

A Review of the Offshore Shrimp Fishery and the 1981 Texas Closure

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Introduction

The Texas closure management measure involved closure of the brown shrimp fishery for the first time from the coastline to 200 miles off Texas and was in effect from 22 May to 15 July 1981. The evaluation of the impact of this management measure has been scrutinized by a series of studies reported in this issue of the *Marine Fisheries Review*. In our paper we review the Texas and Louisiana offshore shrimp fisheries and describe the catch, relative abundance, and recruitment to the offshore fishery from June through August 1981 and compare the 1981 fishery with the fisheries of earlier years.

Statistics describing the U.S. Gulf of Mexico shrimp fishery began in 1956, and the procedures used to collect these data are described by Klima

(1980). These statistics, compiled by the Southeast Fisheries Center (SEFC) Technical and Information Management Services (TIMS), consisting of catch by statistical subarea (Fig. 1) and effort data, were used to analyze the effects of the Texas closure. In 1981, increased emphasis was exerted to collect catch and effort statistics from June through August. Location, catch, and amount of fishing effort expended are obtained by interviewing fishing captains at the termination of their trips. In 1981, the captains of at least 50 percent of the offshore vessels were

interviewed to obtain this specific information. However, in prior years the interview level was usually less than 30 percent.

All catch data were recorded as heads-off by species and size category by statistical subarea, depth zone, and month. These data were used to compile catch per unit effort (CPUE) per 24 hours of fishing and were reported in "Fishery Statistics of the United States" and "Shrimp Landings" (USFWS, 1956-70a, b; NMFS, 1970-79a, b). In addition, surveys of inshore waters of Texas and Louisiana were analyzed by the Texas Parks and Wildlife Department (TPWD) and the Louisiana Department of Wildlife and Fisheries (LDWF) to determine recruitment to the offshore fisheries.

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ABSTRACT — Prohibition of shrimp fishing within 200 miles of the Texas coast on 22 May 1981 resulted in large brown shrimp catches off Texas when the season reopened on 15 July. Catch per unit effort off Texas in late July and August 1981 ranged from 1,349 to 2,250 pounds per fishing day, compared with only 820 to 858 pounds per fishing day for the Louisiana offshore brown shrimp fishery. The July-August 1981 relative abundance (CPUE) off Texas was greater than during similar time periods for any other year. Shrimp caught and landed off Louisiana were also predominantly smaller than those caught and landed off Texas.

Recruitment from Texas bays to the offshore fishery appeared average to good, but was not sufficient to account for the outstanding abundance levels found offshore. The closure of Texas waters to fishing appears to have been a major reason for the large catches and high catch rates in July and August off Texas in 1981.

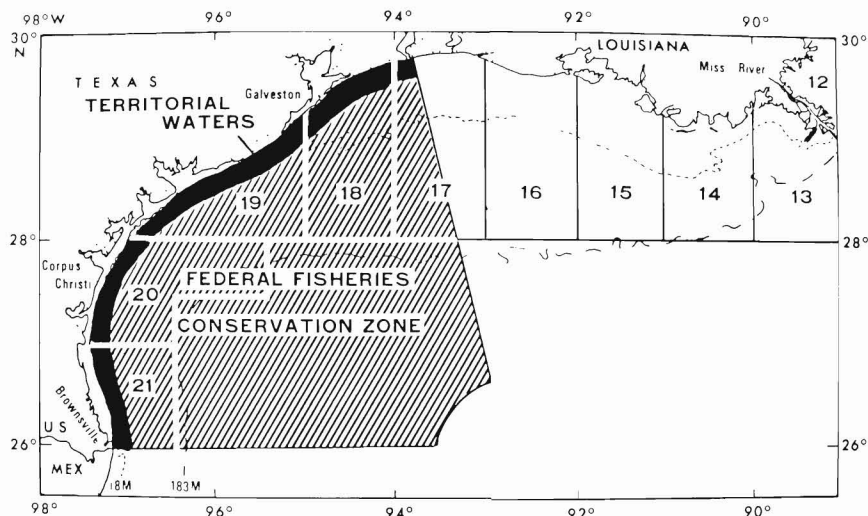


Figure 1.—Locations of statistical subareas (no. 12-21); The Texas territorial waters (solid black band); and the Federal Fisheries Conservation Zone (striped area).

Review of the Shrimp Fishery

Fishery Background

Shrimp have been fished commercially in the Gulf of Mexico since the latter part of the 19th century; commercial records date back to 1880 for Texas and Louisiana. Prior to 1900, shrimp were usually caught with haul seines, which were large, unwieldy nets extending up to 1,800 feet long. These nets required up to 20 men to operate and could be used only in shallow waters; thus many stocks of shrimp were used only seasonally, if at all. This factor appears to have been important in limiting the early growth of the fishery.

Gulf Coast shrimping in its present form began with the introduction of the otter trawl in 1915. This gear could be fished in deeper waters by small crews and proved superior to the haul seine. By 1930, virtually all Gulf shrimpers were trawling rather than seining. The otter trawl has changed little in design since its introduction, although size has varied considerably depending on size and design of the towing vessel. "Single-rigged" trawlers tow one large trawl, which may be as wide as 120 feet at the mouth; "double-rigged" trawlers tow two trawls varying from 40 to 75 feet wide at the mouth (Knake et al., 1958; Captiva, 1966, 1970). The double-rigged arrangement proved to be more effective in catching shrimp than a large single trawl and was used on virtually all large shrimp vessels until the early 1970's.

Commercial fishermen began testing and using twin trawl systems (four trawls are towed simultaneously, from each side and to the stern of the vessel) in 1972. The twin trawl concept (Harrington et al., 1972) has since gained wide acceptance by Gulf and Atlantic coast fishermen and is the most common gear used today on offshore Gulf vessels. Approximately 64 percent of the Texas offshore fishermen use twin trawls (Table 1).

Vessels used in the shrimp industry have varied in size and type from small skiffs to steel-hulled vessels over 100 feet long. It is convenient to divide to-

day's shrimp vessels into two distinct classes: 1) Inshore and 2) offshore vessels. Inshore vessels, which trawl the shallow bays and adjacent offshore waters, are usually wooden hulled, shallow draft boats under 45 feet long, powered by gasoline or diesel engines of less than 140 horsepower (HP). Offshore vessels are constructed from either wood, reinforced fiberglass, aluminum alloy, or steel. These vessels average between 50 and 90 feet long and are powered by diesel engines of up to 750 HP. Such vessels are usually capable of extended trips, which may last as long as 30-50 days. Even larger vessels have been built in recent years.

Biological Background

Although nine species of shrimp contribute to the Gulf fishery, only brown, *Penaeus aztecus*, white, *P. setiferus*, and pink, *P. duorarum*, shrimp are caught in commercial quantities. These shrimp are found in all Continental Shelf waters in the U.S. Gulf of Mexico inside 60 fathoms (fm). The greatest portion of the reported offshore catch of brown shrimp is taken in 11-20 fm, that of white shrimp in 5 fm or less, and that of pink shrimp in 11-15 fm. Highest offshore densities of brown shrimp occur off the Texas/Louisiana coast, the highest densities of white shrimp occur off the Louisiana coast; and highest densities of pink shrimp occur off the southwest coast of Florida.

In Texas and Louisiana only brown, white, and pink shrimp are commercially important and collectively make up over 99 percent of the annual

shrimp catch. In this review, we have considered only brown, white, and pink shrimp. These species have a similar life cycle in which spawning occurs offshore; however, the times that recruits enter the fishery differ for the three species. Eggs generally hatch into planktonic larvae after 10-12 hours. During the next 12-15 days, these larvae metamorphose through additional planktonic stages into postlarvae. Upon entering the estuaries, these postlarvae become benthic and develop quickly into juvenile shrimp.

Brown shrimp begin entering Texas estuaries in mid-February and continue through July, depending on water temperatures and environmental conditions. Several "waves" of postlarvae may enter the estuary, but peak recruitment occurs in March and April and again in September (Baxter and Renfro, 1967). The postlarvae use the estuary as a nursery and eventually migrate back into the Gulf at the sub-adult stage. Emigration begins in May with peak emigration periods usually during May, June, and, to some extent, July. While in the bays, the juvenile shrimp may be exposed to recreational and commercial fishing during the spring and summer months. These fisheries are controlled by the respective states.

White shrimp postlarvae begin entering the Texas estuaries in May, with a peak in June and September and with some recruitment continuing until November (Baxter and Renfro, 1967). These postlarvae use the estuaries as nurseries during summer and fall and grow to harvestable size (120-160 mm total length) in the bays, where they are exploited by recreational and commercial fishermen during late summer. White shrimp emigration is governed by size and environmental conditions within the given bay systems. Usually they begin emigrating in late August and September, when the offshore commercial fishery exploits this resource. The average life span of these three species is thought to be about 18 months, although some live for 3-4 years.

Pink shrimp also are commercially important to the Texas fishery but are

Table 1.—Fishing gear and number of vessels landing in Texas (1980)¹.

Number of nets	Average net size (yards)	Number of vessels
1	19.4	645 ²
2	38.8	579
4	48.5	1,028

¹1980 Operating Units Inventory, Technical and Information Management Services, Galveston Office, Southeast Fisheries Center.

²Almost exclusively inshore fishing vessels.

usually recorded as brown shrimp, since they are not sorted by processors and are more difficult to distinguish from brown shrimp than white shrimp. South Texas apparently has a major pink shrimp fishery in which postlarvae enter the bay systems in early winter, use the bay systems as a nursery, and emigrate offshore in March and April, where they are harvested by the commercial fleet. The percentage of pink shrimp landed is not known. We assume that it does not constitute more than 10 percent of the total shrimp catch off Texas.

Production and Regulations

During the early years of the fishery, Gulf shrimpers caught only white shrimp, as brown and pink shrimp could not be marketed due to their darker color. From 1880 through 1918, the annual white shrimp catch along the Texas coast averaged 172,000 pounds, heads-off¹, and 5.9 million pounds off Louisiana. Although records are incomplete during this time, by 1923 the Texas catch increased to about 2.2 million pounds and by 1927 had reached 7.4 million pounds. The Louisiana catch in 1927 was 26 million pounds. From 1927 to 1945, Texas landed an average of 7.8 million pounds annually of predominantly white shrimp, and Louisiana landed an average of 40.5 million pounds. After World War II, however, large concentrations of brown and pink shrimp were discovered off the coasts of Texas and Florida. The Texas shrimp catch increased dramatically from 13.8 million pounds in 1948 to a peak of 58 million pounds in 1954. By 1956, the Bureau of Commercial Fisheries began to record catch statistics accurately for the entire Gulf of Mexico.

Brown shrimp predominate the Texas catch, although there is a continuing white shrimp fishery. From 1956 through 1976, the average catch of white shrimp was approximately 9.5 million pounds, with a low of approximately 2.3 million pounds in 1957 and

¹All catches reported in pounds, heads-off.

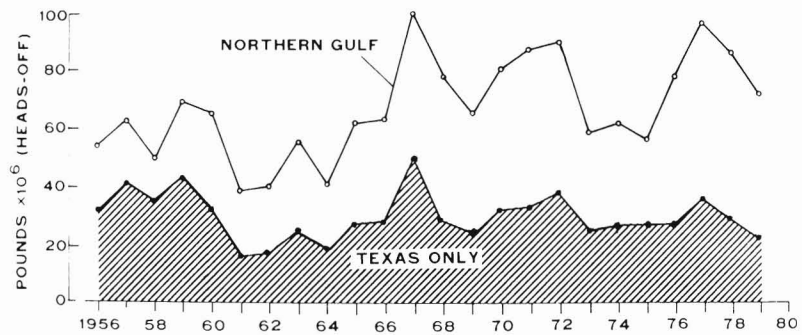


Figure 2.—Average annual landings of brown shrimp for Texas only and for the northern gulf (including Texas, Louisiana, Mississippi, Alabama, Florida, and Mexico) for the period 1956-79.

a high of 14.9 million pounds in 1973 (USFWS, 1956-1970a; NMFS, 1971-1979a). The average Louisiana white shrimp catch for 1956-76 was 20.2 million pounds.

Brown shrimp have been the main focal point for the Texas fishery since adequate recordkeeping began in 1956, averaging approximately 28.6 million pounds for the timespan through 1979, i.e., brown shrimp landed in Texas comprise about 50 percent of the brown shrimp catch in the northern Gulf of Mexico (USFWS, 1956-1970b; NMFS, 1971-1979b). The peak year was 1967, when almost 50 million pounds were caught off Texas; low landings occurred in 1961, 1962, and 1964, when an average of slightly less than 20 million pounds was caught off Texas (USFWS, 1956-1970b). Average annual production from 1970 to 1980 increased to 30.4 million pounds, indicating an increase in brown shrimp production compared with the 20-year average from 1960 (Fig. 2). Production of brown shrimp from bay waters in Texas since 1971 was less than 9 percent of the total annual Texas catch. Fluctuations in catch are notable during the last 20 years and have caused considerable economic hardship to the fishery.

Shrimping regulations vary by states along the Gulf coast and, in fact, the harvesting strategy differs significantly between Louisiana and Texas (Christmas and Etzold, 1977). These two states account for approximately 75

percent by weight of the shrimp landed from the U.S. Gulf of Mexico. In Texas, shrimping regulations generally restrict the landing of small shrimp, whereas in Louisiana there are few restrictions on the taking of small shrimp. The overall results of these two diametrically opposed regulatory schemes are that in Texas the bulk of the catch comes from an offshore fishery and consists mostly of large shrimp, whereas in Louisiana, there is a substantial inshore fishery producing a large volume of small brown and white shrimp. The average ex-vessel value per pound for brown shrimp for 1961 through 1975 was 1.6 times higher in Texas than in Louisiana. Further, the annual total weight and value of brown shrimp landings (Fig. 3) have been greater in Texas than in Louisiana (Caillouet and Patella, 1978).

To protect the small emigrating brown shrimp during peak recruitment periods, Texas enacted a "closed" season in 1959 to enhance shrimp catches by allowing the shrimp to grow to a large size before they were exploited. The Texas law provides for a 45-day closed season in all offshore waters out to 3 marine leagues with a general closing date of 1 June and opening date of about 15 July (Table 2), with the provision that the season can be either opened earlier due to an excess amount of shrimp emigrating early, or closed later. However, the season cannot extend for more than 60 days. Texas is the only coastal state to initiate such a

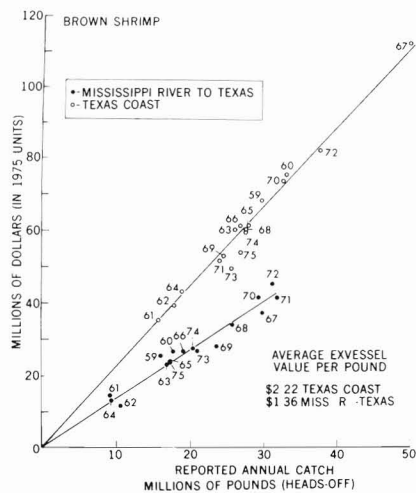


Figure 3.—Relationship between average ex-vessel value per pound of brown shrimp landings and total annual catch for the years 1959-75 on the Texas and Louisiana (Mississippi River to Texas) coasts (Caillouet and Patella, 1978).

Table 2.—Historical dates of the closed shrimp season off Texas¹.

Year	Date closed	Date open
1960-66	1 June	15 July
1967	17 May	1 July
1968-71	1 June	15 July
1972	17 May	1 July
1973-75	1 June	15 July
1976	17 May	15 July
1977-80	1 June	15 July
1981	22 May	15 July

¹C. E. Bryan, Texas Parks and Wildlife Department, Austin, Tex., pers. commun., 1981

law, and it has been in effect for 21 years. During the closed season, Texas permits a daytime white shrimp fishery inside 4 fm, but vessels (or boats) are only permitted to use a single trawl not larger than 25 feet between the trawl doors. In addition, Texas has had restrictions on the size of shrimp landed and prevents the landing of shrimp smaller than 65 count, heads-off (i.e., 65 shrimp/pound) during the regular open season.

In 1981, along with the promulgation of the Shrimp Fishery Management Plan (NOAA, 1980), the size

restriction on brown shrimp was eliminated in Texas. In addition, Texas allows inshore fishing in its bays and estuarine systems from 15 May to 15 July and allows a catch of 300 pounds/day, heads-on, without size restrictions. At present, no size count is in effect for the inshore fishery. Also, a bait shrimp fishery is open year-round and each vessel is permitted to take up to 150 pounds/day, half of which must be kept alive.

Louisiana Fishery

In Louisiana, shrimp fishing in inside waters is regulated by the Louisiana Department of Wildlife and Fisheries. This agency, like the Texas Parks and Wildlife Department, has an intensive sampling program that is the basis upon which they recommend to the Louisiana Wildlife and Fisheries Commission the opening and closing of the brown and white shrimp season in inside waters. The brown shrimp season opens between 15 and 25 May, with the specific date based on the average size expected on the opening date. The season may not run for more than 60 days. To protect juvenile white shrimp, the Commission has the authority to recommend closure of the brown shrimp season by regional areas if large concentrations of juvenile white shrimp are present in the specific bay systems. In 1981, the brown shrimp season was opened on 18 May, and inside waters west of the Mississippi River were closed to brown shrimp fishing on 8 July.

The brown shrimp catch (1977-80) from inside waters ranged from 28 percent to 37 percent of the total annual brown shrimp catch for the State of Louisiana. Peak production from inside waters occurs in May and June, with reduced production in July and August. The total annual brown shrimp production in Louisiana (subareas 13-17) from 1960 to 1979 ranged from a low of 7 million pounds in 1962 to a high catch of 46 million pounds in 1977 and 1978. The average annual production during the period 1960-79 was approximately 24.7 million pounds. Since 1977, over 50 percent of the annual Louisiana brown shrimp

production has occurred in June, July, and August.

The offshore fishery from June through July, based on 1979 data, is usually concentrated in statistical subareas 13 and 15 in the 0-5 fm depth range (Fig. 4, 5, 6). In August, a similar pattern exists, except the fishery moves to slightly deeper waters and is spread throughout the entire coast. We used 1979 to portray the offshore fishery; it probably depicts a typical year in Louisiana as its production of 27 million pounds was near the 15-year average.

Texas Fishery

The offshore fishery in Texas during June 1979 obviously was conducted outside the territorial sea of Texas, because it has been illegal since 1960 to fish inside 3 marine leagues at that time of year. Major production in June 1979 occurred in statistical subarea 21 in depth zones from 11 to 25 fm. The fishery in July 1979 was predominantly in the southern portion of the state, with major production occurring in subareas 20 and 21 in depth zones from 11 to 20 fm. Some production occurred in 16-30 fm; peak production occurred in 6-10 fm in subarea 18, with more or less uniform production in statistical subareas 20 and 21 (Fig. 7, 8, 9). The specific location of peak fishing off Texas varies between years; however, peak production usually occurs in statistical subarea 19 between 11 and 25 fm.

Size Composition 1972, 1977-80

For the past several years, small shrimp (68 count) have dominated the size composition in statistical subareas 13-17 in June (Fig. 10). Usually over 70 percent of the shrimp are 51 count or smaller. In July, the size distribution of shrimp off Louisiana increases to large-size animals. In some years there are two modes: One at size count category 31-40 and another at 51-67. In general, however, at least 60 percent of the brown shrimp catch is composed of shrimp smaller than 41 count/pound. By August, the catch is predominantly 31-40 count shrimp. There is some variation between years, with an occa-

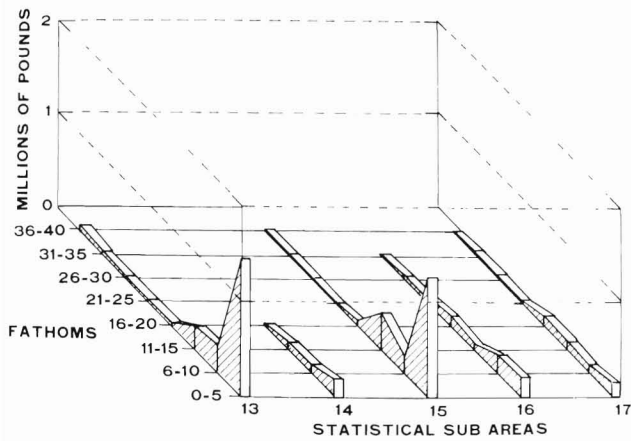


Figure 4.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Louisiana, June 1979.

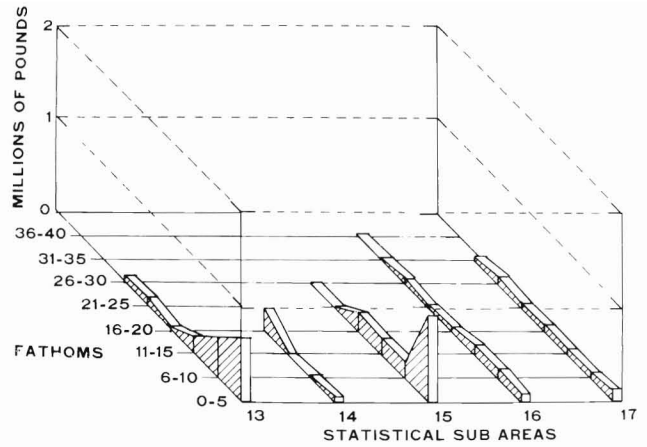


Figure 5.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Louisiana, July 1979.

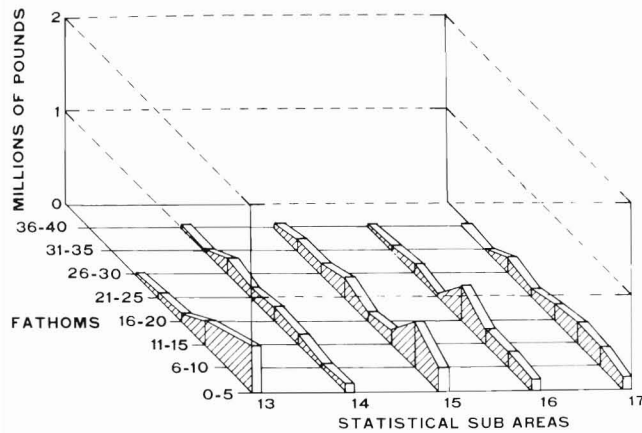


Figure 6.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Louisiana, August 1979.

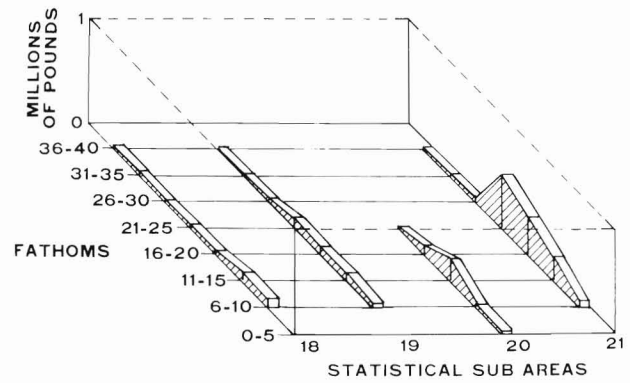


Figure 7.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Texas, June 1979.

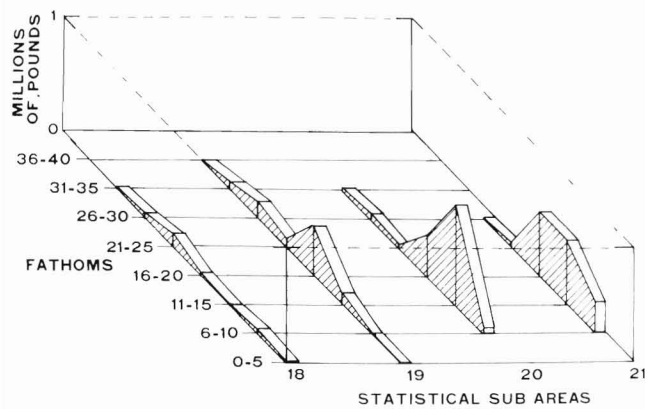


Figure 8.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Texas, July 1979.

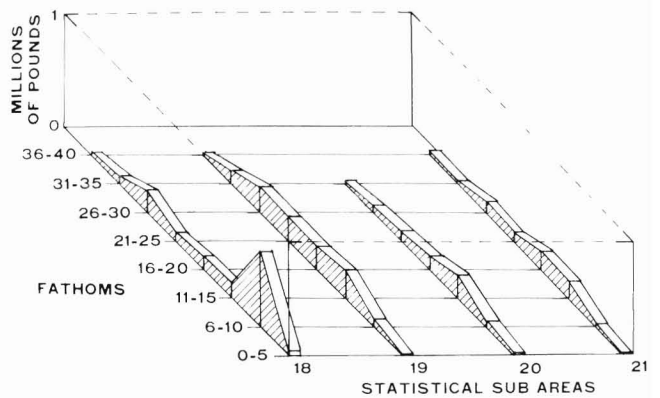


Figure 9.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Texas, August 1979.

sional dominant mode at 51-67 count/pound. However, the general trend for the majority of the catch is in the 31-40 size category.

Off Texas, the percent size composition in June varied considerably between years (Fig. 11). However, the dominant mode is 51-67 count shrimp with usually more than 40 percent of the shrimp comprising this or a smaller size of shrimp. However, one should recall that fishing is not permitted inside 3 marine leagues during June in Texas; therefore, the fleet is prohibited from capturing small shrimp as they immediately egress from the bay systems. Size composition of the commercial landings of brown shrimp in July varies considerably between years. Depending on the year, two peaks in the 61-67 and 31-40 size categories are apparent. In years of high landings, such as 1972 and 1977, there is a definite peak in the 31-40 size category in July. In years of low landings, such as 1980 and 1979, there is a peak in the 51-67 size category. In general, there is considerable variation between years in the size composition landed during July. The size composition in August off Texas is dominated by 31-40 count shrimp.

The 1981 Fishery

In 1981, the FCZ and the territorial sea of the State of Texas were closed to all shrimp fishing from 22 May to 15 July. A daytime fishery from the beach to 4 fm was permitted along the entire Texas coast during this period. The total landed catch in June for the daytime fishery was approximately 28,000 pounds and 4,600 pounds of white and brown shrimp, respectively. The July white shrimp catch was 325,000 pounds. Over 90 percent of the catch was produced in statistical subareas 18 and 19. Since only 182 trips were made in Texas waters in June 1981, the major portion of the Texas fleet apparently did not fish in Texas waters. There were reports of occasional illegal fishing within the zone and approximately seven vessels were cited for infractions.

Louisiana

In June 1981 some Texas vessels

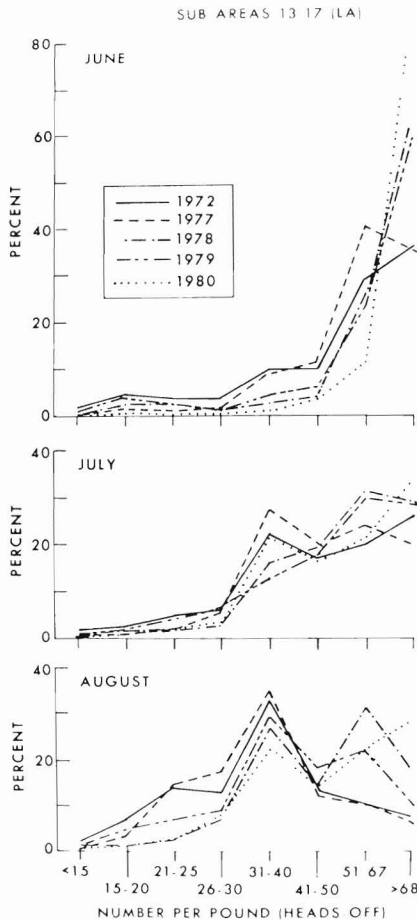


Figure 10.—Percent size composition of brown shrimp landings off Louisiana, June-August 1972, 1977-80.

fished in statistical subareas 17-14 in Louisiana (Fig. 12). The majority of vessels that landed in Texas fished for brown and white shrimp in statistical subarea 17 with over 1.6 million pounds of brown shrimp being produced from that subarea. Also, slightly more than 0.3 million pounds of brown shrimp were produced in subarea 16 and less than 0.1 million pounds were produced in subareas 14 and 15.

Texas vessels made 1,013 fishing trips to these subareas in June 1981. In addition to fishing for brown shrimp at night in statistical subarea 17, these boats also fished for white shrimp in

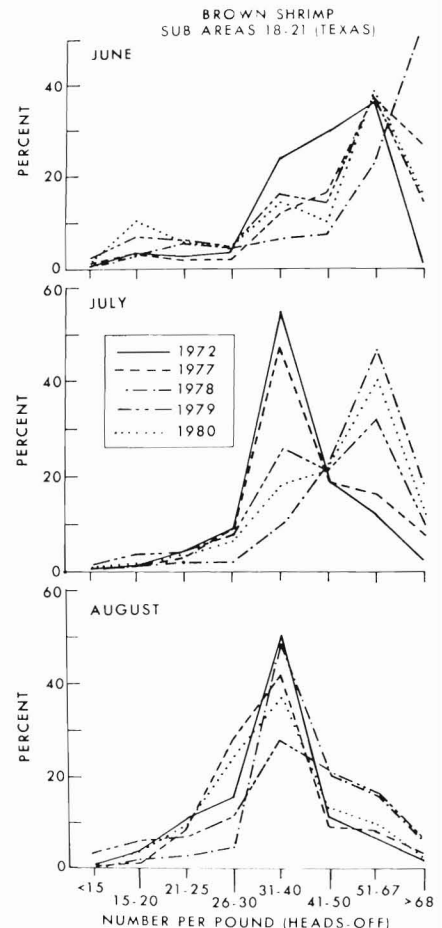


Figure 11.—Percent size composition of brown shrimp landings off Texas, June-August 1972, 1977-80.

the daytime in the 0-5 fm depth range. White shrimp averaged 21-25 count/pound, whereas brown shrimp averaged 51 count/pound or smaller. Over 67 percent of brown and white shrimp from subarea 17 and 32 percent from subarea 16 were landed in Texas ports. The remaining portion of the Louisiana coast was fished predominantly by Louisiana fishermen.

The brown shrimp fishery off Louisiana in June was concentrated basically in three statistical areas: 13, 15, and 17 (Fig. 13). Excepting subarea 17, the catch was produced from the 0-5 fm depth range with very little produced beyond that range. In subarea 17, the

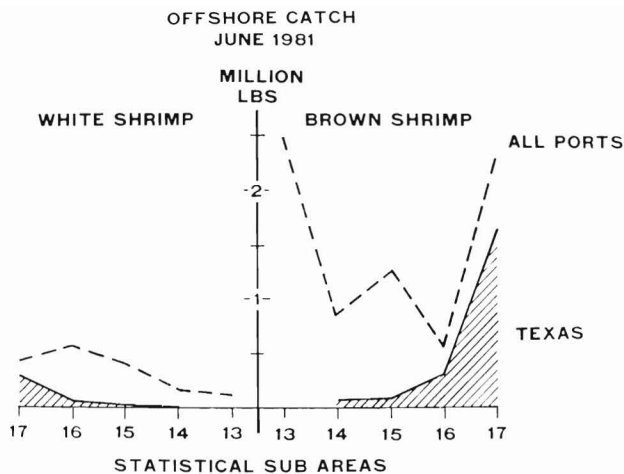


Figure 12.—Weights of offshore white and brown shrimp catches (in 10^6 pounds, heads-off) from statistical subareas 13-17 off Louisiana in June 1981, landed at Texas ports only, and landed at all northern Gulf ports.

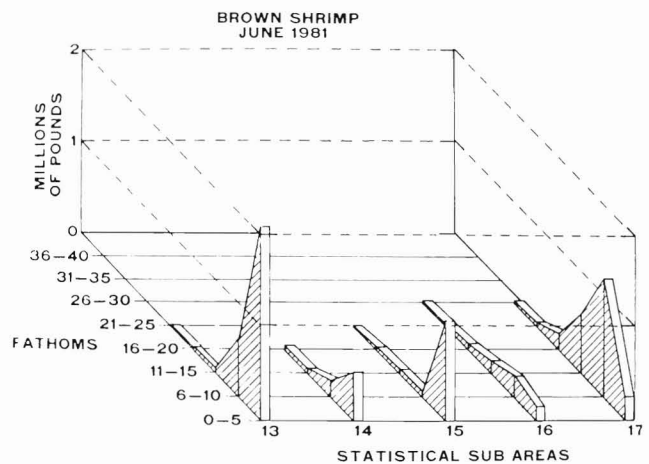


Figure 13.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Louisiana, June 1981.

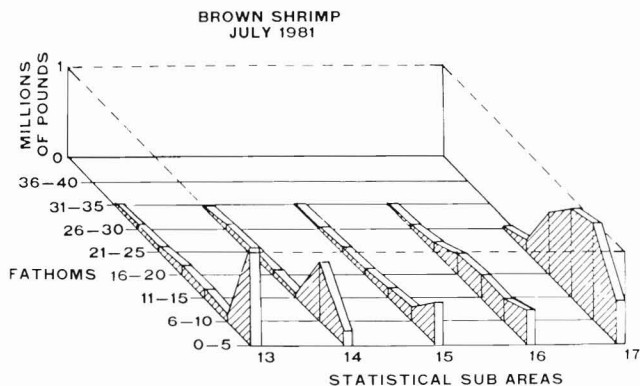


Figure 14.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Louisiana, July 1981.

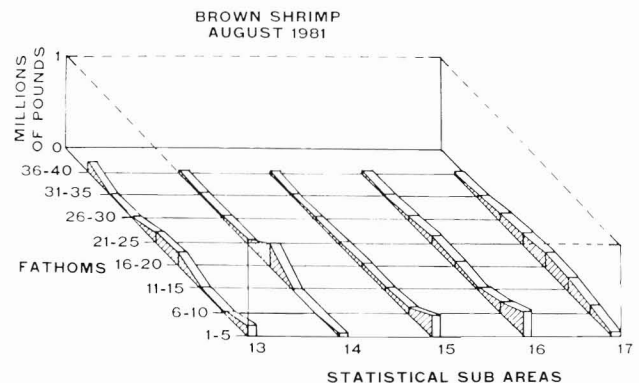


Figure 15.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Louisiana, August 1981.

majority of the catch came from the 6-10 fm depth range with an appreciable amount being produced in 11-15 fm. The majority of the catch landed in statistical subarea 17 was produced by vessels landing in Texas (Fig. 12). The July catch off Louisiana was approximately in the same geographical subarea and same magnitude as the June catch (7.5 and 7.4 million pounds in June and July, respectively). The major producing subareas were 13, 16, and 17. In subarea 17, production was over 3 million pounds with 80 percent being caught in the 6-20 fm depth

range (Fig. 14). In contrast, subarea 13 produced 1.5 million pounds of which 67 percent was caught within 5 fm. The catch off Louisiana in August was extremely low, resulting in approximately 2.9 million pounds being landed. The catch was distributed more or less equally throughout the area, with no one subarea predominating (Fig. 15).

Texas

The July brown shrimp catch off Texas amounted to 10.3 million pounds and was produced in all subareas of

the coast, with the major production occurring in statistical subarea 19 from the 11-20 fm depth range (Fig. 16). The catch was predominantly more offshore than that recorded for Louisiana and was significantly greater than the Louisiana production of 7.4 million pounds. About 80 percent of the Texas catch was produced in the 6-20 fm depth range and over 90 percent between 6 and 25 fm.

Approximately 14.6 million pounds of brown shrimp were caught in August off Texas, and this catch was distributed similarly to the July catch ex-

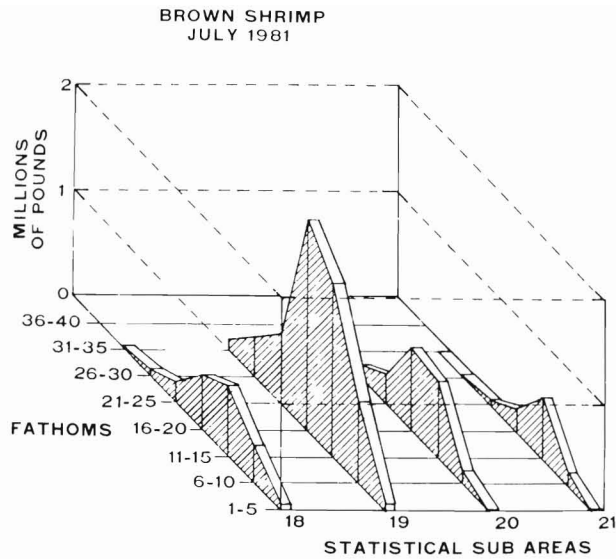


Figure 16.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Texas, July 1981.

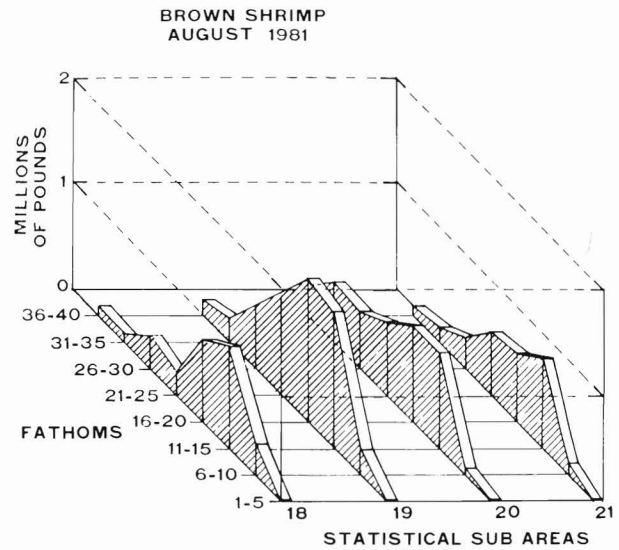


Figure 17.—Relationship of offshore brown shrimp catch to depth and statistical subarea off Texas, August 1981.

cept that more was produced farther offshore than in July. About 59 percent of the catch was caught between 11 and 20 fm and 75 percent from 11 to 25 fm. All subareas produced large quantities of shrimp, with subarea 19 being the largest production zone off Texas (Fig. 17).

The large production of shrimp in July resulted in some serious gluts of shrimp at the dock, with large concentrations of landings occurring in the third and fourth weeks of July. In Texas, shrimp are normally headed at sea. Immediately after the opening of the closed season, however, many of the shrimp boats were unable to head their entire catch and either discarded a portion of the catch or landed the catch heads-on. Since the processing industry was not prepared to process the large quantity of heads-on shrimp landed in July and August in Texas, some problems were encountered. To alleviate this problem, some of the shrimp landed in Texas were shipped to other ports in the Gulf area for processing.

During the first week of the open season, large catches were made offshore, and it has been reported to NMFS Southeast Fisheries Center port

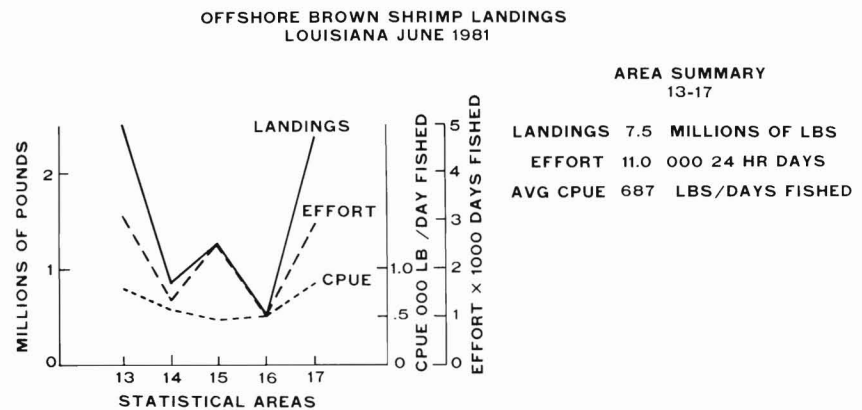


Figure 18.—Relationship of offshore brown shrimp catch, fishing effort, CPUE (catch per unit effort), and statistical subarea off Louisiana, June 1981.

agents that there was some discarding of shrimp all along the coast due to the inability to handle the large catches with the normal 3-4 man crew. Discarding lasted only a couple of days, and thereafter adequate crews were placed aboard the vessels to handle the larger catches.

Relative Abundance

In June, the Louisiana offshore

catch was approximately 7.5 million pounds with approximately 11,000 24-hour days of fishing effort expended. The CPUE was 687 pounds/24-hour day with little variation between statistical subareas 13 and 17 (Fig. 18). The July catch and catch rates off Louisiana were similar to the June figures, although fishing effort was somewhat lower in July. The average catch in July off Louisiana was 858

pounds, with catches varying from a low of 641 pounds in statistical subarea 15 to a high of slightly over 1,000 pounds in subarea 17 (Fig. 19).

Vessels from all over the Gulf and south Atlantic apparently fished Texas waters with catch rates reported as high as 40 boxes²/night in late July. Average catch of shrimp off Texas during the July period was 2,250 pounds/24-hour-day. The CPUE varied from a low of approximately 1,900 pounds in statistical subarea 21 to a high of almost 2,400 pounds in statistical subarea 20 and 2,300 pounds in subarea 19. The two weeks of fishing off Texas in July yielded approximately 10.3 million pounds of brown shrimp. In July, there was a major difference between Texas and Louisiana brown shrimp production as well as the very large difference in the CPUE or relative abundance of brown shrimp. Relative abundance off Texas was almost 2.5 times greater than that experienced in Louisiana.

The catch in Louisiana in August was lower than in previous months, yielding only 2.9 million pounds with an average CPUE of 820 pounds/24-hour-day (Fig. 20). No major difference was observed in the CPUE between statistical subareas 13 and 17 in August. The August catch in Texas was 14.6 million pounds with an average CPUE of 1,346 pounds/24-hour-day. The CPUE ranged from approximately 1,100 pounds in statistical subareas 18 and 21 to a high of 1,600 pounds in subarea 20. The catch was remarkably different between Texas and Louisiana. The low catch in Louisiana contrasted with the high catch in Texas and may be attributed to a lower amount of fishing effort — only 3,500 days fished in Louisiana compared with 10,800 days fished off Texas. However, the real difference observed was a CPUE 1.6 times larger in Texas compared with Louisiana in August.

In comparing the June-August Louisiana catch between 1977 and 1981, it is evident that the catches in 1977, 1978, and 1981 were very similar, with slightly higher production in 1977 and

²Defined as 100 pounds heads-off shrimp.

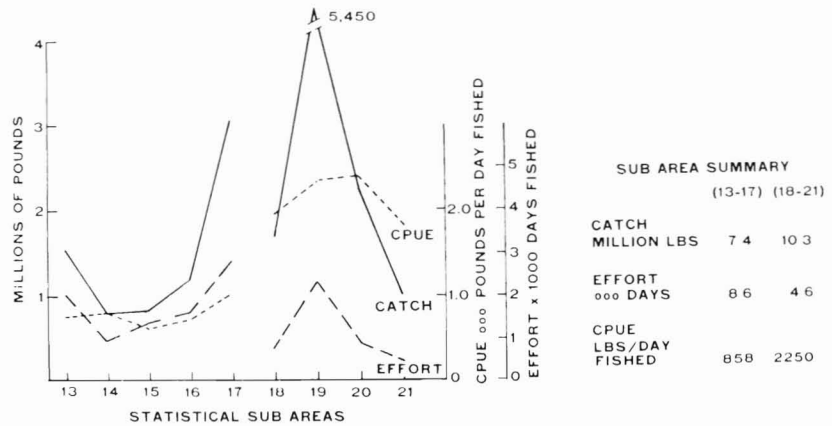


Figure 19.—Relationship of offshore brown shrimp catch, fishing effort, CPUE (catch per unit effort), and statistical subarea off Louisiana and Texas, July 1981.

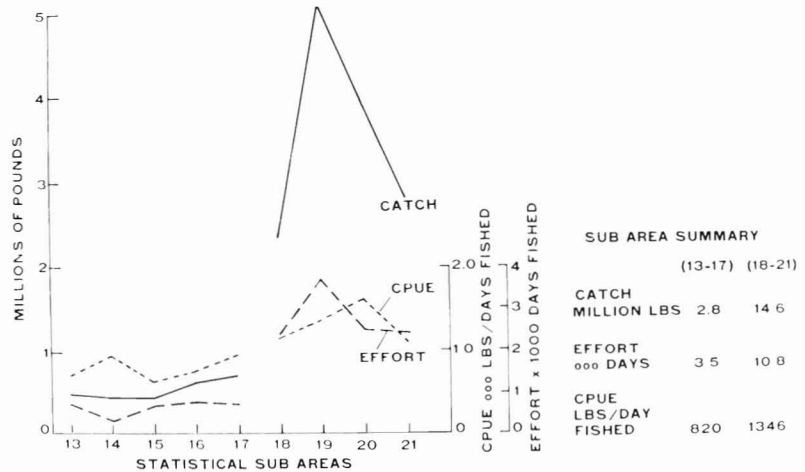


Figure 20.—Relationship of offshore brown shrimp catch, fishing effort, CPUE (catch per unit effort), and statistical subarea off Louisiana and Texas, August 1981.

1978 than in 1981. The notable difference between 1981 and 1977-78 was a 50 percent lower catch in August 1981 as compared with August 1977 and 1978. The catch in 1979 and 1980 in Louisiana was significantly lower than that for the three other years mentioned. In comparing the catches off the Texas coast in statistical subareas 18-21 for the June-August period, it is evident that the total July-August production in 1981 far exceeded the June-August production from 1977 to the

present time as well as the June-August production in 1972, a very good brown shrimp year (Fig. 21).

In comparing the CPUE or relative abundance in statistical subareas 13-17 between 1977 and 1981, it is apparent that the relative abundance in June through August was somewhat similar in 1977, 1978, and 1981 (Fig. 22, Table 3). Average CPUE was 788 pounds/24-hour-day in 1981. In comparing the CPUE for statistical subareas 18-21 off Texas, again it is apparent that the

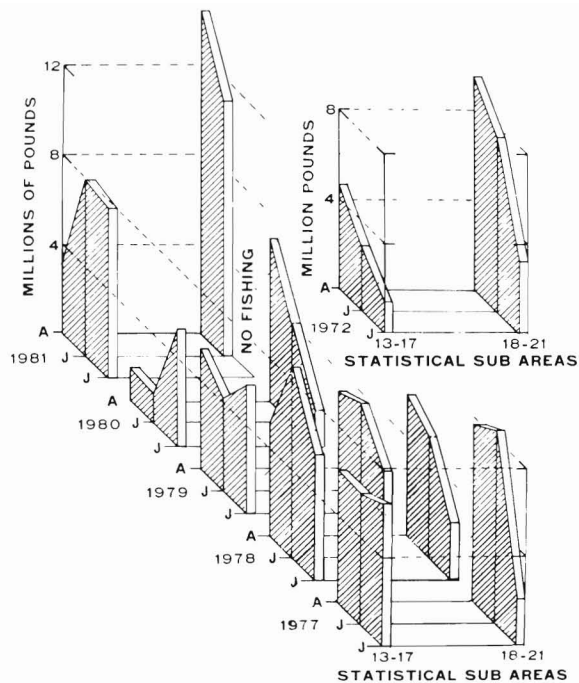


Figure 21.—Comparison of total offshore brown shrimp catches off the Louisiana and Texas coast in June (J), July (J), and August (A) 1972 and 1977-81.

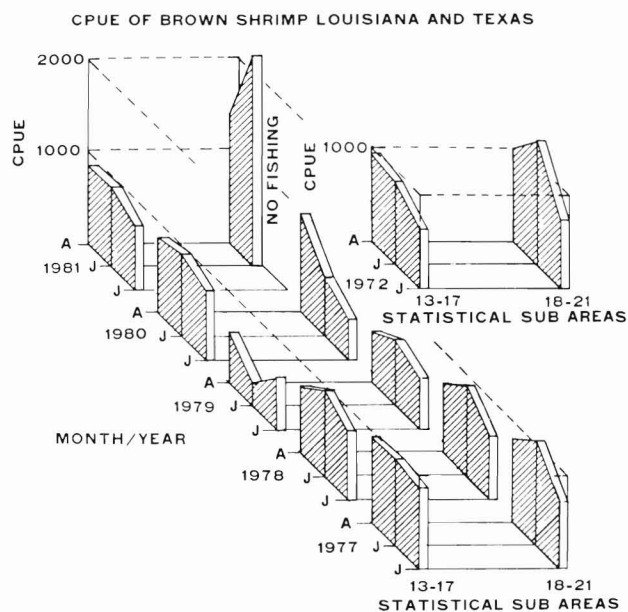


Figure 22.—Comparison of CPUE (catch per unit effort) of brown shrimp off the Louisiana and Texas coast in June (J), July (J), and August (A) 1972 and 1977-81.

relative abundance was significantly greater in July and August 1981 than in any of the previous years examined. Further, it is evident that the 1981 CPUE or relative abundance was much greater off Texas for the 3 months examined compared with the CPUE off Louisiana in 1981.

In addition, we have compared the same catch and relative abundance for a good year, identified as 1972, with 1981. The relative abundance in subareas 13-17 in 1972 was 820 pounds/24-hour-day compared with 788 pounds in 1981 — virtually no difference. Although relative abundance was approximately the same, the total catch in 1972 in this area was 8.8 million pounds compared with 17.7 million pounds in 1981. This large difference in production was due to a low level of fishing effort expended in 1972 compared with 1981 (Table 3). Off Texas in statistical subareas 18-21, the

Table 3.—Summary of brown shrimp catch (millions of pounds), effort ($\times 1000$ days), and CPUE for Louisiana subareas 13-17 and Texas subareas 18-21, June-August 1972 and 1977-1981.

Year and item	June		July		August		Total	
	13-17	18-21	13-17	18-21	13-17	18-21	13-17	18-21
1972								
Landings	1.3	3.1	2.9	7.9	4.6	9.5	8.8	20.5
Effort	2.1	4.1	3.3	7.4	4.8	9.5	10.2	21.0
CPUE	640	771	872	1,073	948	997	820	947
1977								
Landings	6.4	2.1	5.8	8.6	5.9	8.0	18.1	18.7
Effort	7.4	2.9	6.3	7.5	6.1	8.9	19.8	19.3
CPUE	877	729	938	1,136	982	901	932	922
1978								
Landings	5.6	2.6	8.5	5.4	5.1	6.3	19.2	14.3
Effort	7.8	3.8	9.0	5.5	7.0	8.5	23.8	17.8
CPUE	721	675	941	988	733	742	798	801
1979								
Landings	5.7	1.9	4.2	3.9	5.3	3.5	15.2	9.3
Effort	9.8	3.2	14.8	5.5	9.6	6.4	34.2	15.1
CPUE	584	596	281	701	555	544	473	614
1980								
Landings	4.7	¹ 1.4	1.5	4.6	1.8	7.2	7.9	13.2
Effort	6.2	3.5	1.6	6.8	2.1	6.7	9.9	17.0
CPUE	751	400	893	669	849	1,067	831	721
1981								
Landings	7.5	—	7.4	10.3	2.9	14.6	17.8	24.9
Effort	11.0	—	8.6	4.6	3.5	10.8	23.1	15.4
CPUE	687	—	858	2,250	820	1,346	788	1,798

¹Interview data only.

relative abundance in 1972 was approximately 947 pounds/24-hour-day compared with an average of approximately 1,800 pounds in 1981. Total production in 1972 was 20.5 million pounds compared with 24.9 million pounds in 1981. Even though 1972 was a good year, well above the 15-year average, relative abundance and total production for the July-August period in 1981 off the Texas coast far exceeded 1972 figures.

In 1972, the relative abundance between Louisiana and Texas was the same (820 and 947 pounds/24-hour-day, respectively); in fact, in comparing the relative abundance for the June-August period for 1977-80, there is little difference (Table 3). We conclude that there is not normally a great difference in the relative abundance between Louisiana and Texas during the June-August time period and that the CPUE's reflect good, average, and poor shrimp production. There may be large individual differences in CPUE between specific statistical subareas and/or months; however, the average CPUE for the June-August period between Texas and Louisiana does provide a good measure of abundance for the entire area.

A large difference in the CPUE for the June-August period between Louisiana and Texas has not been observed from the data set we examined, except in 1981. The difference in the CPUE between Texas and Louisiana in 1981 may reflect an increase in survival of shrimp because of a decrease of fishing mortality of the 1981 brown shrimp year-class off Texas. However, we caution a conservative interpretation until additional future years replicate the 1981 CPUE information.

Size Composition

In 1981, over 70 percent of the Louisiana brown shrimp catch in June was composed of 51 count/pound or smaller size shrimp (Fig. 12). The July catch was dominated by two modal groups, 31-40 and 68 count/pound or smaller shrimp (29 percent and 28 percent, respectively). Average size composition of the landings in August consisted of 28 percent 31-40 count and 20

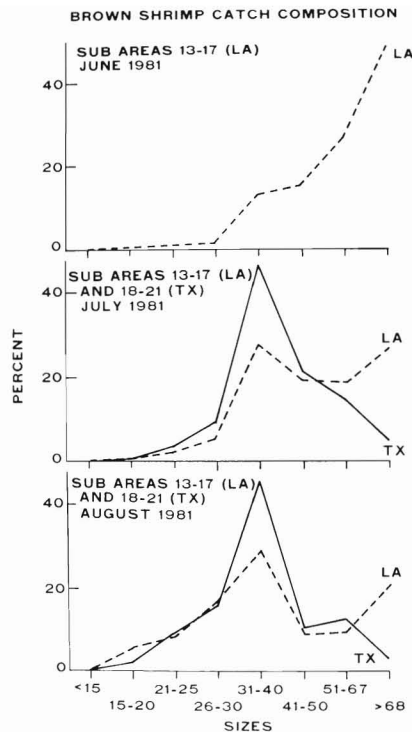


Figure 23.—Percent size composition of brown shrimp catches in June 1981 off Louisiana and in July-August 1981 off Texas and Louisiana.

percent 68-count/pound or smaller shrimp.

In June, no fishing was permitted in statistical subareas 18-21 off Texas, but in July the brown shrimp catch was dominated by a single group of shrimp (31-40 count), which accounted for more than 45 percent of the entire catch (Fig. 23). The catch in August was also dominated by 31-40 count shrimp. Major differences were observed between Texas and Louisiana size compositions in July and, to some degree, in August. In general, the overall size composition of the Louisiana shrimp landed was smaller than of the shrimp landed in Texas (Table 4) in both months.

Of particular interest are both the pounds as well as the number of shrimp caught. To estimate this, the count/size category and pounds landed were used to convert pounds into

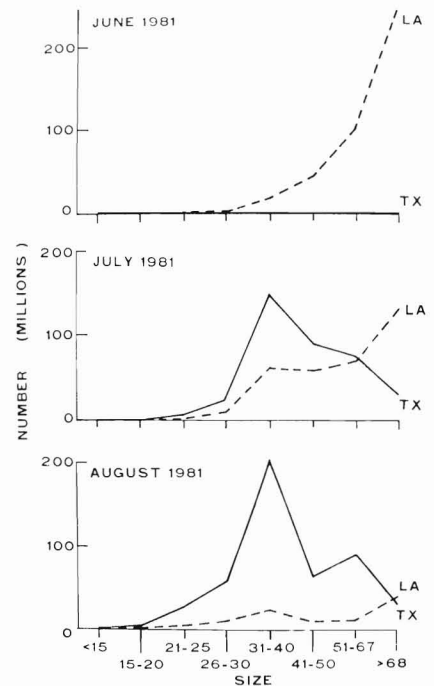


Figure 24.—Number of brown shrimp landed by size category and caught off Texas and Louisiana, June-August 1981.

Table 4.—Percent size composition of 41-count or smaller brown shrimp landings, July and August 1981¹.

Month	Texas	Louisiana
July	41	63
August	27	39

¹Shrimp statistics, Gulf of Mexico monthly landings, Technical and Information Management Services, NMFS, Southeast Fisheries Center, Miami, Fla.

approximate numbers per size category. Although this is a crude measurement, it does provide some indication of the number of shrimp caught by size category and an approximate total per month. These data, plotted in Figure 24, indicate that a preponderance of small shrimp were caught in Louisiana in June and July. Further,

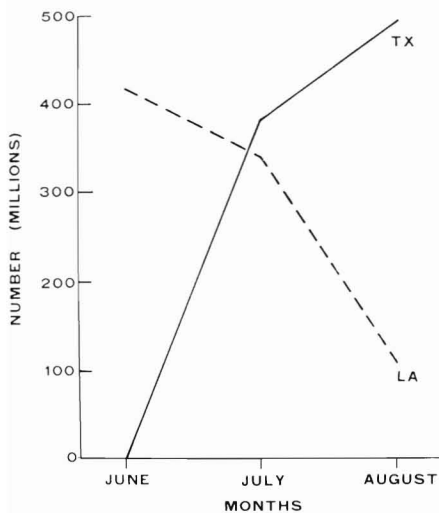


Figure 25.—Comparison of number of brown shrimp caught off Texas and off Louisiana, June-August 1981.

Figure 24 clearly indicates that larger size shrimp were landed in Texas in July and August.

Data on the total number of shrimp caught during the June-August period indicate Louisiana (subareas 13 and 17) produced 868 million shrimp whereas Texas (subareas 18-21), in comparison, produced over 876 million shrimp (Fig. 25). Even though the approximate numbers of shrimp taken in Texas and Louisiana were the same, Texas landings were composed of larger shrimp, presumably because of the closed season, and were correspondingly more valuable—\$62.9 million for Texas vs. \$35.6 million for Louisiana.

In summary, there was a major difference in July and August 1981 brown shrimp size composition between Texas and Louisiana, with larger shrimp landed in Texas than in Louisiana. Recent landings dating back to 1972 indicate that during good brown shrimp years, the 31-40 size category dominates the landings for both July and August in Texas but not necessarily in Louisiana. Landings in Texas in July 1981 are very similar to those in 1972 and 1977, both good brown

shrimp years. The Louisiana shrimp size distribution in July and August 1981 was similar to that indicated by landings in 1977.

Recruitment

A wide array of environmental and biological factors may affect the survival, growth, and subsequent offshore shrimp population. Unfortunately, only a few parameters have been scrutinized. Present understanding of the recruitment process and factors that affect survival are not fully understood. St. Amant et al. (1966) and Barrett and Gillespie (1975) have identified and related temperature and salinity as important factors affecting subsequent production. They showed a direct correlation between salinities during a particular season and subsequent shrimp production. However, the best relationship between a single parameter and brown shrimp catch in Louisiana appears to be the number of hours of water temperature below 20°C after April 8 (Barrett and Ralph, 1977). The size of the nursery area appears to be controlled by the distribution of high saline water, and survival appears to be related to the amount of time water temperatures are above 20°C during critical periods in the spring. Therefore, salinity above and below 19‰ in the upper portion of the bays may greatly expand or contract the shrimp nursery areas and possibly affect survival of juvenile shrimp.

The TPWD has been sampling with bar seines, 10-foot trawls, and 20-foot trawls in the major bay systems for the March-August period since implementation of the offshore closed season in 1960. Richard L. Benefield and C. E. Bryan (TPWD)³ have provided us an information summary of the relative abundance of brown shrimp in Texas bays for this period. The 1981 indices of abundance indicate that, generally, recruitment was less than observed in most bay systems for years of good offshore brown shrimp production

(1967, 1972, 1976, 1977). The major exception was greater abundance levels in the lower Laguna Madre in 1981 than in any other year (Fig. 26, 27, 28).

In 1979, the TPWD initiated random sampling of seven bay systems with a bar seine to sample juveniles, presumably a better measure of abundance than other sampling methods⁴. The 1981 data indicate that recruitment in Texas bays was far greater in 1981 than in 1979 and 1980. However, it should be pointed out that 1979 and 1980 were below-average brown shrimp production years.

The salinity distribution in 1981 in Galveston Bay was apparently ideal for shrimp growth and survival⁵. Temperatures above 20°C were observed throughout the bay in April and May; such temperatures indicate survival should have been good. Further, the high salinity allowed a larger nursery area for shrimp than when salinities were low. This combination of high salinity and temperatures had not been observed previously in Galveston Bay. The 1967 environmental conditions most closely resemble 1981 conditions; however, 1981 salinities were higher than in 1967. Therefore, even though the Galveston Bay CPUE indices were average, it simply may mean the shrimp used a larger area and were not concentrated at times when temperatures and salinities were not optimal, and may indicate the sampling was not adequate to detect this change.

It appears that the abundance of juvenile shrimp in 1981, from the TPWD recruitment data, was either slightly below good year indices or approximately the same. We do not think there was any question that shrimp recruitment in 1981 was greater than in poor years such as 1979 and 1980.

The juvenile shrimp index (catch of brown bait shrimp/hour) in Galveston has been a very good prediction of the offshore catch of brown shrimp in Texas (Caillouet and Baxter, 1973).

³Bryan, C. E., Texas Parks and Wildlife Department, Austin, Tex., and Benefield, R. L., Texas Parks and Wildlife Department, Seabrook, Tex., pers. commun. 1981.

⁴Bryan, C. E., Texas Parks and Wildlife Department, Austin, Tex., pers. commun. 1981.
⁵Benefield, R. L., Texas Parks and Wildlife Department, Seabrook, Tex., pers. commun. 1981.

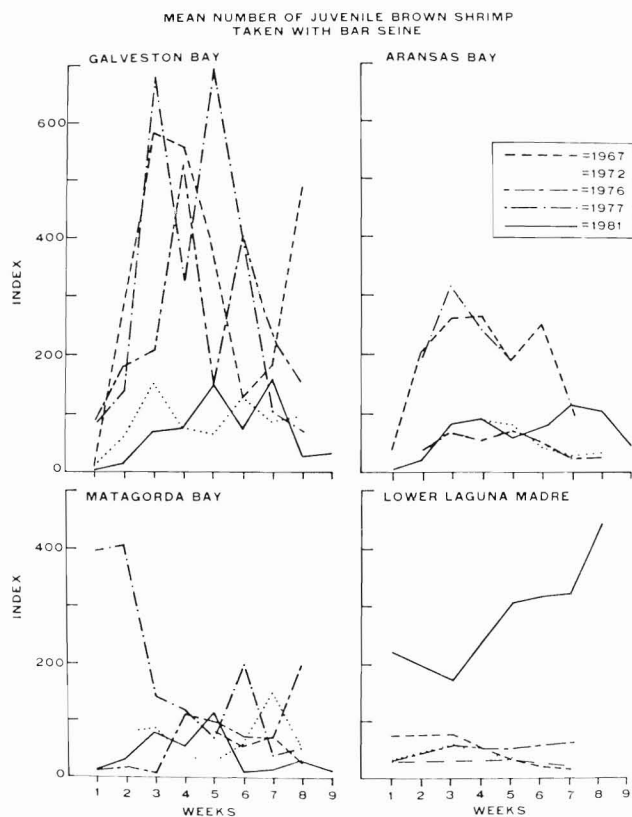


Figure 26.—Mean catch of juvenile brown shrimp taken with bar seines and 10-foot trawls during a 9-week period (March-August) 1967, 1972, 1976-77, and 1981 in four Texas bays (data from Benefield and Bryan, TPWD).

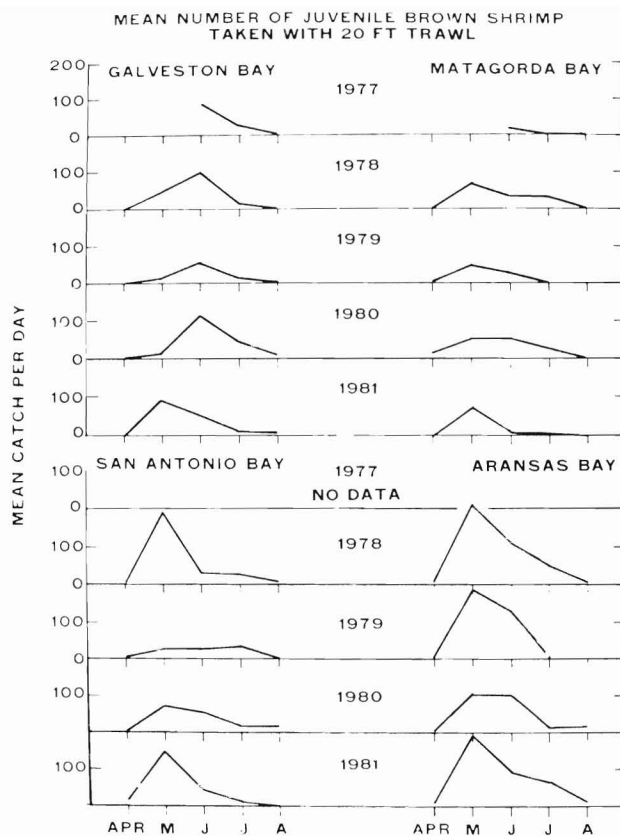


Figure 27.—Mean catch per day of juvenile brown shrimp taken with 20-foot trawls during April-August 1977-81 in four Texas bays (data from Benefield and Bryan, TPWD).

We have updated this model ($R^2 = 0.86$) to include 1960-74 data to predict the 1981 brown shrimp catch in Texas for the July-June period. The 1981 juvenile index predicts a catch of 28.8 million \pm 5.7 million pounds at the 95 percent confidence level (Fig. 29). This index does not indicate a great inshore abundance level but rather an average level of abundance comparable to 1960 or 1963. Based on the 1981 recorded catch in July and August (24.5 million pounds) and production in September-November (12.0 million pounds) and an estimation of production in December-June (5 million pounds), our present best estimate of the July-June offshore brown shrimp catch is 40 million pounds, about 11 million pounds above the level predicted by our model.

This difference is well above the upper 95 percent confidence limit, i.e., 34.1 million pounds, of the predicted catch, and we consider this difference to be significant. We assume the difference in the model's predicted value and the actual catch to be due to the Texas closure.

Discussion

The TPWD data indicated that recruitment of juvenile brown shrimp in Texas bays in 1981 appeared to be about the same level as during good brown shrimp production years (1967, 1972, 1976, 1977). We updated a model to predict the offshore brown shrimp catch based on an index of juvenile brown shrimp in Galveston Bay. This model has predicted the offshore

catch remarkably well from 1960 to 1974. The production index in 1981 indicated average recruitment to offshore waters, very similar to TPWD indices of recruitment levels in 1981. The model indicated that the level of brown shrimp abundance in Galveston Bay was about average, but less than that of good years such as 1967 or 1972.

We conclude that there were average levels of juvenile shrimp abundance in Texas bays in 1981. Environmental conditions were adequate for good survival and growth, resulting in average to good shrimp recruitment to the offshore fishery, but there is no reason to believe that recruitment in 1981 was better than the outstanding years of 1967 and 1972.

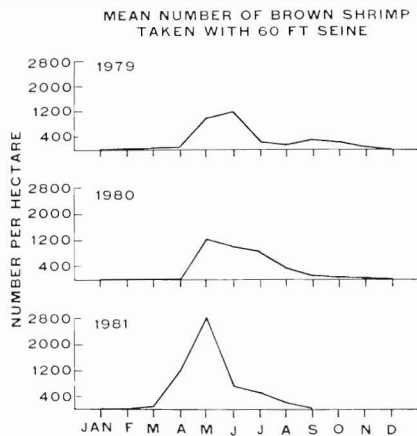


Figure 28.—Mean monthly numbers per hectare of brown shrimp taken with 60-foot bag seines in the Texas bays of Galveston, Matagorda, San Antonio, Aransas, Corpus Christi, and the upper and lower Laguna Madre, 1979-81 (data from Benefield and Bryan, TPWD).

The offshore abundance of brown shrimp in June and early July from survey data collected by the *R/V Oregon II* and *Western Gulf* indicates that the CPUE was extremely high for most of the Texas coastline⁶. In comparison with previous surveys, the CPUE was greater than any other historical data. However, we would like to point out that there is not a great wealth of historical information and, in fact, the surveys conducted this year by the *Western Gulf* and *Oregon II* were at higher sampling levels than were previous surveys. Abundance levels witnessed from the 1981 survey indicated that there would be a good shrimp crop along the entire Texas coast, with high concentrations in the 10-20 fm depth range. Furthermore, size distribution of the shrimp as observed from these surveys indicated

⁶Matthews, G. A., and S. L. Hollaway. 1981. A report on the distribution of *Penaeus* spp. along the Texas coast during the 1981 Texas closure (May-July). Report on file at Galveston Laboratory, Southeast Fisheries Center, National Marine Fisheries Service, NOAA, Galveston, TX 77550.

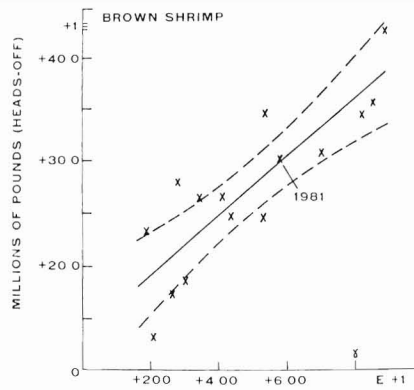


Figure 29.—Predicted annual offshore catches of brown shrimp in Texas 1960-74, and predicted brown shrimp catch July-June (1960-72 data from Caillouet and Baxter, 1973).

that shrimp in the 0-10 fm depth range were approximately the same size as from historical surveys. However, as we progressed to deeper water, the shrimp appeared to be slightly smaller than the historical survey data from 20 fm seaward.

The commercial fishery for brown shrimp began 16 July, with extremely high catches throughout subareas 18-21. In most areas, the CPUE was greater than 2,000 pounds/24-hours fishing during this period. The catch for both July and August was greater than that observed in any other like period off the Texas coast. Further, the catch off Louisiana appeared to be at a good level, with relative abundance levels almost reaching 900 pounds/24-hours fishing. Despite high abundance off Louisiana, many of the vessels in Louisiana diverted to fish in Texas where catch rates were higher. Similar to what we observed during good brown shrimp years, shrimp of 31-40 count size dominated the commercial catch off Texas in July and August 1981.

In reviewing all these data, the following is clear: 1) There was no fishing mortality on the brown shrimp stocks during June and the first 2 weeks in July; 2) size distribution of the offshore stock was similar to that ob-

served during good brown shrimp years; 3) shrimp recruitment to the offshore fishery was average or slightly greater than average; 4) relative abundance, from survey data for the June-July 15 period off Texas, was greater than the historical CPUE's; 5) relative abundance for July-August off Texas was greater than the historical CPUE for the same period off Louisiana in 1981; and 6) the catch off Texas in July-August exceeded the brown shrimp catch for any other year.

Considering all these facts, it appears that the Texas closure did have a significant positive impact on increasing the relative abundance of shrimp as well as total production off the Texas coast.

Summary

1) Shrimping regulations and harvesting strategies vary from state to state along the Gulf coast. In Texas, regulations limit the landing of small shrimp, while in Louisiana there are few restrictions on the harvesting of small shrimp. As a result, the bulk of the Texas catch comes from an offshore brown shrimp fishery consisting of large shrimp, while in Louisiana, a substantial inshore fishery produces a large volume of small brown and white shrimp. Obviously, a higher overall value is realized from harvesting and marketing larger shrimp.

2) Historically, brown shrimp production from Louisiana inside waters is about 40 percent of the total production from May through July. The June-July Louisiana offshore fishery is usually concentrated in statistical subareas 13 and 15 within the 5 fm depth contour. Over 50 percent of Louisiana (subareas 13-17) brown shrimp annual production is produced from May through August. The average annual production from 1960 to 1980 was 24.7 million pounds.

3) In recent years, the specific location of peak production of the offshore Texas fishery varies in July-August between years but is usually concentrated in the 11-20 fm depth zone in statistical subareas 19, 20, and 21. Average annual production from 1960 to 1980 was 28.6 million pounds.

Production of brown shrimp from inside waters in Texas since 1971 has been less than 9 percent of the total annual Texas catch.

4) The size distribution of brown shrimp landed in Louisiana in June is dominated by small shrimp, 68 count/pound. Shrimp size increases to large shrimp by July and usually to a 31-40 count by August. In July, the size of shrimp in Texas is usually larger than shrimp in Louisiana, but it does vary between years.

5) Texas waters and the Fishery Conservation Zone were closed to shrimp fishing from 22 May to 15 July 1981.

6) Texas-based vessels made 1,013 trips to Louisiana in June and caught about 2 million pounds of brown shrimp, mostly in statistical subarea 17.

7) In Texas, a daytime fishery was permitted inside 4 fm, which yielded 26,000 pounds of white shrimp and 4,600 pounds of brown shrimp in June 1981 and 325,000 pounds of white shrimp in July 1981.

8) Recruitment from Texas bays was considered similar to years of good brown shrimp production, but was not as good as 1967 or 1972.

9) The Texas July brown shrimp catch was 10.3 million pounds with major production from 11-20 fm in statistical subarea 19, but with good production along the entire coast.

10) The CPUE off Texas was significantly greater than the CPUE off Louisiana and greater than any other year from 1972 to the present off Texas and Louisiana.

11) The August brown shrimp catch was 14.6 million pounds and was caught in the same statistical subareas

as the July catch except slightly farther offshore; 75 percent were caught from 11 to 25 fm.

12) The June and July brown shrimp fishery in Louisiana was concentrated in statistical subareas 13, 15, and 17, with 7.5 and 7.4 million pounds landed, respectively; August production was 2.9 million pounds.

13) The June-August Louisiana CPUE was 788 pounds/24 hours fished, whereas the Texas July-August CPUE was 1,798 pounds/24 hours fished.

14) During July and August, Texas landed larger shrimp than did Louisiana; the predominant size-count for shrimp off Texas in July and August was 31-40.

15) The predominant size of brown shrimp caught off Louisiana in June was 68 count or smaller; in July it was bimodal with peaks at 31-40 and 68 count or smaller.

16) The total number of shrimp landed from June to August in Louisiana was about the same as the total number of shrimp landed in Texas for July-August.

17) The Texas closure is believed to have had a positive impact on the relative abundance and production of brown shrimp off Texas during July and August 1981.

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