

The Commercial Bait Shrimp Fishery in Galveston Bay, Texas, 1959-87

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Introduction

Live and dead shrimp are a preferred natural bait for recreational fishing. As a result, extensive bait-shrimp fisheries have developed along the Gulf coast, especially in Florida and Texas (De Sylva, 1954; Woodburn et al., 1957; Chin, 1960; Saloman, 1965; Inglis and Chin, 1966; Berry and Baxter, 1969). In 1984, the estimated market yield for bait shrimp landed from the Galveston Bay System was \$4.3 million. Both in-shore and offshore fishermen exploit the same shrimp population, though at different stages of the life cycle. The bait catch, if large enough, could depress the subsequent "table" shrimp catch.

Long-term statistical information pertaining to bait shrimp production along the Gulf of Mexico and Southeast Atlantic is collected in only two states, Florida and Texas. The Florida Department of Natural Resources (formerly, the Florida State Board of Conservation) collects routine production statistics from bait-shrimp fishermen operating in that state (Joyce, 1965; Jones and Smith, 1966). Since 1985, they have incorporated the Marine Fisheries Trip Ticket program, a dock receipt system, which provides production statistics as well as fishing location and effort data¹.

The longest, continuous systematic survey of bait shrimp fishery operations is conducted by the National Marine Fisheries Service (NMFS) in Galveston Bay, Tex. This survey was an outgrowth of the shrimp research program of the Bureau of Commercial Fisheries (now NMFS) which began in the late 1950's.

Surveys of the bait shrimp fishery of Galveston Bay began in 1957. Background information, including data on landings and species composition, was reported by Chin (1960). These surveys provide detailed measures of relative abundance and species composition of juvenile and subadult shrimp in the study area. The statistics provide a check on the validity and effectiveness of the NMFS index of postlarval shrimp abundance obtained by sampling at the entrance to Galveston Bay (Baxter, 1963).

As an outgrowth of the average weekly catch per unit effort (CPUE) data collected from the Galveston Bay bait shrimp fishery during late April through early June, the bait index was developed (Baxter, 1963; Berry and Baxter, 1969; Caillouet and Baxter, 1973; Baxter and Sullivan, 1986; Klima et al., 1982-87).

A regression model (Fig. 1) derived from the bait index versus subsequent offshore production from 1960 through 1986 ($r^2 = 0.826$) is used to predict the annual offshore Texas brown shrimp catches (Table 1).

Additionally, these indices of post-larval and juvenile shrimp abundance provide valuable comparisons for long-term assessment of the relation between abundance and changing environmental conditions and specific information concerning local fishing practices and trends for 1959 through 1987. Summaries of the survey results including catch, effort, species composition, and

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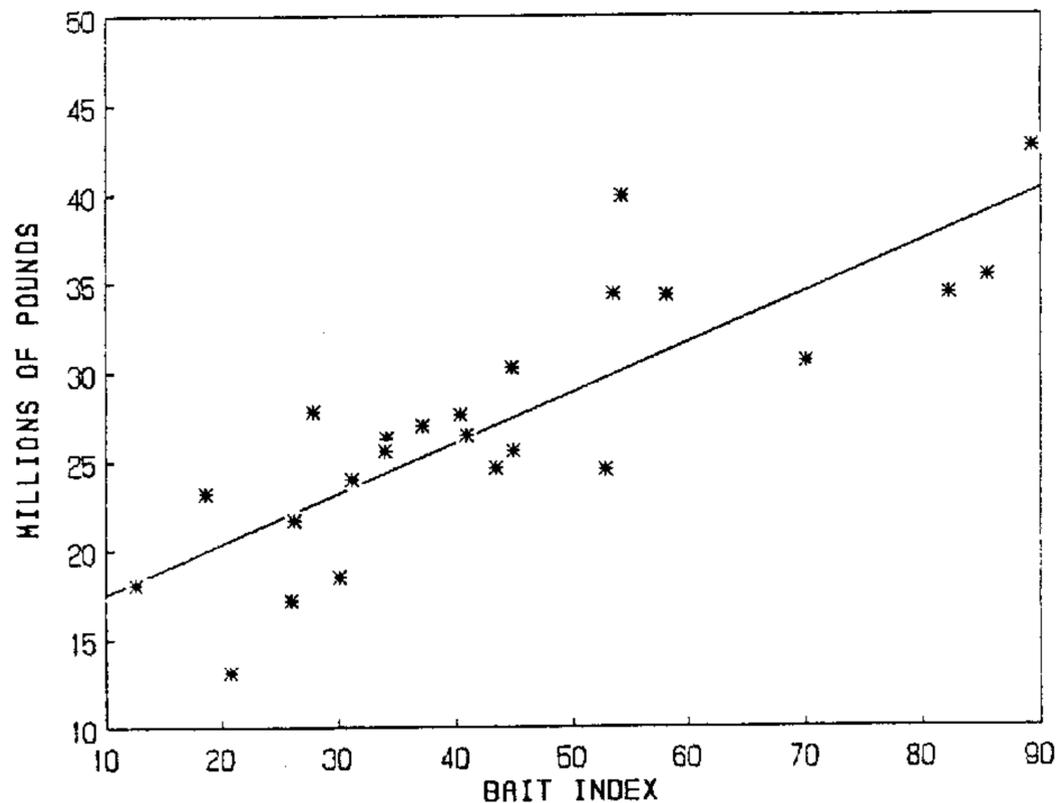


Figure 1.—Galveston Bay bait index versus Texas offshore actual catch, 1960-1986.

¹Kennedy, S. 1987. Florida Department of Natural Resources, St. Petersburg. Personal commun.

Table 1.—Galveston Bay bait shrimp index values from 1960 to 1987 used to predict annual (July-June) Texas offshore brown shrimp catches (Kilma et al., 1987).

Year	Bait index	Catch data (millions of pounds)		
		Predicted catch	Actual catch	Difference in catch
1960	53.6	29.1	34.5	+5.4
1961	20.8	20.0	13.2	-6.8
1962	26.1	21.5	17.3	-4.2
1963	53.0	29.0	24.6	-4.4
1964	30.2	22.6	18.6	-3.9
1965	41.0	25.8	26.4	+0.8
1966			31.5	
1967	89.4	39.0	42.7	+3.7
1968	28.0	22.0	27.9	+5.9
1969	43.5	26.3	24.7	-1.6
1970	70.0	33.7	30.7	-3.0
1971	82.3	37.1	34.4	-2.6
1972	85.6	38.0	35.5	-2.5
1973	18.7	19.4	23.3	+3.9
1974	34.3	23.8	26.4	+2.6
1975			23.7	
1976	34.2	23.8	25.7	+1.9
1977	58.5	30.5	34.4	+3.9
1978	40.5	25.5	27.7	+2.2
1979			18.5	
1980	45.0	26.7	25.7	-1.0
1981	54.3	29.3	40.0	+10.7
1982	26.3	21.5	21.8	+0.3
1983	12.7	17.8	18.2	+0.4
1984	31.2	22.9	24.1	+1.2
1985	44.9 ¹	29.0	30.4	+1.4
1986	37.2	25.3	24.4 ²	-0.9
1987	36.6	25.7	NA	NA

¹Modified bait index model used.

²Preliminary data.

Table 2.—Number of bay shrimp licenses sold by the State of Texas, 1960-87.

Year	Individual bait shrimp trawl	Commercial bay bait trawl	Commercial bay shrimp boat	Commercial bait shrimp boat
1960	8,837	1,846		
1961	7,399	2,506		
1962	6,249	2,456		
1963	7,003	3,228	24	5
1964	6,367		1,849	1,196
1965	7,034		2,217	1,321
1966	7,144		1,969	1,460
1967	7,324		1,760	1,752
1968	7,508		1,953	632
1969	8,553		2,457	768
1970	9,682		3,218	381
1971	9,947		3,743	966
1972	9,296		3,995	1,265
1973	9,537		3,974	1,365
1974	10,521		3,747	1,590
1975	9,281		3,523	1,368
1976	8,866		2,917	1,406
1977	9,707		3,232	1,449
1978	9,982		3,768	1,521
1979	10,349		4,444	1,752
1980	8,925		4,473	2,016
1981	8,729		5,215	2,217
1982	7,433		4,479	2,283
1983	6,921		4,711	2,723
1984	5,339		4,922	3,103
1985	4,547		4,367	2,396
1986	4,147		3,813	2,680
1987	3,597		3,402	2,527

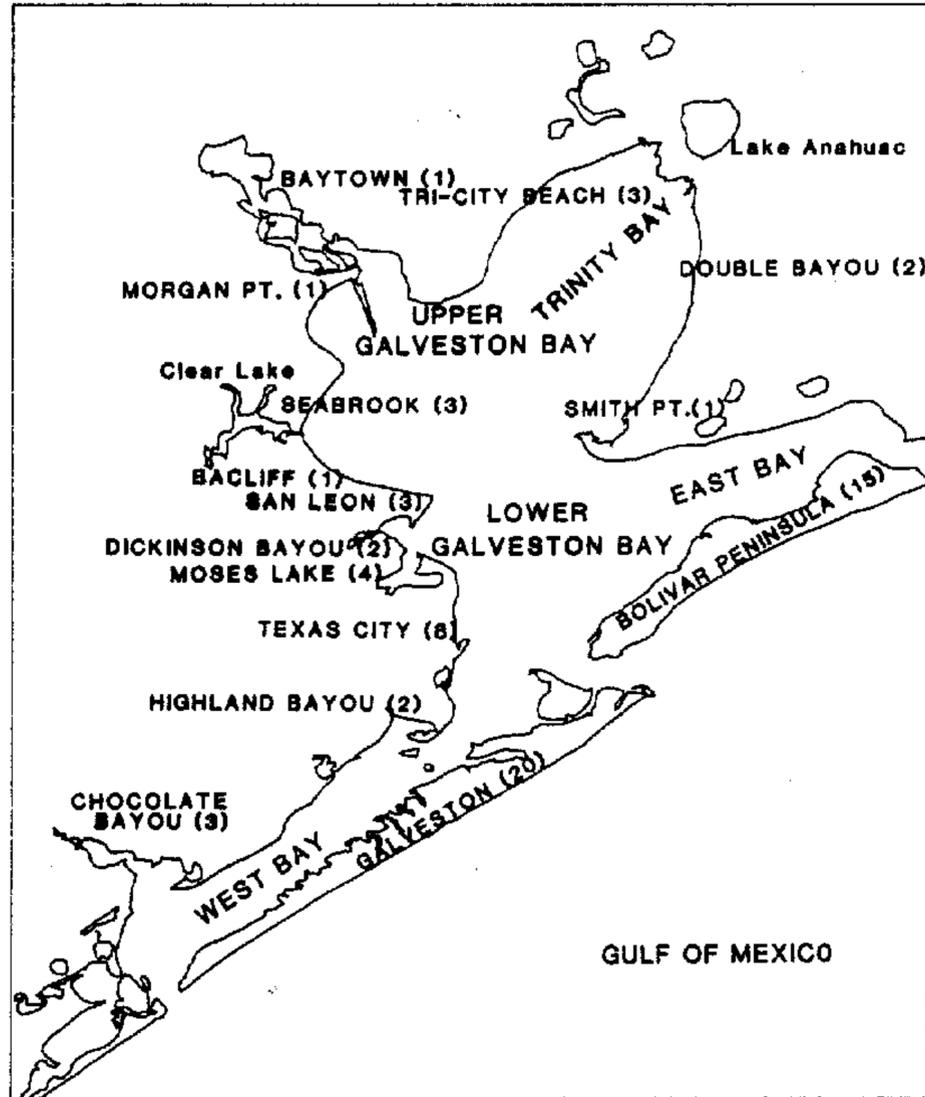


Figure 2.—The Galveston Bay system showing location and number of bait shrimp dealers in 1987.

numbers of active dealers and fishermen are prepared monthly (1959-84, except 1975, partial 1985-87) and are available to the public. These data serve an important role as guidelines for making management suggestions and provide background for continuing research on this natural resource.

Scope of the Fishery

The Galveston Bay System, covering some 336,000 surface acres (135,979 ha), averages 14 miles (22.5 km) long, 8 miles (12.9 km) wide, and about 5 feet (1.5 m) deep. For reporting purposes, this area has been divided into West Bay, Lower Galveston Bay, Upper Galveston Bay, Trinity Bay, East Bay, and major back-bay areas such as Chocolate Bayou, Dickinson Bayou, Moses Lake, and Clear Lake (Fig. 2).

Chin (1960) reported that about 200 bait dealers operated in this area at the time of his survey in November 1956. That number remained fairly constant

until Hurricane Carla struck the Galveston area on 9 September 1961 and severely damaged the bait-shrimp facilities of Galveston Bay. Many bait establishments were completely destroyed due to the hurricane and many were not rebuilt. After 1961, the number of bait facilities gradually increased until Hurricane Alicia struck on 17 August 1983. An assessment made 9 September 1983, revealed that of about 90 bait camps in the Galveston Bay area, 31 percent were destroyed, 42 percent were damaged and/or closed, and 27 percent were open with little or no damage. The number of bait dealers now operating is near 70.

Commercial bait dealers operate their own vessels or are supplied by commercial fishermen (or both). The number of bay-bait shrimp trawlers, as reflected by Texas Parks and Wildlife Department (TPWD) license sales (Hamilton, 1983), ranged from 1,846 in 1960 to 3,228 in 1963 (Table 2). Near the end of 1963, however, separate licenses were

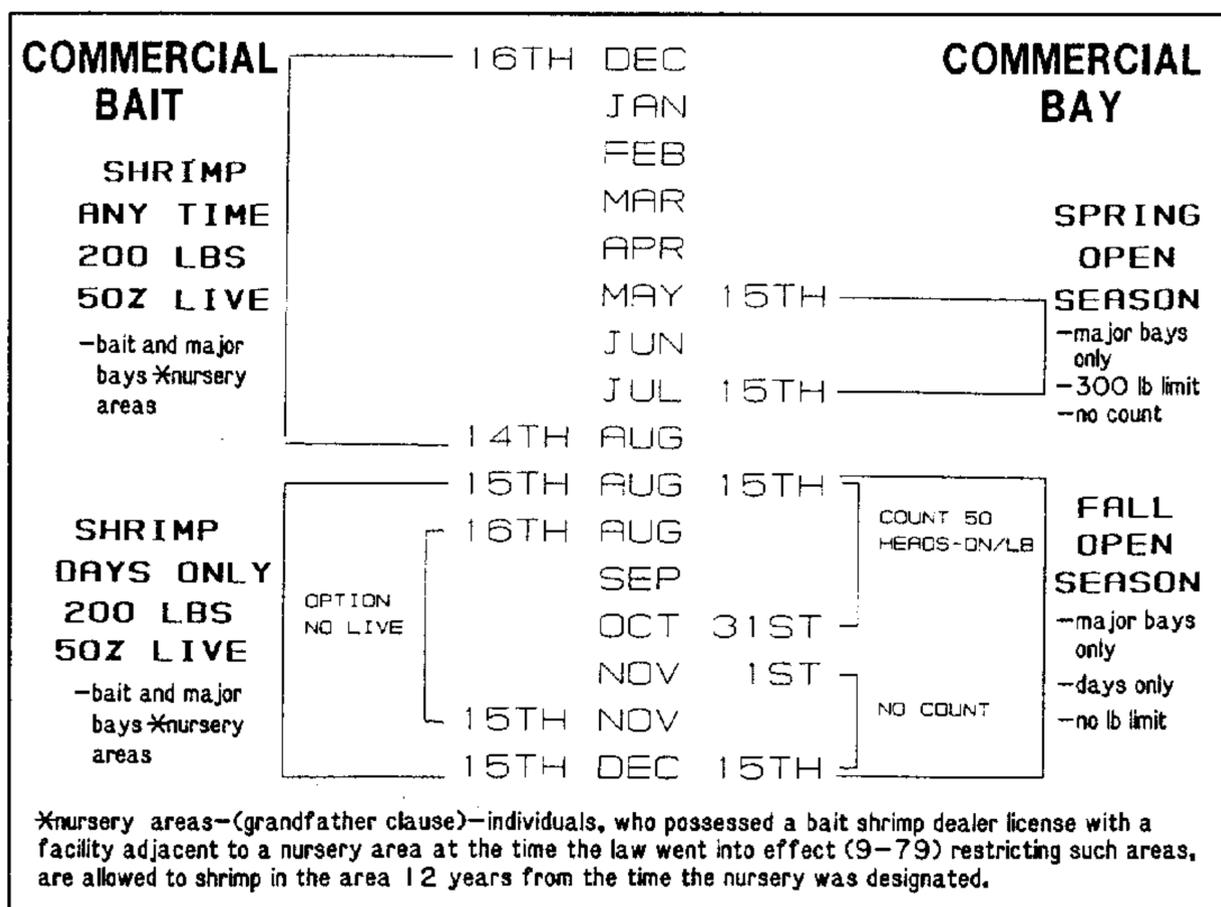


Figure 3.—Commercial bait and bay regulations, 1987.

required of commercial bait and commercial bay shrimp fishermen. Current TPWD commercial regulations require both an individual bait shrimp trawl license and a sport license for persons taking shrimp for personal use only, a commercial bay boat license for persons taking shrimp for pay or sale from major bays, and a commercial bait-boat license for those taking bait shrimp for pay or sale in bay waters (Krauthamer et al., 1984; TPWD, 1987). One person may possess a commercial bay and a commercial bait license; however, different restrictions apply (Fig. 3).

The sharp drop in commercial bait shrimp boat license sales in 1968 (Table 2) was due to a law change in 1967 regulating the holding of live shrimp. The law stipulated that bait fishermen must have aboard their boats a tank or box capable of holding and keeping alive at least 50 percent of the shrimp catch. On 31 August 1981, however, this law was revised: The catch limit for bait shrimp was raised from 150 to 200 pounds per day with no requirement to maintain 50 percent alive from 16 August through 15 November (TPWD, 1981). It appears

that commercial bait license sales increased annually from 1968 to a maximum in 1984 (Table 2). Collectively, since 1985, license sales have been declining. This decrease may be attributed to one or more of the following:

1) A reduction in "part-timers" purchasing commercial shrimp licenses^{2,3}. Part-timers are categorized as individuals who typically own a small boat (<25 feet) and shrimp weekends and/or vacations, especially during the white shrimp or fall open season³. In 1985 the price of commercial bait and bay licenses jumped from \$60 to \$80. This price increase, coupled with the depressed Texas economy, possibly discouraged individuals from renewing commercial licenses.

2) High inshore salinities and low white shrimp production in recent years.

3) Materials for boat construction

²Bryan, C. E. 1988. Texas Parks and Wildlife Department, Austin, Personal commun.

³Standley, C. L. 1988. President, Professional Involvement of Seafood Concerned Enterprises (P.I.S.C.E.S.), Galveston, Tex. Personal commun.

and/or maintenance and operational costs for existing boats exceed profits³.

Shrimp Fauna

The Galveston Bay system serves as a nursery area for several commercially important species of penaeid shrimp. The bait shrimp fishery depends primarily on white shrimp, *Penaeus setiferus*, and brown shrimp, *P. aztecus*. Other species taken infrequently in the catch include pink shrimp, *P. duorarum*; broken neck shrimp, *Trachypenaeus similis*; seabob, *Xiphopenaeus kroyeri*; rock shrimp, *Sicyonia dorsalis*; grass shrimp, *Palaemonetes* sp.; and river shrimp, *Macrobrachium* sp. The combined catch of these latter species, however, did not exceed 3 percent of the total annual catch in any year of this study (Table 3). Of the two major species involved, brown shrimp are the dominant species from May through July (Fig. 4) while white shrimp dominate the catch from August through April (Chin, 1960; Inglis and Chin, 1966; Trent, 1966; Baxter and Renfro, 1967; Pullen and Trent, 1969; Parker, 1970; Lampkin, 1984).

The species composition of bait shrimp catches varies from bay to bay along the Texas coast (Baxter, 1966). Bait shrimp catches from Galveston Bay are predominately white and brown shrimp throughout the year, while those from Aransas Bay and Laguna Madre show a high incidence of pink shrimp (Table 4). These figures do not necessarily reflect the relative abundance of the three species of shrimp, however, since each spends a different proportion of its life in estuarine waters.

Vessels, Fishing Gear, and Holding Equipment

The otter or shrimp trawl was first introduced in 1912 (Anderson et al., 1949). Over the years, Galveston Bay shrimp fishermen have made major changes in their boats and gear. When this survey began in 1959, more than half used outboard motor powered skiffs less than 18 feet (5.5 m) long. Nets usually were retrieved by hand since net size was limited by law to a width of 10 feet (3.0 m) between doors. By 1987, however, over 95 percent of the fisher-

Table 3.—Annual estimated catch (thousand pounds, live and dead), by species in the Galveston bay bait-shrimp fishery, 1959-87. Percentage of annual bait harvest by species, in parenthesis.

Year	Shrimp species				Total Lb.	Percent of total bay landings ²				
	Brown		White				Pink		Other ¹	
	Lb.	%	Lb.	%			Lb.	%	Lb.	%
1959 ³	88.0	(20)	342.8	(80)		0.2	(<1)	431.0		
1960	384.7	(41)	558.1	(59)		0.8	(<1)	943.4		
1961	427.7	(59)	302.8	(41)		0.3	(<1)	731.2	38	
1962	455.9	(43)	606.4	(57)		0.5	(<1)	1,062.8	20	
1963	385.5	(39)	606.9	(61)		0.8	(<1)	994.6	22	
1964	253.9	(30)	581.2	(69)		10.9	(1)	846.6	14	
1965	482.0	(49)	493.9	(50)		5.6	(<1)	984.9	19	
1966	375.4	(48)	405.7	(52)		3.4	(<1)	785.9	29	
1967	600.9	(55)	483.2	(44)		3.3	(<1)	1,087.9	33	
1968	373.7	(34)	726.2	(66)		2.6	(<1)	1,102.6	28	
1969	384.3	(38)	622.8	(62)		0.1	(<1)	1,007.5	19	
1970	456.4	(46)	544.7	(54)		1.6	(<1)	1,002.7	16	
1971	574.3	(49)	605.8	(51)		1.8	(<1)	1,182.3	19	
1972	635.2	(51)	605.6	(48)		6.6	(<1)	1,249.1	21	
1973	411.7	(37)	679.9	(62)		8.4	(<1)	1,100.0	18	
1974	529.8	(45)	655.0	(55)		0.8	(<1)	1,186.1	24	
1975 ³	247.9	(82)	55.9	(18)		0.2	(<1)	304.0		
1976	456.8	(47)	502.1	(52)		0.4	(<1)	963.3	16	
1977	353.7	(41)	497.7	(58)		1.1	(<1)	852.8	19	
1978	399.2	(48)	427.9	(51)		3.4	(<1)	830.9	17	
1979	303.8	(53)	267.3	(47)		2.0	(<1)	573.1	15	
1980	353.6	(49)	358.4	(50)		1.5	(<1)	714.7	11	
1981	463.8	(44)	583.8	(55)		5.1	(<1)	1,062.0	21	
1982	414.5	(51)	400.5	(49)		1.5	(<1)	816.9	14	
1983	446.5	(64)	250.0	(36)		5.3	(<1)	702.5	14	
1984	312.3	(40)	471.8	(60)		0.4	(<1)	784.9	11	
1985 ³	180.7	(80)	40.8	(18)		4.6	(2)	226.2		
1986 ³	249.1	(94)	10.5	(4)		4.3	(2)	263.9		
1987 ³	229.9	(90)	23.5	(9)		1.2	(<1)	255.4		

¹*Trachypenaeus similis*, *Xiphopenaeus kroyeri*, *Sicyonia dorsalis*, and *Macrobrachium* sp.
²Percent of shrimp taken from Galveston Bay by bait fishermen; the remaining percentage (100 percent-C) was taken by commercial bay fishermen.
³Incomplete data.

men were using inboard trawlers in the 20- to 45-foot (6.1-13.7 m) class and two nets were in general use: A try net not to exceed 12 feet (3.7 m) and a main net not to exceed 54 feet (16.5 m) as measured from the tip of the door along the corkline to the leading tip of the other door (TPWD, 1987). Variations of the basic otter trawl employed in the Galveston Bay system include box, flat, and semi-balloon net types (Watson et al., 1984; Bessette, 1985). Trawl mesh sizes vary from 1¼ to 2 inches (3.2-5.1 cm stretched) measure. Trawl doors may range from 3 to 10 feet (0.9-3.0 m). Almost without exception, nets are now retrieved by mechanical hoists or winches.

Holding equipment also has been upgraded considerably. During the early days of the fishery, shrimp were simply

placed in bait wells or barges alongside the vessel. Due to excessive mortalities resulting from high surface water temperatures, the practice gave way to bait tanks on the decks of catch boats. Bait tanks used on boats are somewhat smaller than those used on land. Tank sizes vary but are generally 3 × 4 × 6 feet (0.9 × 1.2 × 1.8 m). They contain 2-4 compartments and water is circulated through them continuously by gasoline- or electric-powered pumps.

When the catch comes aboard, it is released into the first compartment where unwanted fish, invertebrates, and

other matter are culled and discarded. Species of commercial bait value such as striped mullet, *Mugil cephalus*; Atlantic cutlassfish or ribbonfish, *Trichiurus lepturus*; and squid, *Loliguncula brevis*, are retained for packaging. Sheridan (1983) and Bessette (1985) described, in detail, the trawl-caught fauna from the Galveston Bay system. Incidental species to be kept alive and sold for human consumption, such as crabs, *Callinectes* sp., and flounder, *Paralichthys* sp., are transferred to another compartment. Live shrimp are placed in the remaining compartments.

Table 4.—Species composition (percent within each bay) of bait shrimp samples from the major bay systems along the Texas Coast (Baxter, 1966).

Year and date	Galveston Bay			Aransas Bay			Lower Laguna Madre		
	Brown	White	Pink	Brown	White	Pink	Brown	White	Pink
1964									
Aug.	4	96	0	8	91	1	11	48	43
Sept.	9	91	0	8	79	13	3	0	97
Oct.	7	93	0	23	67	10	19	36	45
Nov.	3	96	1	42	33	25	0	1	99
Dec.	1	99	0	2	98	0	1	25	73 ¹
1965									
Jan.	0	98	0 ¹	5	70	24 ¹	3	26	71
Feb.	4	90	1 ¹	16	48	28 ¹	1	2	96 ¹
March	0	98	2	14	36	48 ¹	2	1	96 ¹
April	4	68	28	1	22	76 ¹	17	1	81 ¹
May	84	11	5	72	0	28	68	0	34
June	98	1	1	95	0	5	80	0	19 ¹
July	73	27	0	8	91	1	89	4	5

¹Balance composed of *Trachypenaeus* sp., *Xiphopenaeus kroyeri*, *Sicyonia dorsalis*, or *Macrobrachium* sp.

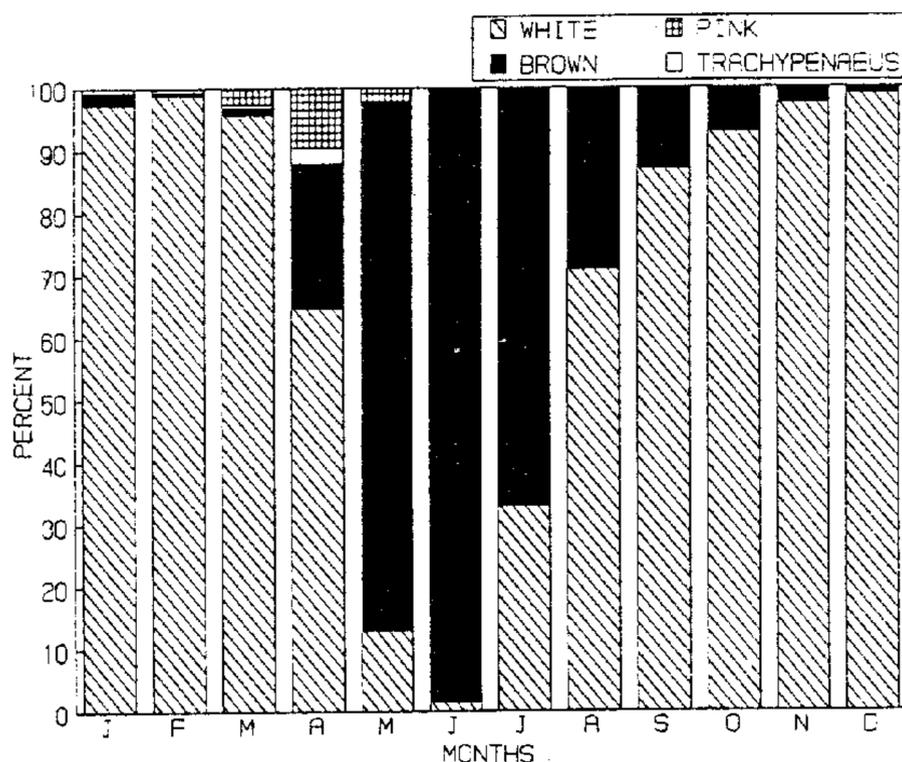


Figure 4.—Average species composition by month (1960-87).

When the boat reaches shore, the live shrimp are transferred to stationary holding tanks. Shrimp are sometimes transported in aerated tanks on trucks to dealers not located near the landing site.

Holding Tanks at Retail Outlets

Shrimp holding tanks or boxes are generally of two functional types. One type is lowered into the water where circulation is accomplished by natural currents. The other type is placed some distance from the water's edge and requires a pump for circulation.

Holding tanks that are suspended in the water are usually constructed in one of three ways: Wooden frames with wooden slats, wooden frames with perforated fiberboard on the sides and bottom, or metal frames enclosed in heavy galvanized mesh wire. By far the most common and least expensive is the slatted holding tank. The wooden slats are of cypress as it is quite durable and does not swell excessively. The slats are placed from $\frac{3}{16}$ to $\frac{1}{4}$ inch (5-6 mm) apart to retain shrimp and to provide water circulation. The most common tanks in use measure $4 \times 4 \times 8$ feet ($1.2 \times 1.2 \times 2.4$ m). All bait boxes that are placed in the water can be raised or lowered as the tide changes and can be lifted free of the water when not in use or during adverse weather or repair. Ropes are attached at each end of the box and pass around a rounded overhead beam turned by handles at either end.

Holding facilities on shore are fabricated primarily from lumber, concrete, and fiberglass. Wooden boxes are most common, but there has been a definite trend toward concrete and fiberglass structures in the last few years. Water is continually circulated through shore tanks by electric pumps, and waste products pass out an overflow (Inglis and Chin, 1966). About one-third of the shore tanks in the Galveston Bay area are equipped with filters to clear the water of debris, silt, and waste products. Most dealers use filters only to clear incoming water, but some also use filters to clean recirculated water. A majority of the wooden tanks measure $4 \times 4 \times$

8 feet ($1.2 \times 1.2 \times 2.4$ m), whereas concrete tanks are usually $4 \times 4 \times 16$ feet ($1.2 \times 1.2 \times 2.8$ m). Some circular concrete structures are 4 feet (1.2 m) deep and 12 to 18 feet (3.6 to 5.5 m) in diameter (Inglis and Chin, 1966). Circular fiberglass tanks, measuring 2.5 feet (0.8 m) deep and 6 feet (1.8 m) in diameter, are used by some bait-camp operators in the Galveston Bay area.

Keeping Shrimp Alive

Various devices and methods are used to keep shrimp alive. During summer months, water in unprotected tanks often becomes excessively hot; consequently, most tanks are shaded. Shading also retards growth of algae. Ice, held in plastic bags to prevent dilution, is used by some dealers to cool water in holding boxes. Other methods for cooling and aerating include wooden cooling towers, overhead perforated pipes or hoses that spray fresh water into the tanks, and overhead racks covered with burlap bags that cool water by evaporation as it trickles down through the burlap. Some fishermen cool water in holding tanks on their boats by recirculating it through copper tubing covered by block or crushed ice. One bait establishment has a complete electric temperature-control system, but the expense of installation, operation, and maintenance prohibits widespread use of such equipment. During winter the water is warmed by incandescent or infrared lights strung overhead.

Dead shrimp are removed regularly from tanks to reduce fouling and to discourage cannibalism. A net of nylon or cotton mesh stretched flat over a wire loop on a long handle is commonly used to cull waste matter and unwanted animals. The net, pushed slowly along the bottom of the tank, scoops up dead shrimp and recently shed exoskeletons while allowing live shrimp to swim free.

Some dealers attach burlap or a similar coarse material to the sides of their holding boxes so that shrimp will have more resting space, thereby preventing crowding at the bottom and probably reducing cannibalism. The practice of putting small stingrays,

Dasyatis sp., with barbs removed into holding tanks to keep shrimp moving and thus avoiding suffocation has been discontinued. It is now believed that this practice agitates shrimp to a point where oxygen demand is unnecessarily increased.

Retailing Bait Shrimp

Trade practices of Galveston Bay bait shrimp fishermen and dealers are discussed by Inglis and Chin (1966). All dealers now are selling live shrimp by the quart, but in the late 1950's most dealers sold live shrimp at \$0.02 each. Retailing by the quart was adopted because this method eliminates the time-consuming chore of counting shrimp individually and furnishes a more uniform measure of shrimp to the customer regardless of shrimp size. With the exception of 1 year of price wars between dealers (1962), the retail price of domestic live shrimp remained at \$2.00 per quart between 1959 and 1966. In the spring of 1967, dealers in all but two areas of the bay system raised the price of live shrimp to \$2.50 per quart. By early 1968, a majority of dealers in the Galveston-Texas City area had increased the price of live shrimp to \$3.00 per quart. By 1973, the average price per quart had reached \$3.50. Increases occurred almost annually between 1973 and 1984 (Table 5). The average price per quart from 1984 to 1987 was \$8.50. The retail price of dead bait, which sold for \$0.50 per pound through 1968, rose to \$1.00 per pound by 1973, and by 1981

Table 5.—Average value of bait shrimp, 1959-87.

Year	Price	
	Live shrimp (quart)	Dead shrimp (pound)
1959-1966	\$2.00	\$0.50
1967	\$2.50	\$0.50
1968-1972	\$3.00	\$0.50
1973	\$3.50	\$1.00
1974	\$4.00	\$1.00
1975	\$4.50	\$1.00
1976-1978	\$5.00	\$1.75
1979	\$6.00	\$2.00
1980	\$7.00	\$2.00
1981-1983	\$8.00	\$2.50
1984-1987	\$8.50	\$2.50

reached the present price of \$2.50 per pound.

Collecting Statistics

Bait dealerships in the Galveston Bay system are grouped according to the following geographic retailing areas: I, Galveston Island; II, Virginia Point to Eagle Point; III, Eagle Point to Morgan Point; IV, Morgan Point to Smith Point; and V, Smith Point to Port Bolivar (Fig. 5). Fishing areas are designated as: 18.1, West Bay; 18.2, Trinity Bay; 18.3, Upper Galveston Bay; 18.4, East Bay; and 18.5, Lower Galveston Bay. At least 50 percent of the bait dealers and bait shrimp fishermen operating in these areas are interviewed weekly. Daily catch figures, total daily dragging time, area(s) fished, and number of trips are recorded. In addition, 1-quart bait samples are purchased randomly from dealers within each area fished. These samples are iced and returned to the laboratory where the contents are counted, weighed, and identified to species so that weekly estimates can be made of bay-wide species composition.

The interview route is designed to eliminate visiting the same area twice weekly. The usual practice is to canvas dealers in the two areas farthest from the laboratory during the first part of the week. On Monday, for example, area V is covered. On Tuesday and Wednesday, areas II and I are sampled. The two remaining areas are surveyed on Thursday with return calls made on Friday. Although no attempt is made to interview all dealers, a weekly visual check is made of each camp to determine whether it is open for business. A weekly record of the total number of active dealers is kept. With this information and interviews from half the fishery, estimates of total production and total effort are computed.

Interviewing

Until 1985 one person devoted full time to interviewing bait camp operators and bait fishermen during the 7 or 8 months that the fishery is at peak activity. Beginning in 1985, however, interviewing was reduced to include only the brown shrimp season (April-June), to

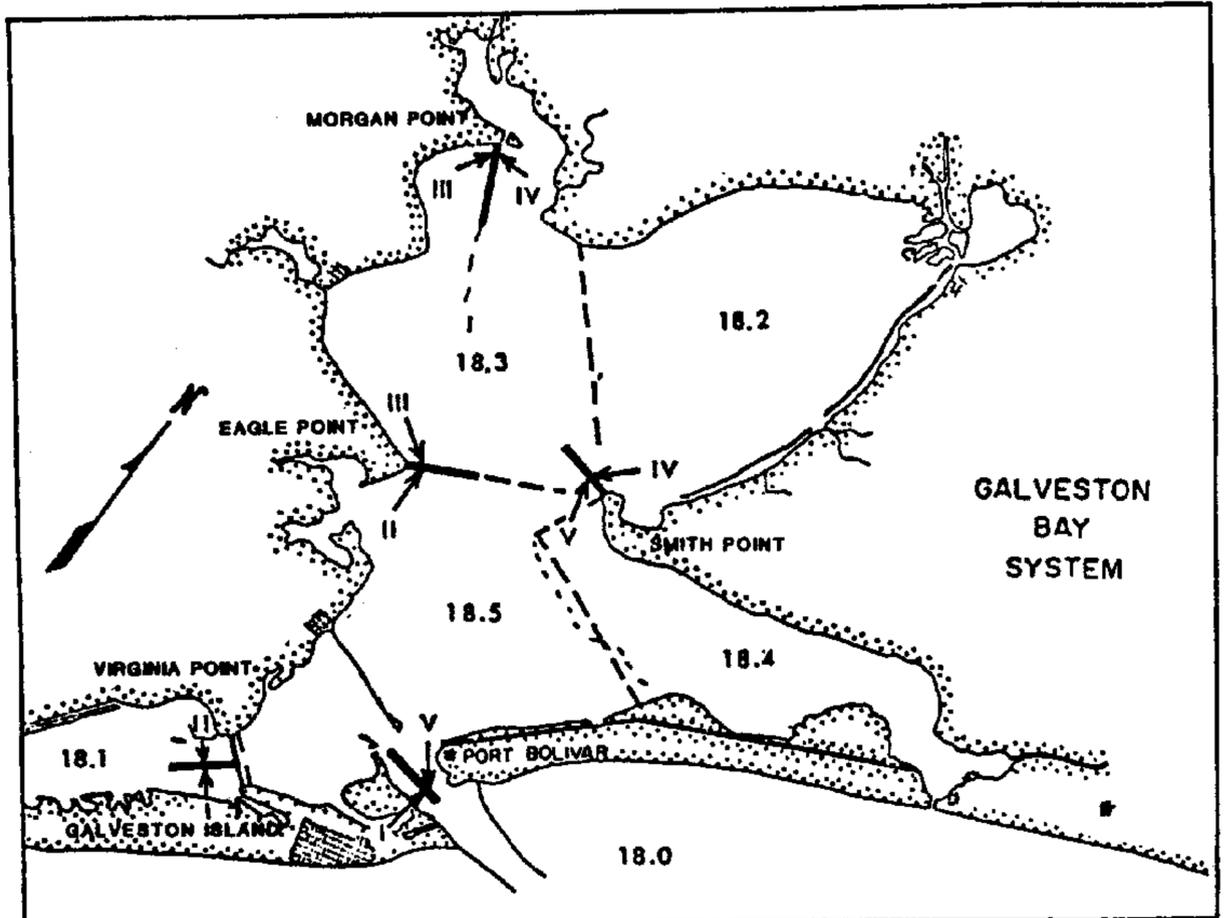


Figure 5.—Retailing areas I-V and fishing areas 18.1-18.5 used during the bait shrimp survey of Galveston Bay.

continue the formulation of a bait shrimp index for forecasting. Although the bait fishery is quite active between May and November in most years, during years of mild winter weather, activities continue through December. Dealers are readily available for interviews as their camps are open from early morning until dark. Some who have lighted fishing piers remain open 24 hours a day.

Fishermen are more difficult to interview, chiefly due to their practice of shrimping during early morning and late afternoon hours. This problem has been partially overcome by providing log books to fishermen who agree to keep records of their fishing activities. The logs are left aboard the bait boats and information relative to catch, effort, percentage of catch kept alive, and area fished is copied from them at the convenience of the fishermen. Catch data from those who do not keep logs is more difficult to secure. Often several return trips are required to obtain catch statistics from these fishermen. The key to

acquisition of valid data is the positive attitude of the interviewer.

Although all shrimp catch and effort statistics are ultimately converted to pounds and hours, they are reported to the interviewer in a variety of forms such as quarts, pounds, bushels, baskets, tubs, boxes, pails, and numbers. Most catches are given in quarts and pounds, but the interviewer must be familiar with the terminology of each dealer. For example, a bushel of shrimp usually contains 50 pounds, but a box may mean 5 pounds, 1 pound, 12 ounces, or 8 ounces, depending on the dealer. Usually live shrimp are reported in quarts and dead shrimp are reported in pounds, but a few dealers report the entire catch in gallons, bushels, or pounds regardless of whether they are referring to live or dead bait shrimp.

Calculation Procedure

The calculation procedure for estimating total landings and total effort expenditures for bait fishermen operating

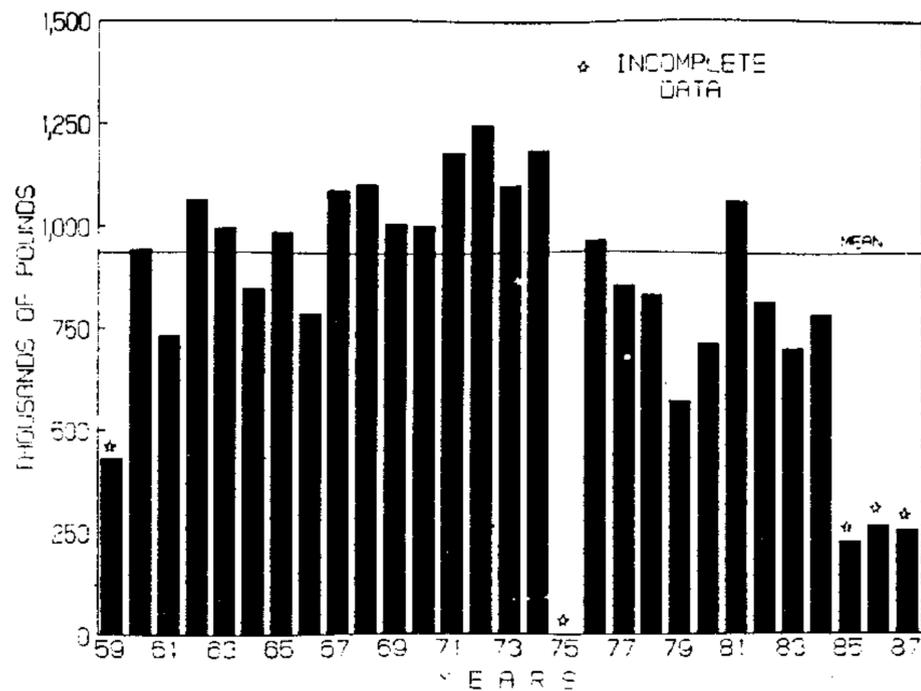


Figure 6.—Estimated annual bait shrimp catch from Galveston Bay, 1959-87.

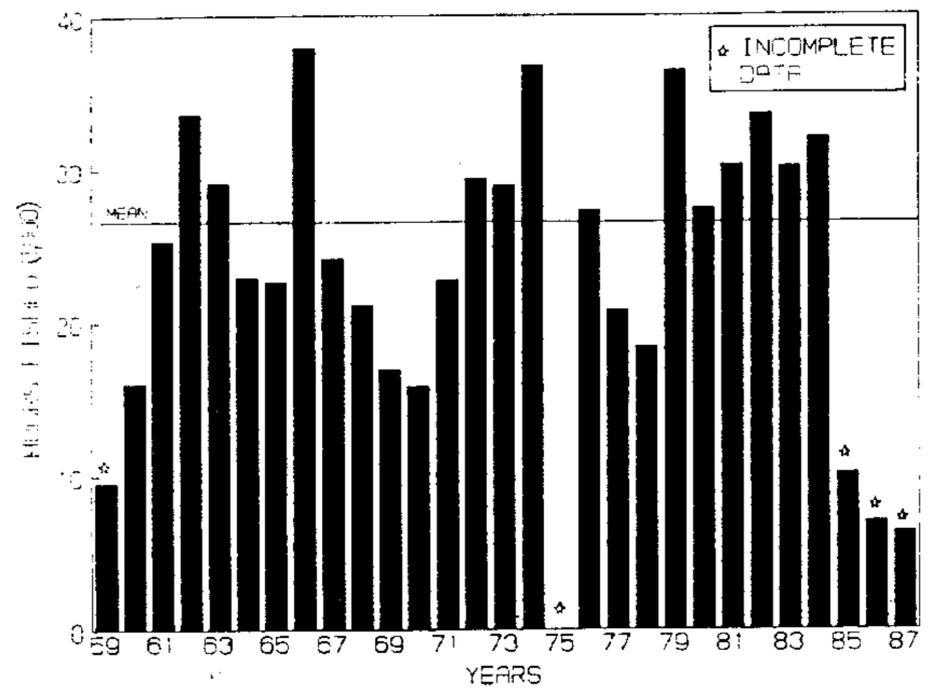


Figure 7.—Estimated annual bait shrimp effort from Galveston Bay, 1959-87.

in the Galveston Bay system is outlined below.

1) Number of active dealers and shrimping vessels are recorded for each area and week.

2) Number of active dealers interviewed and shrimping vessels interviewed are recorded for each area and week.

3) Weekly raw data from each of the five geographic areas of the bay are converted to pounds and hours, with 1 quart = 1.5 pounds.

4) Pounds and hours are summed within each area.

5) And, CPUE calculations are made:

- Sums of squares for pounds and hours within each area,
- Mean pounds of bait shrimp produced and mean hours of shrimping effort expended for each area during each week,
- Variance for pounds and hours for each area,
- Variance for mean pounds and mean hours for each area,
- Stratified mean for pounds and hours,
- Variance and standard errors of stratified means,
- Estimates of total pounds of bait

shrimp handled and total hours of shrimping expended,

- Confidence intervals at the 80 percent level for catch effort,
- Stratified estimates of proportions of brown, white, and other entering weekly landings, and
- An approximation of total pounds of various shrimp entering weekly landings.

Discussion

Galveston Bay bait shrimp fishermen exert only as much effort as it necessary to supply the demand for bait shrimp. Although the 1960-84 catch fluctuated between 0.6 and 1.2 million pounds (Fig. 6), effort varied from near 16,000 to 37,880 hours (Fig. 7). Fishing effort for 1975 was not recorded. Additionally, in recent years there was reduced sampling (1985-87). The average bait catch for 1960-84 was 940,378 pounds. Since 1977 (with the exception of 1981), the annual bait catches have been below average, but average number of hours expended (with the exception of 1977 and 1978), has been above the 1960-84 average of 26,693 hours.

The highest estimated annual catch during the survey was 1,249,100 pounds in 1972. CPUE ranged between 15.7 pounds/hour and 63.0 pounds/hour (Fig.

8), with the poorest years being 1966 and 1979. Unprecedented quantities of fresh water from spring floods decreased salinities in the upper bay during those years, creating conditions not conducive to brown shrimp growth (Gunter et al., 1964; Zein-Eldin and Renaud, 1986). These suboptimal conditions in the bay most likely caused young shrimp to leave the nursery area prematurely. Only a portion of the juvenile brown shrimp stock then remained to be fished by the bait fishery in 1966 and 1979.

Considering that both bait and commercial bay fishermen exploit the same shrimp crop, the below-average bait catches in recent years would suggest that the commercial bay catches should also be below average. This has not been the case. According to Klima et al. (1984), the average commercial catch (heads off) for 1960-82 from Texas bays was 1.9 million pounds. Additionally, for 1984 and 1985 the catches were 7.1 and 5.4 million pounds, respectively (Klima et al., 1987). More specifically, the NMFS Economics and Statistics Office data on Galveston Bay commercial shrimp landings (Fig. 9) indicate above-average landings in recent years. These inconsistencies between bait and commercial bay production might be attrib-

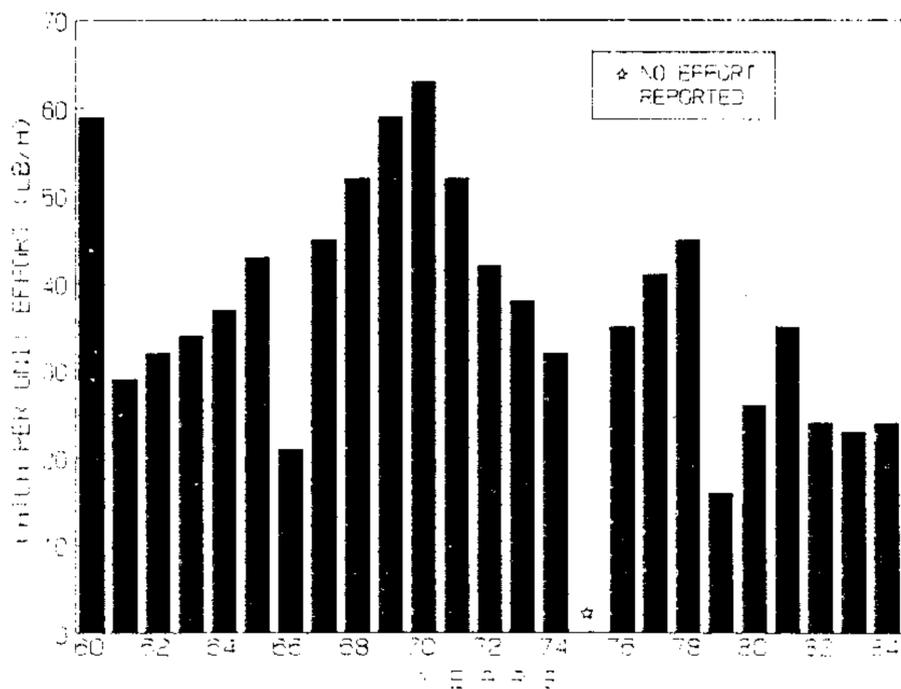


Figure 8.—Estimated catch per unit effort (CPUE) of bait shrimp from the Galveston Bay system, 1960-84.

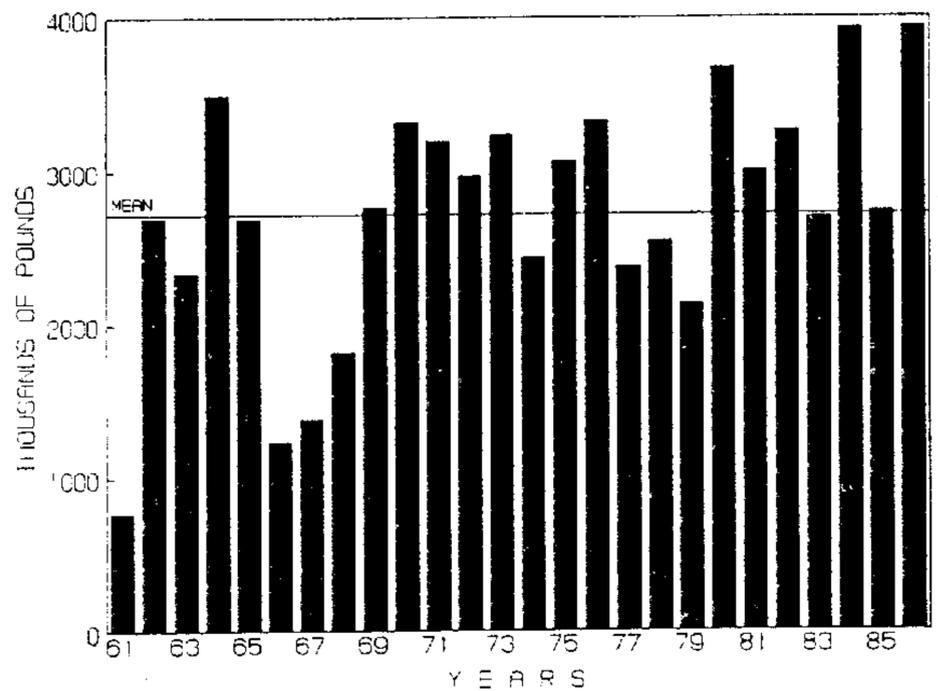


Figure 9.—Galveston Bay commercial landings (heads off) 1961-86.

uted to an increase in the number of boats fishing for commercial purposes.

Extensive changes have taken place in the bait fishery over the past 26 years. Bait shrimp dealerships have evolved from small stands that retailed live and dead bait, rented skiffs and motors, and provided launch ramps, to diversified establishments. In addition to bait shrimp, merchandise now sold includes fishing tackle, boat accessories and supplies, fuel, ice chests, ice, lanterns, food, soft drinks, liquor, and beer. Some have complete restaurants, marinas, and elaborate boat lift and storage facilities.

In summary, information about landing and species composition associated with the bait shrimp industry of the Galveston Bay system has been collected on a weekly schedule from 1959 through 1984 and on a more limited basis since 1985. Collectively, the bait index and the postlarval index (Baxter, 1963; Baxter and Sullivan, 1986) provide: 1) A reliable indication of the subsequent offshore harvest and 2) a long term correlation between juvenile abundance and changing environmental conditions. In addition, insight into local fishing practices and trends provide background for continuing research needed to enhance production and value of the shrimp stock.

Acknowledgments

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