	0.8	2.16	2.8	2.5	3.0	1.6	1.75	2.5	* +	* +
	10	1.4	2.57	2.5	2.4	2.7	0.8	2.08	2.4	2.4	3.1	0.9	1.64	3.3	2.3	2.7
	11	2.0	2.24	2.5	* +	3.1	0.4	2.06	2.9	2.6	3.0	0.8	1.42	2.3	2.1	3.9
	12	1.5	2.29	2.6	2.9	0.2	0.1	1.86	2.8	2.3	3.9	0.8	1.42	2.4	2.0	10.4
	Avg.	1.88	2.47	2.5	2.46	2.85	0.68	2.04	2.7	2.5	3.2	1.22	1.57	2.6	2.0	4.97

* mg. of arabinose equivalent/l.
** mg. /l. acetone extract
*** μg. at. PO_4-P/l.
\+ Sample lost

Marking Spiny Lobsters, *Panulirus argus*, and Blue Crabs, *Callinectes sapidus*, With Biological Stains

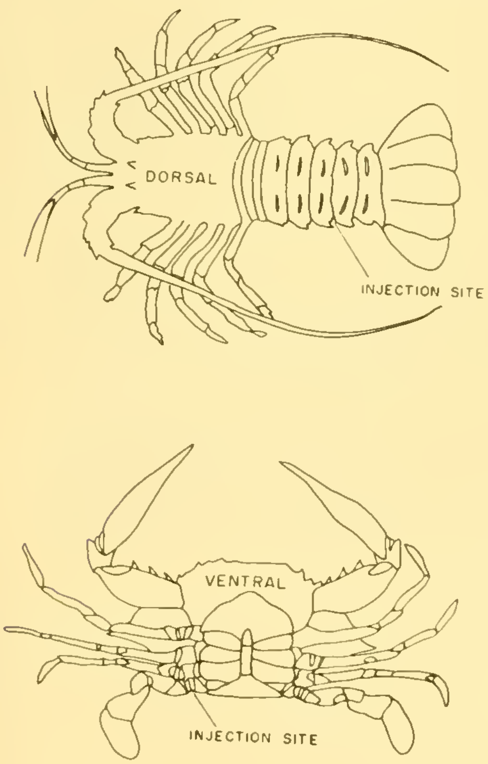
Thomas J. Costello, Donald M. Allen, and Carl H. Saloman

Biological stains injected into penaeid shrimp produce a lasting mark and have been used extensively in mark-recapture experiments. Success of the stain injection method suggested that such a procedure could be used to mark other decapods. Since the spiny lobster (*Panulirus argus*) and the blue crab (*Callinectes sapidus*) have commercial importance and are available in south Florida waters, these two species were selected to test their acceptance and retention of biological stains.

The injection equipment consisted of $\frac{1}{2}$-cc. tuberculin syringes with 27-gauge, $\frac{1}{4}$-inch hypodermic needles. A larger syringe, perhaps 2 cc., would be preferable for extensive field use. Two stains were used, one a 0.25-percent aqueous solution of Trypan blue, the other a 0.5-percent solution of fast green FCF.

The spiny lobster has a physical structure comparable to that of a penaeid shrimp; therefore, the quantity of stain per g. used for shrimp weighing about 30 g. was multiplied proportionately to mark the lobsters, which weighed roughly 180 g. each.

Injection was made laterally into the abdomen at the articulation of the fourth and fifth segments, where the needle was inserted its full length at an angle of about 45 degrees. Almost immediately after injection, the lobsters acquired a general faint bluish or greenish tinge, depending upon the stain used, which could be seen through the more transparent portions of the exoskeleton. However, all color which could be seen externally disappeared within 2 days. After 40 days, the agile and healthy-appearing survivors were killed. The gill filaments of all the lobsters were clearly marked with either green or blue. Molting in one individual did not affect stain retention. The concentration and volume of stain injected seem adequate to mark spiny lobsters of the size used.



Points for injecting marking stains into spiny lobsters and blue crabs.

Blue crabs proved more difficult to mark successfully than lobsters. Injections were made in the ventral surface of the swimming leg, at the articulation of the coxa and basis. This often produced a very faint, temporary discoloration which could be seen externally overall. Most of the crabs molted at least once during the holding period. When killed after 40 days, the crabs marked with fast green FCF had a distinct green color in the gill filaments. Those marked with Trypan blue had a fair blue color in the gill filaments, suggesting that they were administered an inadequate amount of stain. The results indicate that to insure optimum marking and survival particular attention should be given to the amount of stain selected in respect to individual crab weight.

A marking technique is most useful if a marked animal can be readily recognized at the time of recapture. Since the exoskeleton of both spiny lobsters and blue crabs is opaque, marked individuals would not normally be noted when first captured. As the Florida spiny lobster industry is now conducted, recovery of marked individuals together with the necessary biological information would present a problem. Spiny lobsters may be marketed as whole animals either live or dead. Therefore, the gills are not normally exposed until the lobster reaches the consumer. Spiny lobsters may also be sold as "tails," in which case the entire cephalothorax is removed by the producer. The gills of an intact lobster, however, either alive or dead, can be examined for stain by lifting the carapace with needle-nose pliers. The stain injection technique of marking spiny lobsters would probably be limited to studying local populations, where captures could be examined by trained observers.

There are several methods of marketing blue crabs. Soft-shell crabs and large male crabs are marketed alive. Consequently, they are generally in the hands of the consumer when the carapace is removed. The great majority of blue crabs, however, are utilized in the production of picked crab meat. In this process, blue crabs are cooked, the carapace removed, and the meat picked, usually in a plant near the area of capture. The stained gill filaments do not fade with cooking so there is a good opportunity to recover marked individuals, together with the desired biological information.

Species and stain	Specimens injected	Average weight	Amount of stain	Initial deaths	Specimens* alive at end of 40 days	Visibility of stain
	Number	Grams	Milliliters	Number	Number	
Lobsters:						
Trypan blue	3	180	0.42	1	2	distinct
Fast green FCF	3	180	1.08	0	2**	distinct
Crabs:						
Trypan blue	6	90	0.15	1	3	fair
Fast green FCF	6	90	0.30	0	5	distinct
Do.	5	75	0.20	3	1	distinct
Do.	1	9	0.05	0	1	distinct

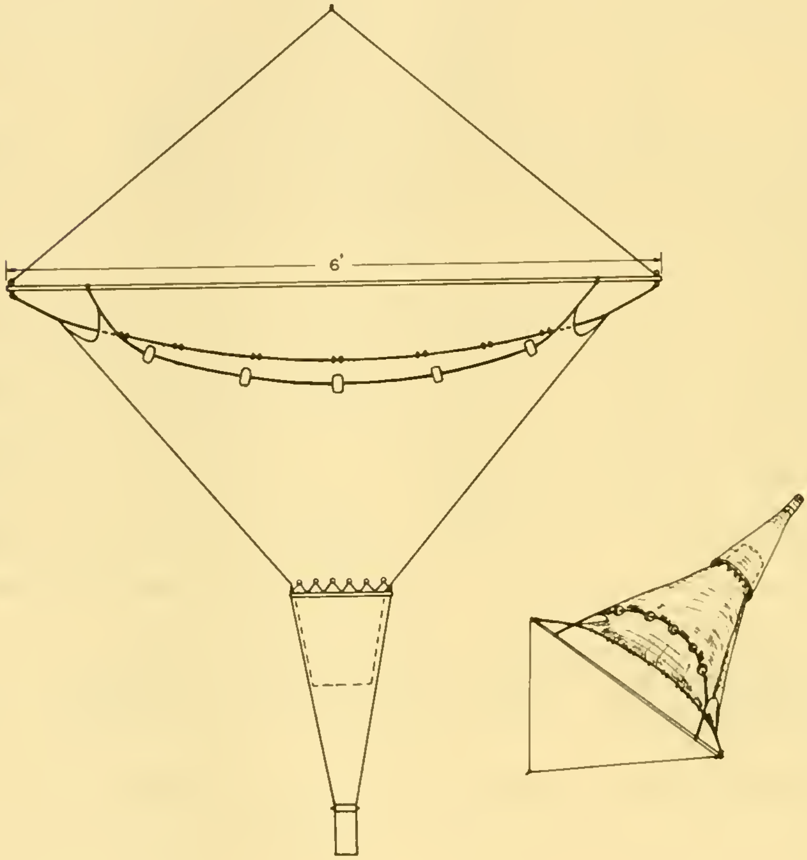
* Four crabs escaped during holding period and have not been included among survivors.

** One lobster was killed after molting at the end of 22 days - stain distinct.

Small Beam Net for Sampling Postlarval Shrimp

William C. Renfro

Postlarval penaeid shrimp entering estuarine nursery grounds through Galveston Entrance have been sampled twice weekly since November 1959. Study of these samples has shown seasonal fluctuations in immigration and size composition of white and grooved shrimp postlarvae.



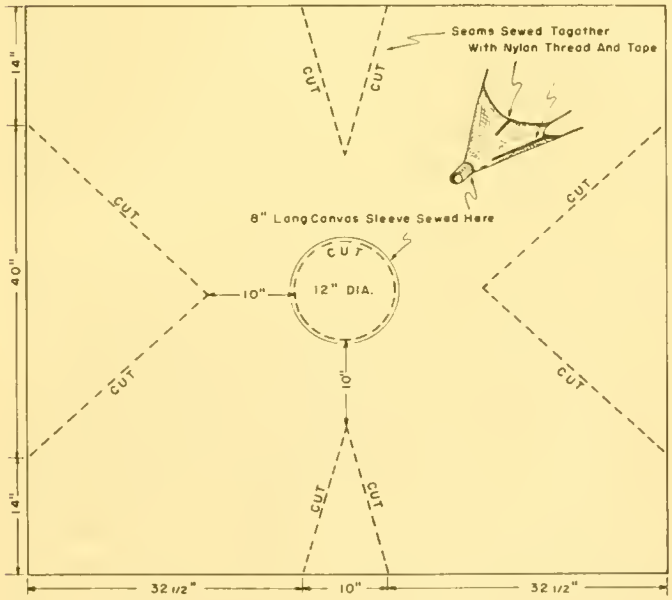
Small beam net used for sampling postlarval shrimp.

To catch postlarvae in shallow areas along the shore, a net was designed which could be easily handled by one man wading. Essentially it is a small beam trawl or bar net. The body is cut from a single piece of nylon netting 75 by 68 inches, having 50 openings per square centimeter. The finished net is 5 feet wide on both the head and footropes by 28 inches long. The throat is a canvas cylinder 8 inches long and 12 inches in diameter sewed to the end of the body. Over the throat is tied a conventional 12-inch, No. 1 mesh plankton net with a removable bucket. This plankton net can be readily removed because it is secured to the larger net (or body) by means of a cord and ring arrangement. A 7-foot, 3/16-inch stainless steel cable with lead weights serves as the footrope. The headrope is threaded through five, 2 3/8-inch-diameter sponge floats. Ends of the footrope and headrope are attached to a 6-foot, 3/4-inch stainless steel pipe which functions as the beam.

In operation, the net is pulled by a bridle attached to the ends of the pipe. When pulled slowly, the pipe drags along the bottom frightening postlarvae off the bottom and into the net mouth.

The standard practice is to attach a nylon cord to a stake driven into the ground at the waterline. The cord is stretched taut parallel to the waterline and used as a constant radius as the net is pulled along the bottom in a half circle. This method assures that the length of tow, bottom area, and volume of water strained will be the same for each sample.

Organisms regularly taken with this gear include: penaeid shrimp 5 to 50 mm. long; *Mysis* larvae and adults; crabs and crab larvae; amphipods; arrow worms; fish eggs and fish 4 to 75 mm. long; ctenophores; diatoms; and many other small planktonic and benthic animals. In one 425-foot tow, 4,700 penaeid postlarvae were caught.



Pattern for cutting mesh body of beam net.

The Use of Atkins-Type Tags on Shrimp

Donald M. Allen and Thomas J. Costello

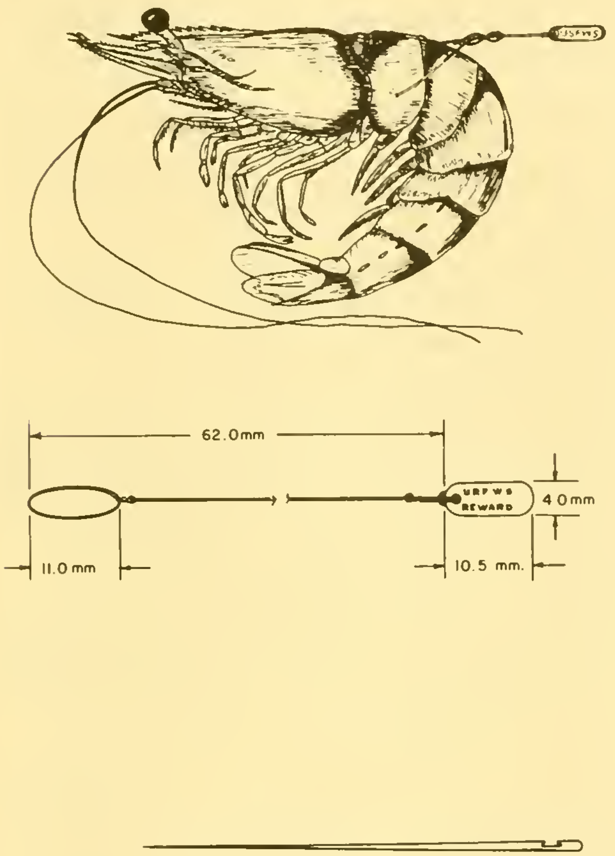
An ideal tag should be easily recognized by a casual observer, yet have no abnormal effect upon movement, growth, or survival of the tagged animals. In the case of crustaceans, such as shrimp, the tag must be retained through successive molts. Petersen disk tags have been used extensively to mark shrimp since 1934. Such tags are easily recognized and are retained through molting. The information derived from experiments in which shrimp were marked with Petersen disks has contributed greatly to our knowledge of certain aspects of shrimp biology. Observations reveal, however, that shrimp tagged with Petersen disks undergo excessive mortality, which apparently increases as the size of shrimp marked decreases. An additional disadvantage is the fact that such tags restrict shrimp agility, which could affect normal movement and survival.

The deleterious effects of the Petersen disk tag may, in part, be attributed to trauma, resulting from continued impalement on the rigid nickel pin, the excessive weight of the plastic disk-nickel pin assembly, and the increased water resistance to the disks which may "toe out" as the shrimp moves forward. The latter deficiency is particularly apparent where extra pin length is allowed between the disks for growth.

In recent years, shrimp have been marked with biological stains which apparently have little, if any, effect upon movement, growth, and survival of marked individuals. The biological stain marks are retained through ecdysis. Although stain marks are not recognized as readily as mechanical tags and their use requires an intensive recovery campaign, the stain-marking technique has been used successfully to study growth, migrations, and mortality rates of commercial shrimp populations. However, there is still a need for a numbered tag which can be used to follow growth and migrations of individual animals.

It is probably not possible to design a mechanical tag which can favorably compare with a biological stain mark in respect to the effect upon shrimp survival and movement. However, a modified Atkins tag commonly used on fish has several advantages over the Petersen disk tag when used for marking shrimp. This tag is composed of a small oblong strip of cellulose acetate (0.8 mm. thick and inscribed with printed information) secured to a short length of monofilament nylon line, which has a loop in the free end. The tag is attached to the shrimp by means of a slender surgical needle (intestinal thin), which has had the eye cut open on one side. The nylon loop is hooked by the needle eye, and the needle is inserted laterally through the muscle tissue of the first abdominal somite of the shrimp, taking care to avoid the nerve cord and gut. After the nylon line is drawn through, the plastic strip is passed through the nylon loop twice, securing the tag in position.

Shrimp tagged with the Atkins-type tag have been held with a control group for $3\frac{1}{2}$ months in a salt-water pond. During this time, they passed through a series of molts. Growth of tagged shrimp was comparable to that of untagged individuals. Comparisons of the more obvious differences between the Atkins-type tag and the Petersen tag revealed the following:



The position of attachment for the Atkins tag on shrimp and the modified needle used to insert the monofilament nylon harness.

Weight - The Atkins-type tag is slightly heavier than water and weighs only one-eighth as much as the Petersen tag (Atkins tag and nylon line, 0.0292 g.; Petersen tags and pin, 0.233 g.).

Water resistance - The oblong plastic strip of the Atkins-type tag trails the shrimp dorsoposteriorally to the point of attachment. In this position, and with its small size, it presents a very narrow surface to the flow of water, probably creating less water resistance than the Petersen tag.

Attachment - The time required to attach each tag is approximately equal. Both tags are attached to the shrimp through the first abdominal somite. The Atkins-type tag is attached to the shrimp with 3-pound-test monofilament nylon line, diameter 0.3 mm. while the Petersen tag is affixed with a nickel pin, 0.9 mm. in diameter. It appears that the relatively thick, rigid pin causes more tissue damage than the thin, pliable nylon line.

Indications are that the Atkins tag, relatively streamlined, lightweight, and flexible, is an improvement over the Petersen tag and may be particularly useful for tagging small-sized shrimp. Final evaluation, however, must await experiments which compare survival rates of shrimp tagged with Atkins tags, with those of unmarked shrimp and shrimp tagged with Petersen disks.

Immersion Staining of Postlarval Shrimp

Ray S. Wheeler

The purpose of this preliminary immersion staining study was to find a nontoxic substance that would stain postlarval shrimp vividly enough to render them easily detectable with the unaided eye and would persist for an extended period. Postlarval shrimp are so small that neither tagging nor injection of biological stains is feasible.

Eleven stains have been screened as possible larval shrimp stains. These include six liquid food colors (Brand A green, red, blue, and yellow; Brand B red and green), an Easter egg dye, and four biological stains (neutral red medium, Bismarck brown Y, Nile blue A, and neutral red).

The postlarval shrimp used in this study measured 10 ± 1 mm. They were held in recirculating sea-water tanks or aquaria until they had become adjusted to these conditions, after which they were immersed in the various stains. During the testing period, the animals were not fed.

The effectiveness of the stains was observed at varying time intervals of 1, 3, 5, and 10 minutes with different stain concentrations. Two individuals were stained simultaneously in each combination and afterward placed in separate petri dishes. The results of each experiment were observed for 7 days. Control animals were handled in the same manner, except that no stain was added. Liquid food colors were used at concentrations of 100, 50, 25, and 12½ percent of the commercial stock solution. Sea water was used in making dilutions. Solutions made from dry biological stains, and the Easter egg dye varied from 333:1 to 1,280,000:1 by weight.

Stains were found to differ in persistency, intensity, and toxicity. The uptake of stain varied between individuals even though they were stained simultaneously in the same container.

Liquid food colors (Brand A) were found to be nontoxic at 100 percent concentration for the maximum time interval of 10 minutes. Shrimp stained with the red, blue, and green colors appeared quite brilliant at the higher concentrations, although color intensity diminished at the lower concentrations and shorter immersion intervals. Even at the lower concentrations, stained shrimp were easily distinguished when released among a group of unstained shrimp. Color was concentrated in the digestive tract with only little staining noted in the thoracic or abdominal tissue. Of the three colors, red seemed initially to be the most conspicuous and stood out with the greatest brilliance. Although each of these colors faded toward the end of the 7-day test period, fading was most noticed in the brilliant red coloration, which became pinkish red. This faded shade of red could be confused with the natural red pigmentation that occurs near the base of the appendages of some small shrimp.

Yellow food coloring (Brand A) was light in color, lacking the contrast necessary to make it readily distinguishable. For this reason it was regarded as unsuitable.

Shrimp stained with green food color (Brand B) showed good coloration of the gastric mill and gut. Immediately after staining, signs of distress were noted and heavy mortality occurred overnight. This stain was therefore regarded as unsatisfactory.

Red food color of Brand B demonstrated the same qualities as those of Brand A.

At concentrations of 1,000:1 by weight, the Easter egg dye was neither toxic nor did it stain.

Neutral red medium at the lower concentrations failed to stain and at the higher concentrations proved to be toxic.

The color imparted by Nile blue A, although faint at the higher concentrations, showed promise in that it was not toxic. The color within the abdominal tissue persisted throughout the observation period.

Neutral red was not toxic and demonstrated good staining qualities at the higher concentrations and longer time intervals. The digestive tract was colored a dark red and the abdominal tissue a lighter red. This color persisted throughout the observation period.

Bismarck brown Y was not intense enough nor was there enough contrast to make it easily detectable. Mortality was low.

In addition to the standard tests, two groups of postlarvae were stained and held for 2 weeks in 15-gallon aquaria. The aquaria bottoms were covered with sand, and Mysidacea were introduced as food. Group 1 was stained with Brand B red food color, while neutral red was used in group 2.

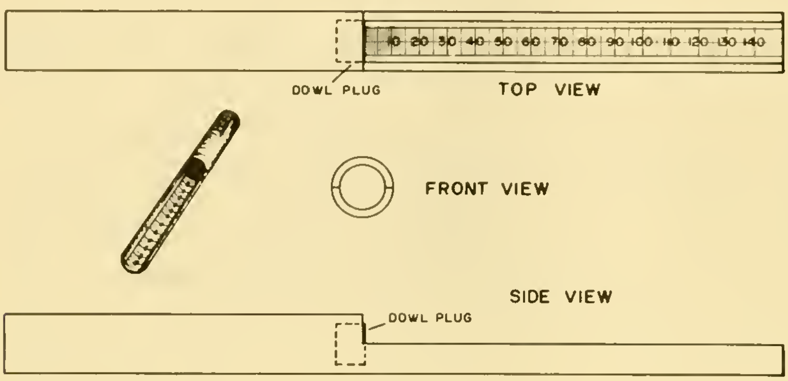
Although mortality was low, the intensity of the stain in group 1 diminished each successive day until on the 3d day many of the shrimp had lost their color entirely. On the 4th day, we examined each individual and found that only 7 of the 50 originally stained had retained enough color to make them easily distinguishable with the unaided eye. Twenty-three others bore enough stain to be distinguishable under the binocular microscope. Several digestive tracts contained sand, suggesting that the dye had been eliminated in the feces.

In group 2, some color had faded, but enough color was retained in the digestive tract and abdominal tissue at the end of the 2d week to make it distinguishable with the unaided eye.

As previously indicated, the work presented here is preliminary. Indications are, however, that additional work will yield a suitable stain.

Donald M. Allen

Growth studies of shrimp using the mark-recapture method require a rapid and accurate method of measuring large numbers of the living animals. Previous experience using vernier calipers to measure carapace length and conventional fish-measuring boards to measure total length showed these methods to be unsuitable. The grip required to secure a live shrimp for measurement may injure the animal, and the time involved is prohibitive. These problems are magnified when dealing with very small shrimp, which are both agile and fragile.



Shrimp measuring device made of plastic tubing.

A simple device to measure live shrimp with none of the above disadvantages was developed. The device, essentially a calibrated trough with a handle, is constructed of clear plastic tubing having a 1/8-inch wall. The length and diameter of the tubing are determined by the sizes of the shrimp to be measured. For shrimp ranging from about 60 to 140 mm. total length, an 11-inch length of 3/4-inch tubing is used. Five inches of tubing is retained as a handle. The trough is formed by removing, lengthwise, one-half of the remaining 6-inch section of the tube. A short, slightly tapered plastic dowel is forced into the tube where it joins the trough and cemented. The exposed end of the secured dowel forms a base line for calibration and measuring purposes. To determine absolute total lengths, a strip of millimeter paper, appropriately numbered, is taped to the convex surface of the transparent trough where it can be easily read but not become worn. To rapidly separate large numbers of shrimp into preselected size groups, variously colored strips of plastic tape, each representing a narrow size range, are affixed to the trough at appropriate distances from the base line.

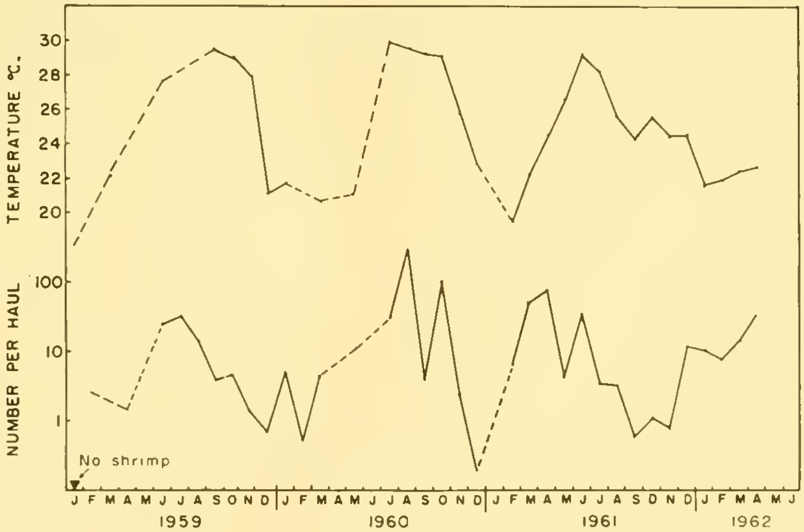
In use, the device is held by the handle in one hand. A shrimp is laid in the trough with the tip of the rostrum touching the exposed dowel end. The trough restricts movement and holds the shrimp in an extended position so that an accurate total-length measurement can be made with a minimum of handling or pressure. Using this device, several hundred live shrimp can be measured per hour with practically no mortality.

Distribution of Pink Shrimp Larvae and Postlarvae

C. P. Idyll, Albert C. Jones, and D. Dimitriou
University of Miami, Institute of Marine Science
(Contract No. 14-17-0002-4)

Research on the production and distribution of planktonic larvae and postlarvae of pink shrimp, Penaeus duorarum, was performed by the Institute of Marine Science of the University of Miami. Over a thousand plankton hauls were made and hydrographic data collected on 20 cruises from July 1961 through May 1962 to the Tortugas Shelf. In addition, information on water currents was obtained on two cruises in August and Septemper 1961, and previously collected current data were summarized.

The currents in shallow water less than 15 meters in depth are primarily tidal. At depths from 15 to 33 meters, resultant currents show both tidal and wind-driven components. Beyond depths of 33 meters to the western side of a salinity ridge, whose position varies seasonally, the currents are wind driven with no visible effects from the tide. To the west of the salinity ridge and to the limits of the area sampled, the currents are density currents.



Relative abundance of pink shrimp larvae and postlarvae and average bottom water temperatures on the Tortugas Shelf from January 1959 to April 1962.

The velocities of the resultant tidal and wind-driven currents are small and apparently are not sufficient to account for transport of shrimp larvae from the offshore spawning grounds to mainland nursery areas. The density currents are of higher velocity but generally occur west of the principal spawning area. In August and September 1961, however, a southwesterly density current was observed on the spawning grounds.

The spawning season of pink shrimp, as indicated by the presence of young stages in the plankton, extends throughout the year. A seasonal peak in spawning occurs in spring or summer and generally is associated with rising water temperatures. In 1960, a seasonal peak in spawning occurred in midsummer. In 1961, the spawning peak was in the spring. It was followed by low spawning intensity during the summer, associated with low temperature of the bottom water over much of the spawning area.

The average age of pink shrimp in the plankton increased from 5.5 days at the western edge of the spawning area to 29.7 days near the mainland. This increase suggests a movement from the spawning area across the Tortugas Shelf towards the mainland but does not exclude the possibility that planktonic stages may also move toward the Florida Keys. Shrimp of greatest average age were taken off the principal entrances to the Whitewater Bay estuary, which is known to be a nursery area for the Tortugas pink shrimp. Since resultant currents of the Tortugas Shelf do not move in an easterly direction, it is apparent that at least the older planktonic stages do not freely drift in the water mass but either actively swim across the Shelf towards shallow water or take advantage of the east-west movement of tidal currents.

Library

Stella Breedlove

At the end of fiscal year 1962, the library contained a total of 11,779 items. This number represents an increase of 2,871 items and includes 273 volumes of books and journals added during the year. Unbound journals, reprints, microfilms, photographs, translations, and miscellaneous material are included in the remainder. All items have been cataloged or entered in the records maintained by the library.

Use of the library has increased during the year. The total number of reference questions, excluding directional questions, has been estimated at 1,012, and the items loaned total approximately 2,500. A noticeable increase in attendance and use of publications in the library has also been evident.

There were 63 items borrowed from other institutions for the use of the staff, and 175 volumes were loaned to other libraries and laboratories. A total of 125 volumes of journals and miscellaneous publications was bound or prepared for binding during the year. Work was completed on the alphabetical list, with cross references, of the material shelved in the journal file. This list serves as a guide to the material that is shelved following the classified book collection. Complete cataloging of the collection of translations was accomplished.

Over 50 laboratories and Government offices were contacted for official publications of interest to this laboratory, with a favorable response in each case.

A list of library acquisitions was prepared and distributed weekly to staff members, including those at the field stations, also to selected Service laboratories and other laboratories requesting inclusion on our mailing list.

The library compiled a list of recent publications in the field of fisheries and related sciences for the quarterly issues of the Transactions of the American Fisheries Society.

The library assisted in the evaluation survey by the National Science Foundation on the use of translated Soviet scientific journals. Program leaders and selected scientists of the laboratory staff participated in this survey. I compiled a list of Service publications for the Summer Science Institute, Baylor University, and gave similar assistance to other educational projects.

The Chief of the East Gulf Estuarine Investigations included the library in his visit to the laboratory. Library practices prior to the establishment of the independent field station at St. Petersburg Beach, Fla., were reviewed, and consideration was given to future cooperation between the two libraries. The acting librarian of the Biological Laboratory, Brunswick, Ga., spent 3 days in the library to obtain information on library techniques, principally in Service libraries. Since that time, questions concerning various phases of library practice have been handled through correspondence.

An additional 16 feet of shelving were added to the library, making a total of 463 linear feet. Space is limited, however, and additional shelving is needed to incorporate new material in the collection.

Assistance in the library during the year was limited to typing correspondence.

Statistical Summary of Library Collection

	On hand 1961	Additions 1962	On hand 1962
Books	1,657	211	1,868
Journals	352	62	414
Journals (unbound)	890	164	1,054
Reprints	1,930	290	2,220
Institutional	3,210	2,081	5,291
Other	869	63	932
Total items	8,908	2,871	11,779

SEMINARS

Bottom types and salinities. Anthony Inglis
Gulf of Panama anchoveta tagging. Edward F. Klima
Fisheries of Taiwan. Mr. Po-wei Yuan, Formosa
Invertebrate indicators. David V. Aldrich
Shrimp fecundity studies. Harold A. Brusher
Marine reptiles - recent and fossil. Richard A. Diener
Yucatan and Campeche shelf geology. William B. Wilson
Shrimp spawning populations. William C. Renfro
Currents and their influence on the distribution of brit herring in the Gulf of Maine. Robert F. Temple
Currents on the continental shelf of the northern Gulf coast. J. Bruce Kimsey
Engineering projects in Louisiana. Charles R. Chapman, Vicksburg, Miss.
The origin, uses, and associated fauna of the pelagic Sargassum weed. Charles H. Koski

MEETINGS ATTENDED*

American Institute of Biological Sciences, Lafayette, Ind., August (1)
American Society of Limnology and Oceanography and the Instrument Society of America, Woods Hole, Mass., September (1)
American Fisheries Society, Memphis, Tenn., September (1)
Water for Texas, College Station, Tex., September (1)
Gulf States Marine Fisheries Commission, New Orleans, La., October (2)
First National Shallow Water Research Conference, Tallahassee, Fla., October (2)
Gulf and Caribbean Fisheries Institute, Miami, Fla., November (4)
American Fisheries Advisory Committee, Galveston, Tex., December (6)
Bureau of Commercial Fisheries Laboratory Directors' Meeting, Galveston, Tex., January (6)
Texas Shrimp Association, Brownsville, Tex., January (1)
Gulf States Marine Fisheries Commission, Galveston, Tex., March (4)

WORK CONFERENCES*

Bureau of Commercial Fisheries Meeting on Instrumentation Requirements, Stanford, Calif., October (1)
Lake Pontchartrain Hurricane Study Meeting, State Marine Laboratory, Grand Terre Island, and New Orleans, La., September, December, and January (1)
American Mosquito Control Association, Galveston, Tex., March (2)
Trip to examine Louisiana and Texas estuaries and visit to Corps of Engineers Waterways Experiment Station, Vicksburg, Miss., April (1)
Texas Shrimp Association, Brownsville, Tex., April (2)

*Attendance shown in parentheses.

PUBLICATIONS

Allen, Donald M., and T. J. Costello.
1962. Grading large numbers of live shrimp for marking experiments. U. S. Fish and Wildlife Service, Progressive Fish-Culturist, vol. 24, no. 1 (January), p. 46-48.

Costello, T. J.
1961. Use of stains in shrimp mark-recapture experiments. ICNAF North Atlantic Fish Marking Symposium, May 1961, Contribution No. 23, 5 p.

Costello, T. J., and D. M. Allen.
1962. Survival of tagged, stained, and unmarked shrimp in the presence of predators. Proceedings of the Gulf and Caribbean Fisheries Institute, 14th Annual Session, 1961, p. 16-20.

Dobkin, Sheldon.
*1961. Early developmental stages of the pink shrimp, Penaeus duorarum, from Florida waters. U. S. Fish and Wildlife Service, Fishery Bulletin 190, vol. 61, p. 321-349.

Dragovich, Alexander, and Billie Z. May.
1962. Hydrological characteristics of Tampa Bay Tributaries. U. S. Fish and Wildlife Service, Fishery Bulletin 205, vol. 62, p. 163-176.

Kimsey, J. Bruce.
1962. Rate of metabolism and food requirements of fishes, by G. G. Winberg. [A review.] Transactions of the American Fisheries Society, vol. 91, no. 1, p. 129-130.

Kutkuhn, Joseph H.
1962a. Conversion of "whole" and "headless" weights in commercial Gulf of Mexico shrimps. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries No. 409, 7 p.

1962b. Recent trends in white shrimp stocks of the northern Gulf. Proceedings of the Gulf and Caribbean Fisheries Institute, 14th Annual Session, 1961, p. 3-16.

1962c. Research at the Galveston Biological Laboratory. In Proceedings of the First National Coastal and Shallow Water Research Conference, October 1961. National Science Foundation and the Office of Naval Research, Tallahassee, Florida, p. 251-256.

Marvin, Kenneth T., Larence M. Lansford, and Ray S. Wheeler.
1961. Effects of copper ore on the ecology of a lagoon. U. S. Fish and Wildlife Service, Fishery Bulletin 184, vol. 61, p. 153-160.

Rounsefell, George A.
1962a. Relationships among North American Salmonidae. U. S. Fish and Wildlife Service, Fishery Bulletin 209, vol. 62, p. 235-270

1962b. Introduction to the study of animal populations, by H. G. Andrewartha. [A review.] Transactions of the American Fisheries Society, vol. 91, no. 3, p. 330.

Temple, Robert F.
1962. Measuring the production of marine phytoplankton, by J. D. H. Strickland. [A review.] Transactions of the American Fisheries Society, vol. 91, no. 1, p. 129.

U. S. Fish and Wildlife Service.
1961a. The Florida red tide, by Staff of the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas. U. S. Fish and Wildlife Service, Fishery Leaflet 506, 8 p.

1961b. Galveston Biological Laboratory Fishery Research for the year ending June 30, 1961. U. S. Fish and Wildlife Service, Circular 129, 82 p.

VanDerwalker, John G., and Edward Chin.
1962. A device for feeding brine shrimp to fishes. Transactions of the American Fisheries Society, vol. 91, no. 2, p. 230-231.

*Contract research.

MANUSCRIPTS IN PRESS

Aldrich, David V.
Photoautotrophy in *Gymnodinium breve* Davis. Science (10 MS. p.).

Chin, Edward, and John G. VanDerwalker.
The relative toxicities of some chlorinated hydrocarbons to postlarvae of brown shrimp and blue crab. U. S. Fish and Wildlife Service, Special Scientific Report--Fisheries (15 MS. p., 2 figs.).

Kutkuhn, Joseph H.
Gulf of Mexico commercial shrimp populations - trends and characteristics 1956-1959. U. S. Fish and Wildlife Service, Fishery Bulletin 212, vol. 62 (173 MS. p., 25 figs.).

Marvin, Kenneth T., and Larence M. Lansford.
Phosphorus content of some fishes and shrimp in the Gulf of Mexico. Publications of the Institute of Marine Science (10 MS. p.).

Proctor, Raphael R., Jr.
Stabilization of the nitrite content of sea water by freezing. Limnology and Oceanography (5 MS. p., 1 fig.).

Renfro, William C., and Harry L. Cook.
Early larval stages of the seabob, *Xiphopeneus krøyeri* (Heller). U. S. Fish and Wildlife Service, Fishery Bulletin (37 MS. p., 20 figs.).

Rounsefell, George A.
The Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas. U. S. Fish and Wildlife Service, Circular (31 MS. p., 37 figs.).

MANUSCRIPTS SUBMITTED

Kutkuhn, Joseph H.
Dynamics of a penaeid shrimp population and management implications. U. S. Fish and Wildlife Service, Fishery Bulletin (82 MS. p., 13 figs.).

Marvin, Kenneth T., C. M. Proctor, and J. E. Stein.
Factors affecting the reliability of chlorinity analyses. Limnology and Oceanography (16 MS. p.).

Rounsefell, George A.
Marking of fish and invertebrates. U. S. Fish and Wildlife Service, Fishery Leaflet (26 MS. p., 1 fig.).

MS #1271

GPO 940442

Created in 1849, the Department of the Interior—America's Department of Natural Resources—is concerned with the management, conservation, and development of the Nation's water, fish, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

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

U.S. DEPARTMENT OF THE INTERIOR

MARCH 3, 1849