Life History and Fishery of the Red Snapper (*Lutjanus Campechanus*) in the Northwestern Gulf of Mexico: 1970-1974*

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Abstract

Trawl-caught snappers were taken between 5.5 and 82.3 m (3 and 45 fm). The highest catch per effort was in 29.3-45.7 m (16-25 fm) off Freeport-Galveston, Texas. Hook-and-line caught snappers were taken on reefs located in 13.7 to 146.3 m (7.5 to 80 fm) of water. Snappers exhibited a seasonal inshore-offshore movement and were not confined to rough bottom areas. Peak spawning occurred in June and July. Snappers grew approximately 200 mm (FL) during the first year and 60 to 90 mm in succeeding years. Young red snappers feed primarily on invertebrates; adults feed on vertebrates. Catch per effort and total effort by commercial fishermen have declined, while sports fishing for the species has increased. Shrimp fishermen marketed the larger snappers captured in trawls and discarded the smaller ones. The pressures applied to the fishery have adversely affected commercial landings on the Texas coast.

INTRODUCTION

Historically the red snapper *(Lutjanus campechanus)* has been one of the most economically important fin-fish landed on the Texas coast and in recent years has increased in popularity with sports fishermen (Moseley 1966). Annual commercial landings in Texas have decreased from 1020.6 metric tons (2.25 million lb) in 1964 to approximately 453.6 metric tons (1 million lb) each year from 1969 to 1973 (Lyles 1967 and *Texas Landings* 1969-1973). Few reports have been written on the biology of the red snapper and the present study was initiated to help determine the growth rates, spawning habits, food preference, and distribution of the species along the Texas coast.

Camber (1955) studied the fishery and fish with emphasis on the Campeche Banks. Moseley (1966) studied the life history of the red snapper found in Texas and Louisiana waters. Most other literature deals with descriptions of the fishery, fishing methods and exploratory cruises for new fishing grounds. Stearns (1884), Smith (1885a, 1885b), Collins (1887) and Adams and Kendall (1891) dealt with exploratory cruises for new snapper fishing grounds. Stearns (1885),

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Jarvis (1935) and Smith (1948a, 1948b) dealt with improving catch methods. Carpenter (1965) reviewed the fisheries, describing methods used, fishing grounds, production and marketing.

The taxonomy of the red snapper has been in question for many years. Three specific names have been used in the literature: *L. campechanus, L. aya* and *L. blackfordi* (Anderson 1967). The American Fisheries Society (1970) follows the nomenclature of Rivas (1966) and uses *L. campechanus*.

MATERIALS AND METHODS

Random samples of red snappers were taken by hook and line from reefs along the entire Texas coast, but most work was concentrated in the area off Port Aransas. Both electric and manual reels were used. Catch per effort was based on 15 hooks fished for 1 hour. Smaller snappers were caught with 13.5 m (45 ft) flat otter trawls of 4.4 cm to 5.1 cm (1 ¾ to 2 in.) stretched mesh. Trawling times varied from 10 minutes to 2 hours, depending upon depth and bottom conditions. Most tows were for 30 minutes.

Snappers were measured for fork and standard length (SL) (Fig. 1). In this report measurements are in fork length (FL) unless stated otherwise. The fish were weighed, their stomach contents were analyzed and gonadal development was noted. Stages of sexual maturity were determined by using the numerical index taken from the "Field Methods of Fishery Biology" (Food and Agricultural Organization of the United Nations, 1960). Identifiable food was blotted dry and each different food item was measured by displacement of water in a graduated cylinder. Water samples were taken with a Nansen bottle and temperatures recorded in degrees Celsius.

When seasons are referred to in the text or figures, the months are grouped in the following manner: summer (June, July, August), fall (September, October, November), winter (December, January, February), spring (March, April, May).

Sport and commercial fishermen were interviewed monthly. Fish from their catches were measured and, if possible, the locale in which they were caught and catch per effort were obtained. Several trips were made aboard party boats to observe sport fishery methods and catches.

Ninety-eight bottom trawl samples were taken in 1970, 84 in 1971 and 118 in 1972. From June 1973 through January 1974, 36 trawl samples were taken in areas where a shrimp fleet was working. In June, July and August 1974, 45 samples were taken with the fleet. All boats within an approximate radius of 10-12 miles were counted to determine the fleet size.

Trawl sampling depths ranged between 5.5 and 173.7 m (3 and 95 fm). Field work was accomplished from aboard the Texas Parks and Wildlife Department vessel *Western Gulf*, a 21.9 m (72 ft) long, double-rigged, steel hull shrimp trawler. An attempt was made to take samples at 9.1 m (5 fm) intervals each month, with supplementary sampling as time allowed. The majority of collections were obtained between 7.3 m and 64.0 m (4 and 35 fm) off shore of Port Aransas and Freeport-Galveston. In this study the Texas coast was arbitrarily

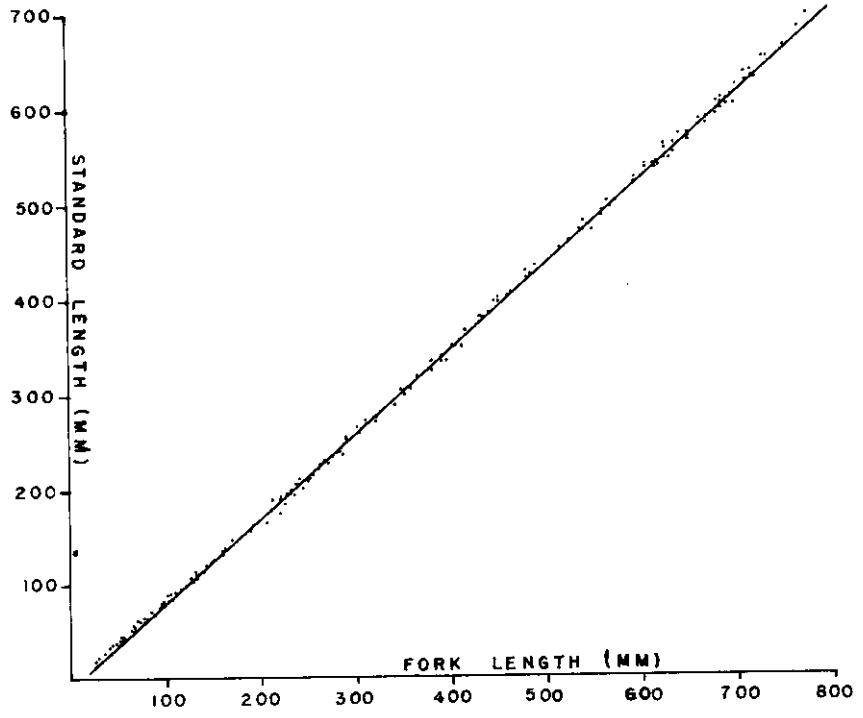

Fig. 1. Standard length vs. fork length of *L. campechanus*.

divided into three areas (Fig. 2); Area I is the region off Galveston-Freeport, Area II is the region off Port Aransas and Area III is the region off Port Isabel-Port Mansfield.

The project area covered in this report lies in the Gulf of Mexico from latitude 26° N to latitude 29°40′ N and bounded by the coastline of Texas and longitude 93°50′ W.

RESULTS AND DISCUSSION

General Distribution

Red snappers were found along the Texas coast from Galveston to Port Isabel. Hook and line samples (64) were taken on 11 reefs found in water depths of 13.7 to 146.3 m (7.5 to 80 fm) and *L. campechanus* was found at all the sites (Fig. 2). Young (34 to 250 mm) red snappers were taken in trawls from 5.5 to 82.3 m (3 to 45 fm) Table I).

Between February 1970 and January 1972, 64 trawl samples were made off Area I of the coast, 209 were taken off Area II and 27 were taken off Area III. In Area I, no juvenile snappers were found within 18.3 m (10 fm). They were most abundant between 29.3 and 45.7 m (16 and 25 fm) (Table II). A mean of

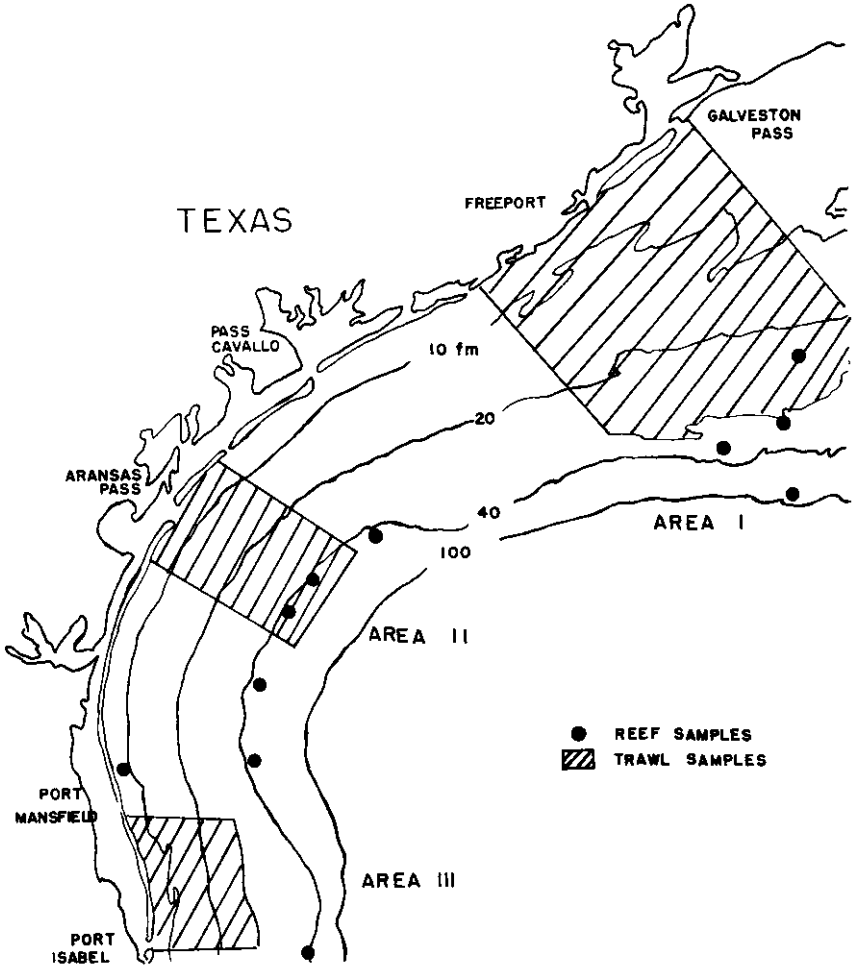

Fig. 2. General sampling areas for *L. campechanus*.

59.13 young red snappers were taken per trawl-hour from the 29.3-36.6 m (16-20 fm) depth zone. During the same period in Area II, the highest per hour mean catch was 4.94 per trawl and the young were found from 5.5 and 82.3 m (3 to 45 fm). Only 25 young snappers were caught in 27 trawl samples taken in Area III. Of these, 15 were from the 20.1-27.4 m (11-15 fm) zone.

Hook-and-line caught snappers were taken from reefs in all areas and months in which samples were obtained. Sizes of these snappers ranged from 200 to 845 mm. The largest individual weighed 12.0 kg (26.5 lb).

Camber (1955) reported commercial catches of snappers out to 219.5 m

Table I. Catch per hour of *L. campechanus* in the different depth zones 1970-1972

Depth fathoms	# Trawls	# Hours trawled	Total # Snappers	# Snappers per hour
0-5	54	14.75	5	.34
6-10	59	21.08	10	.47
11-15	48	31.08	79	2.54
16-20	46	27.75	405	14.59
21-25	35	19.97	317	15.87
26-30	25	15.75	74	4.70
31-35	17	9.00	40	4.44
36-40	6	3.42	1	.29
41-45	3	3.50	7	2.00
46-50	1	1.00	0	0
51-65	1	2.00	0	0
66-95	5	7.75	0	0
	300	156.75	938	5.98

(120 fm) off Campeche, Mexico, but he found them to be more abundant in depths from 36.6 to 146.3 m (20 to 80 fm). Moseley (1966) noted that adult snappers were caught in the Aransas Pass Channel in October of 1964. He assumed that these fish moved offshore shortly thereafter. During the present study, snappers were captured on reefs in water depths ranging from 18.7 m (7.5 fm) off Port Mansfield to 146.3 m (80 fm) off Galveston. The most prominent fishing reefs off Texas are located along the 73.2 m (40 fm) depth contour (Fig. 2). Sampling was concentrated on these reefs and most of the adult snappers were taken there.

Seasonal Distribution and Abundance

Little work has been done concerning the distribution of young snappers. Hildebrand (1954) took only 151 during intensive trawling off the Texas coast. Moseley (1966) and Miller (1965) sampled stations in 11.0, 16.5, 21.9, 27.4, 32.9 and 38.4 m (6, 9, 12, 15, 18 and 21 fm) off Port Aransas. Moseley stated that young snappers were more abundant in 16.5 m (9 fm) during September and 32.9 m (18 fm) in October. Miller reported no snappers in his collection. Gunter (1945) sampled two stations monthly in the shallow Gulf and also reported no red snappers. Camber (1955) collected young snappers in 13 trawl samples taken off Campeche, Mexico. His samples were taken from 28.3 to 32.9 m (15.5 to 18 fm) in August and he found that small red snappers were more abundant in 29.3 m (16 fm) than in 32.9 m (18 fm).

Our study demonstrated that young red snappers were present on level, trawlable bottom along the entire coast and that their distribution and abundance varied with the seasons. Monthly transects off Port Aransas showed the depth zones of abundance to be 20.1 to 27.4 m (11 to 15 fm) in the summer, 29.3 to

Table. II. Comparison between trawl catches of *L. campechanus* in Areas I, II, III (1970-71)

Depth Fathoms	# Trawls	# Hours trawled	# Snapper	# per hour
AREA I				
0-5	16	4.25	0	0
6-10	12	5.25	0	0
11-15	8	6.25	30	4.80
16-20	8	5.75	340	59.13
21-25	16	10.17	287	28.22
26-30	3	3.00	11	3.67
31-35	1	.25	0	0.0
	64	34.92	668	19.13
AREA II				
0-5	32	9.00	2	.22
6-10	42	14.08	4	.28
11-15	32	19.92	34	1.71
16-20	33	19.75	64	3.24
21-25	16	8.25	30	3.64
26-30	22	12.75	63	4.94
31-35	16	8.75	40	4.57
36-40	6	3.42	1	.29
41-45	3	3.50	7	2.00
46+	7	10.75	0	.00
	209	110.17	245	2.22
AREA III				
0-5	6	1.50	3	2.00
6-10	5	1.75	6	3.43
11-15	8	4.92	15	3.05
16-20	5	2.25	1	0.40
21-25	3	1.25	0	0.00
	27	11.67	25	2.14

64.0 m (16 to 35 fm) during the fall and 38.4 to 64.0 m (21 to 35 fm) in the winter. During the spring the fish were generally larger in size, fewer in number and distributed more widely (Fig. 3).

During the summer, juvenile snappers were taken from depths of 11.0 to 82.3 m (6 to 45 fm). The highest catch rate (18 per hour) was in 20.1-27.4 m (11-15 fm). These fish were caught during August and were the smallest (48 mm) mean sized snappers taken during the year. Summer catches of snappers in the other depth zones were composed of fewer (<2 per hour), but larger individuals (Fig. 3).

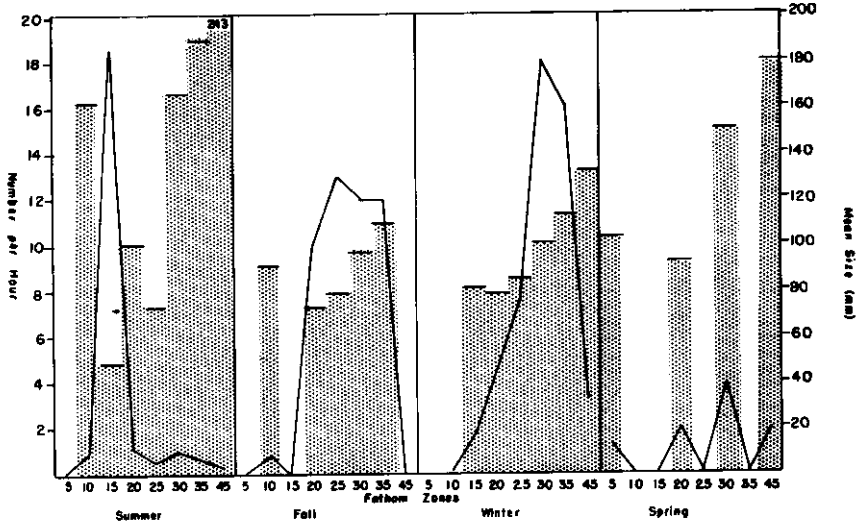

Fig. 3. Seasonal abundance and mean size (shaded areas) of *L. campechanus* caught by trawl in Area II, 1972.

Highest catch rates in fall ranged from 10-13 fish per hour between 29.3 and 64.0 m (16 and 35 fm). Young snappers were most abundant in 38.4-45.7 m (21-25 fm) at a mean size of 80 mm. The larger individuals found during the summer had disappeared from the catches.

The majority of trawl-caught red snappers taken in winter were found from 38.4 to 64.0 m (21 to 35 fm) where the number per hour ranged from 7 to 18. Most of the snappers were captured in the 47.6 to 54.9 m (26 to 30 fm) depth zone at a mean size of 100 mm. During the winter young snappers were taken as far out as 45 fathoms at a rate of three per hour.

In the spring, the catch rate declined and snappers were found from within 9.1 m (5 fm) to beyond 64.0 m (35 fm). The highest catch rate was four per hour in the 47.5-54.9 m (26-30 fm) zone. The mean size of these fish was 150 mm. In the other depth zones where snappers were taken, the catch rate was one to two per hour. Fish captured in 0.9 m (0-5 fm) had a mean size of 104 mm, the ones in 29.3-36.6 m (16-20 fm) averaged 94 mm, and those caught beyond 64 m (35 fm) had a mean size of 180 mm. Spring was the only season in which snappers were taken within 9.1 m (5 fm).

The youngest snappers were captured in the summer, and as the seasons progressed the fish continued to move offshore. Relatively few snappers above the length of 160 mm were captured by trawl. Apparently they moved to different habitat or were able to avoid the trawl. Fish as small as 150 mm (Fig. 4) were caught by sportsfishermen, but those between 150 and 220 mm were not numerous in trawl or hook and line catches (Fig. 5). Moseley (1966) also found relatively few fish at these sizes.

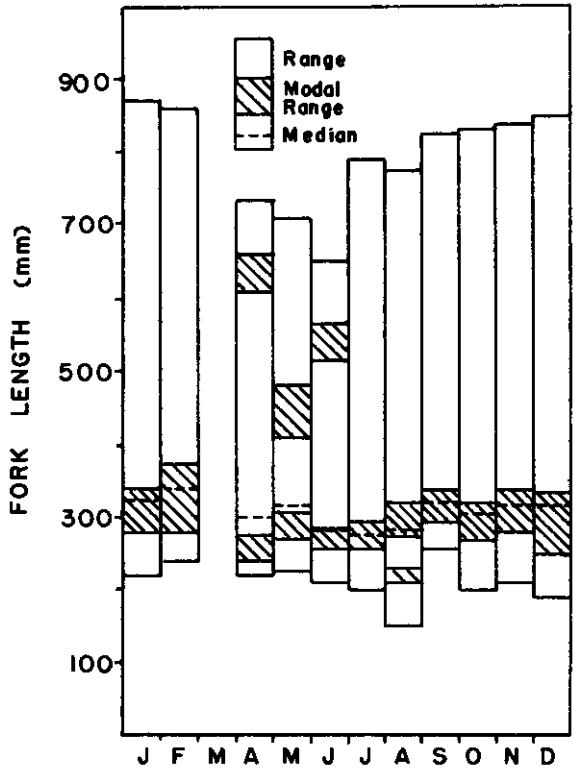

Fig. 4. Monthly range, modal range and median sizes of *L. campechanus* caught by party boat and shrimp fishermen, 1970-71.

Adams and Kendall (1891), Camber (1955) and Moseley (1966) suggested that as snappers grow they seek deeper waters. This agrees with our findings, but our data also indicate a movement of a portion of the population back to shallower water in the spring and summer months.

Moseley (1966) found no relationship between temperature and the offshore movement suggesting instead that the movement was caused by food availability in the deeper water. Bottom water temperatures in 1972 did not begin to fall appreciably until November, but the offshore movement of red snappers began in October, indicating that some factor other than temperature precipitated the movement. Mean bottom water temperatures were 27.4°C in August, 27.3°C in October and 23.4°C in November.

Seasonal hook and line catches in our study were different from the commercial catches. The months of lowest commercial production were November, December, and January, while high production months were March, April, and August (Fig. 6). Our best catch per effort was during the winter months, while

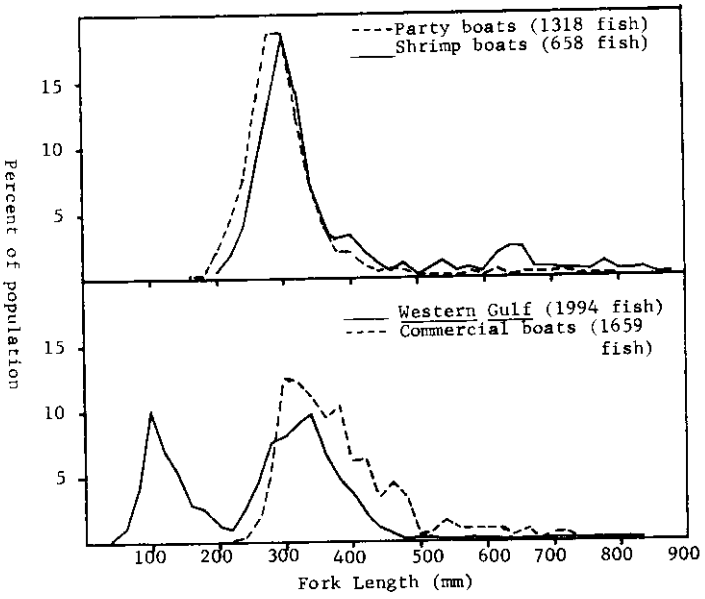

Fig. 5. Comparison of length frequencies between WESTERN GULF, commercial, party and shrimp boat catches of *L. campechanus* (WESTERN GULF catches include those caught by trawl).

the lowest was in the spring (Fig. 7). A fish house operator stated that less pressure was exerted during those months of low production because of poor weather conditions and the holiday season. Some of the fishermen fished the level bottom areas during the warm weather and moved to the reefs during the winter. This seasonal fishing may reflect a movement of larger fish off the reefs during the warm spawning season and movement back during the colder months. Our catches which were made on the reefs support this theory.

Camber (1955) reported that fish captured during the summer were smaller than those caught in the winter. The catch rate during this study was greatest during the winter, with the highest production both in weight and number per hour coming in February. The fish were generally larger during the late fall and winter, and the smallest sizes were captured in August. The smaller fish averaged less than 0.45 kg (1 lb) and probably reflect the previous years' spawn entering the catch. Catches of small fish also occurred in October and April. Measurements of snappers in the fish houses and party boats illustrate the small fish were entering the fishery continuously, but that there was a trend toward smaller fish during the summer months, especially in August. The smallest modal size of fish entering the fishery was 210 to 230 mm (Fig. 4).

In general, night fishing was much more productive on the reefs (Figs. 7 and 8). The few fish caught during the day were usually large individuals. A diel sample off Port Aransas in March 1970 produced an average number per hour

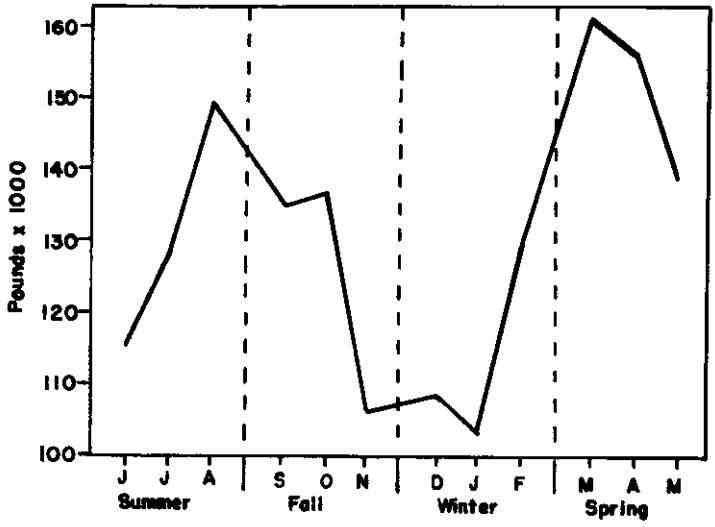

Fig. 6. Average monthly commercial landings of *L. campechanus*, 1961-70. Source: *Texas Landings*.

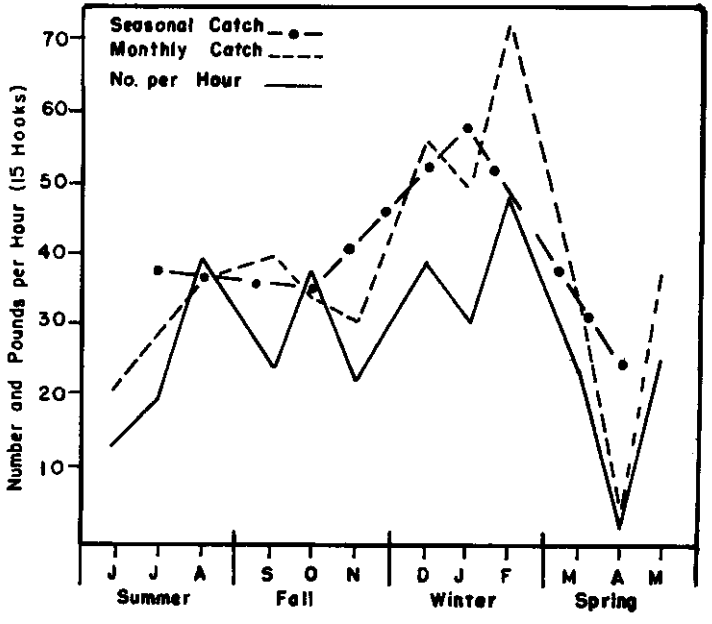

Fig. 7. Average seasonal and monthly catch in pounds per hour of *L. campechanus* and average number per hour per month caught on reefs during nighttime hours, 1970-71.

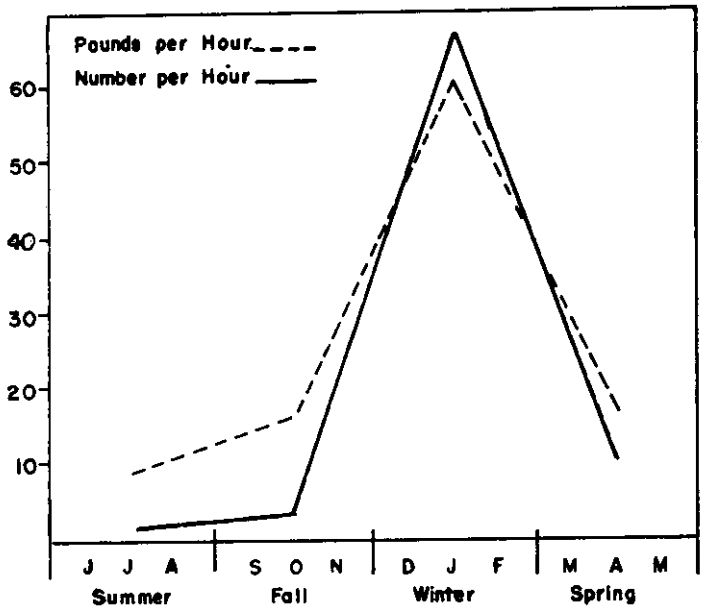

Fig. 8. Average number per hour and pounds per hour of *L. campechanus* caught on reefs during daylight hours, 1970-71.

of 0.5 at 1200-1400 hours, 40 at 1800-2000 hours, 30 at 2400-0100 hours and 4 at 0600-0700 hours. This was the general pattern (at least off Port Aransas) as most of the best catches were made at sunset and declined after midnight. The exception to this pattern was found in January 1971 on the 13.7 m (7.5 fm) reef near Port Mansfield where the catch rate during the day was 120.7 kg (266 lb) per hour of small fish (225-275 mm) and 3.0 kg (6.6 lb) per hour during a night sample. This may have been an incidental catch, but according to interviews with sport and commercial fishermen the area near Port Mansfield-Port Isabel produced good daytime fishing. Moseley (1966) mentioned "night lumps" off Louisiana where fishing was better after dark, and it may be that the reefs off of Port Aransas are comparable.

The interviews with fishermen and our data indicate that like juvenile snappers, the adults also demonstrate some inshore-offshore movement in relation to the seasons. It is probable that during the warmer months the adult snappers move inshore from the reef areas, spawn, and then move back toward deeper water in the cooler months. Moe (1963) stated that commercial and party fishing vessels off Florida accepted the seasonal movement as fact.

Spawning

The spawning period of the red snapper may be longer than has been previously postulated. Camber (1955) reported that spawning on the Campeche Banks

Table III. Red snapper (*L. campechanus*) examined for gonadal development, 1970-72

Month	No. females	No. maturing	% maturing	Smallest maturing individuals (mm)	No. males	No. maturing	% maturing	Smallest maturing individuals (mm)	Overall percentage
Feb.	17	0	0	0	15	0	0	0	0
Mar.	28	0	0	0	24	0	0	0	0
Apr.	9	0	0	0	1	0	0	0	0
May	67	18	27	270	80	9	11	265	18
June	57	29	51	255	50	20	40	250	46
July	169	44	26	265	142	38	27	260	26
Aug.	45	2	4	440	60	4	7	385	6
Sept.	30	1	3	470	46	9	20	230	13
Oct.	42	1	2	290	31	1	3	405	3
Nov.	28	6	21	335	18	2	11	240	17
Dec.	20	3	15	360	27	0	0		6
Jan.	57	1	2	410	66	0	0		
	569				560				

was from July to September with the major activity occurring in July and August. Moseley (1966) stated that spawning off the Texas coast extended from early June through mid-September. He took his smallest snappers (average 49 mm standard length) in September. Baughman (1943) found a 45 mm individual off Galveston in July and Hildebrand (1954) reported the smallest fish (51-54 mm fork length) in November and December.

The smallest snappers taken in our samples during 1970 were 60 mm in March, 65 mm in June and 48 mm in October. In 1971 the smallest snappers were 65 mm in June, 58 mm in July, 60 mm in September and 54 mm in December. During 1972 small individuals were taken in June (69 mm), July (70 mm), August (34 mm), September (61 mm), October (34 mm), December (53 mm), and January (66 mm).

Maturing fish were found from May through January, but the major period of spawning was June and July (Table III). Snappers with gonadal development of stage three (testis and ovaries occupy ½ of ventral cavity, eggs visible to eye as whitish granular) or higher were considered as maturing. Some spawning probably occurred in April, but too few fish were caught to reflect it. The percentage of maturing snappers increased during November indicating a second smaller spawning period in the fall.

The sex ratio was nearly 1:1. Of 1129 adult snappers examined, 560 were males and 569 were females. Five hundred seventy five juvenile and sub-adult snappers were examined and the sex could not be discerned in the majority of

them. The smallest female found was 138 mm, while the smallest male was 149 mm long. Moseley (1966) noted one growth ring on scales of individuals slightly over 100 mm SL. The percentage of individuals with one growth ring began to increase significantly when the fish were 200 mm SL in length. The smallest snappers in our samples containing maturing (Stage 3+) gonads were a 255 mm female and a 230 mm male (Table III).

Camber (1955) suggested that snappers do not feed while spawning and Moseley (1966) based his scale analysis on the growth checks formed during a non-feeding period. Commercial fishermen using hook-and-line sometimes caught gravid females, but they believed that feeding was at least curtailed. Some feeding does take place during spawning, as we examined a commercial red snapper catch in August 1971 and found that 8% of the fish were ripe. In 1971 commercial fishermen in Port Isabel noted that there were more snappers with roe from the latter part of May through June, and that the number of roe-bearing females decreased significantly in July catches.

The fishermen stated that catches in June were generally low. Monthly mean commercial landings show that June was the lowest month of production and that catches rose in July (Fig. 7). The higher July catches may reflect increased feeding by the snappers following the spawning period. The best commercial production was in March and April, indicating an increase in feeding activity prior to spawning. The high spring catches are during months of generally poor weather conditions on the Texas coast, indicating a good catch per effort. The third highest month of production was in August, which may reflect post-spawning feeding activity, plus recruitment into the population of fish spawned the previous year (Fig. 4).

No red snapper spawning grounds were found during the study. Commercial fishermen reported catches of roe-bearing females on level bottom within 36.6 m (20 fm). Moe (1963) reported spawning areas off the northwest coast of Florida between 18.3 and 36.6 m (10 to 20 fm). We caught the smallest snappers (34 mm) between 20.1 and 27.4 m (11 and 15 fm) in August, which indicates that spawning also occurs within 36.6 m (20 fm) off the Texas coast. However, larval studies of red snappers are needed to confirm this. Only 13 gravid (Stage 5) females were caught off the reefs during the survey, indicating that feeding is curtailed during spawning and spawning does not occur primarily on the reefs.

Age and growth

Due to the apparent long spawning season and constant recruitment into the population, we had difficulty in determining age and growth rates of red snappers. We did not study scales or otoliths, but made our estimates by using the length frequency method and increases in mean sizes. The snapper catch was grouped by month, by season, catch by various means (party boat, commercial catch, shrimp boat, and our catch), the total catch, males vs. females; no method proved satisfactory. Modes of abundance in the populations were evident, but varied widely in individual samples, making it difficult to determine age classes and growth.

Moseley (1966) made age-growth studies of red snappers by reading growth checks on scales and found a great deal of overlap of length frequencies and age classes. He indicated that snappers grow approximately 90 mm between spawnings up to the fourth spawning period and reach 200-220 mm SL during their first year. Growth is probably accelerated during the first few months of life since he captured juveniles in September and October that had a mean size of 49 mm and 75 mm SL, respectively. In 1972 our samples showed a similar pattern with juveniles averaging 49 mm in August and 74 mm 32 days later.

Studies being carried out by the University of Texas Institute of Marine Science (unpublished) indicate a slower growth rate after the first year. Preliminary results showed that the majority of fish had an initial growth check at a size of 200 mm FL. The smallest size at which a growth check could be determined was 120 mm FL. Their data indicated a growth of 75 mm in the second year, 53 mm during the third year, 47 mm in the fourth year and 65 mm between the fourth and fifth years. The mean rate of increase was 60 mm per year between the first ring (200 mm) and the fifth ring (440 mm).

Snappers tagged in Florida had a mean growth rate of approximately 65 mm per year (Beaumariage 1964; Beaumariage and Wittich 1966). These data were based on 29 fish ranging between 189 mm and 383 mm SL. They were free for 346 to 766 days and growth ranged from 11 mm to 112 mm per year. Moe, Beaumariage, and Topp (1970) reported a tagged snapper that was recaptured after almost six (5.8) years of freedom. It was 307 mm SL (370 mm TL) when tagged and had grown to 765 mm TL. The mean increase per year was approximately 68 mm. It is possible that the tags hindered growth, but these findings agree with the scale studies done by personnel from the University of Texas. According to Moseley's (1966) size distribution the snapper was probably over 2 years old when tagged and over 8 years old when recovered.

Our trawl data indicated that snappers disappeared from the catches at an approximate size of 200 mm and began to enter the hook and line fishery. They began to disappear from the trawl catches at about 160 mm to 240 mm FL and entered the hook and line catches at about 200-230 mm primarily in the summer months or approximately one year after the major spawning period (Figs. 3 and 4). This indicates that at about 1 year after spawning the fish are approximately 200 mm FL. At this size they may have been able to avoid the trawls and had not fully entered the hook and line fishery. Relatively few between the size of 160 mm and 225 mm were found in the samples and year class 1 fish may not have been represented in the length frequency distributions (Fig. 5).

The length frequency distribution of the commercial catch shows modes of abundance that generally agree with the growth rate of the fish reported by Moe, *et al.* (1970) (Fig. 5). The majority of fish were 300 mm long and probably 1½ to 2 years of age (Moseley 1966). They represent the initial peak of abundance in the commercial catch. Seven modes of abundance follow indicating successive year classes. The last peak at 720 mm illustrates that red snappers are approximately 8½ to 9 years old at this size. These findings are comparable to the actual growth rate reported by Moe, *et al.* (1970).

Our findings show growth rates after year class 1 of about 40 to 80 mm per year (Fig. 5). Scale studies and tagging data have demonstrated mean rates of growth from 60 to 90 mm per year. Growth of individual fish varies widely and with available data it appears that the mean growth rate of red snappers is approximately 75 mm per year after year class 1.

Food Habits

Stearns (1884), Adams and Kendall (1891), Camber (1955), and Moseley (1966) all reported on the difficulty of carrying out an adequate food-preference study for red snappers. When these fish are brought to the surface from the depths, many evert their stomachs due to the decrease in pressure, thus causing a loss of any food they might have contained. Stearns (1884) examined 450 fish and found food in only one. Camber (1955) studied 100 specimens and found 24 which contained food. Moseley (1966) found food items in the stomachs of 187 fish out of 712 which were examined. During the present study, 575 trawl-caught juvenile and sub-adult red snapper stomachs were examined. Of these, 52 were everted, 265 were empty and 258 contained food items. Also, out of 1,139 reef-caught red snapper stomachs examined, 687 were everted, 262 were empty and 190 had food in them.

The high percentage of food retention in the juveniles which were examined is probably because they were brought up slowly in trawls from lesser depths with smaller variations in pressure. The adult snappers were taken mostly on reefs along the 40-fathom line and were captured with commercial-type electric reels. The rapid ascent of the fish caused by the reel speed exerts pressure on the air bladder of most fish caught and causes them to evert their stomachs.

Juvenile red snappers were mostly dependent upon shrimp for food throughout the year; crabs and other crustaceans were also important (Table IV). These data are in agreement with Moseley (1966) who found high percentages of shrimp and other crustacea in the stomachs of juveniles from off Texas during the fall of 1964.

Adult red snappers were found to depend primarily on other fish as a source of food. During the fall and winter, these snappers also turned to the lesser blue crab *(Callinectes danae)* and other crustaceans for food.

In the spring, 13% of adult snapper food by frequency and 21% by volume was found to be tunicates. Similar observations were also noted by Camber (1955), Moseley (1966), and commercial fishermen off the Texas coast (Personal communication). Apparently snappers feed on those items which are most readily available, and the spring bloom of tunicates in some areas provides them with abundant grazing material.

Fewer and more varied items were found in the juvenile stomachs during spring than other times of the year. Unidentified shrimp and crustaceans made up 50% of the food items found (Fig. 9) and penaeid shrimp composed the greatest volume (Fig. 10). This leads to speculation that many of the shrimp or crustaceans that were small and unable to be accurately identified were probably *Acetes* sp., which were found most of the year, but which were not large enough to have much effect on the total food volume.

In summer, free-swimming squid made up a large portion of the young red snap-

Table IV. Stomach contents of red snapper, 1970 and 1971
(Presented as seasonal frequency of each item)

	JUVENILES (Trawl)			ADULTS (Reef)		
	Contents	Number	Percent	Contents	Number	Percent
Spring						
	Shrimp	6	6	Triglidae	1	2
	Crustacea	3	3	Synodus sp.	3	7
	Crab	1	2	Engraulidae	24	52
	Fish	3	3	Fish	5	11
	Squid	1	2	T. lepturus	1	2
	Detritus	79	84	Squid	1	2
				Alpheidae	1	2
				Crab	4	9
				Tunicate	6	13
Summer						
	Crustacea	3	10	Triglidae	3	7
	Shrimp	17	53	Fish	20	48
	Crab	3	10	Ophichthidae	2	5
	Detritus	2	6	Crab	5	12
				Detritus	7	17
				Crustacea	1	2
				Isopoda	1	2
				Shrimp	3	7
Fall						
	Shrimp	5	83	Fish	5	38
	Detritus	1	17	Crustacea	1	6
				C. danae	5	38
				Mantis Shrimp	1	6
				Tunicate	1	6
				Shell fragment	1	6
Winter						
	Shrimp	1	25	Fish	19	42
	Detritus	3	75	C. danae	5	12
				Sicyonia sp.	5	12
				Penaeus sp.	6	13
				Squid	2	4
				Shrimp	1	2
				Detritus	6	13
				Tunicate	1	2

per diet. This was true for both frequency and volumetric tabulations. Bottom-dwelling crabs and mantis shrimp were also important as well as fish which made up a large percentage of the food supply throughout the year.

The octopus was greatly utilized by juvenile red snappers during the fall of 1972. The data are influenced by catches from off the Freeport area, but fall samples off Port Aransas also contained octopods.

More varied food forms were utilized by young snappers during winter than any other season. Apparently the fish have to live off a wider variety of organisms due to the scarcity of more preferred food. Organisms which were found in juvenile stomachs only during winter include *Lucifer* sp., leptocephalus eel larvae, pelagic copepods, polychaete worms, and pistol shrimp (Alpheidae). These food items were found only occasionally and did not have an appreciable effect on the total volume of food which was measured.

All food items found in juvenile red snapper stomachs in 1972 are given in Table V. These items are listed as to the size of fish in which they were found. The general trend seems to be that the very young red snappers depend almost exclusively upon invertebrates for food and that there is a gradual increase in de-

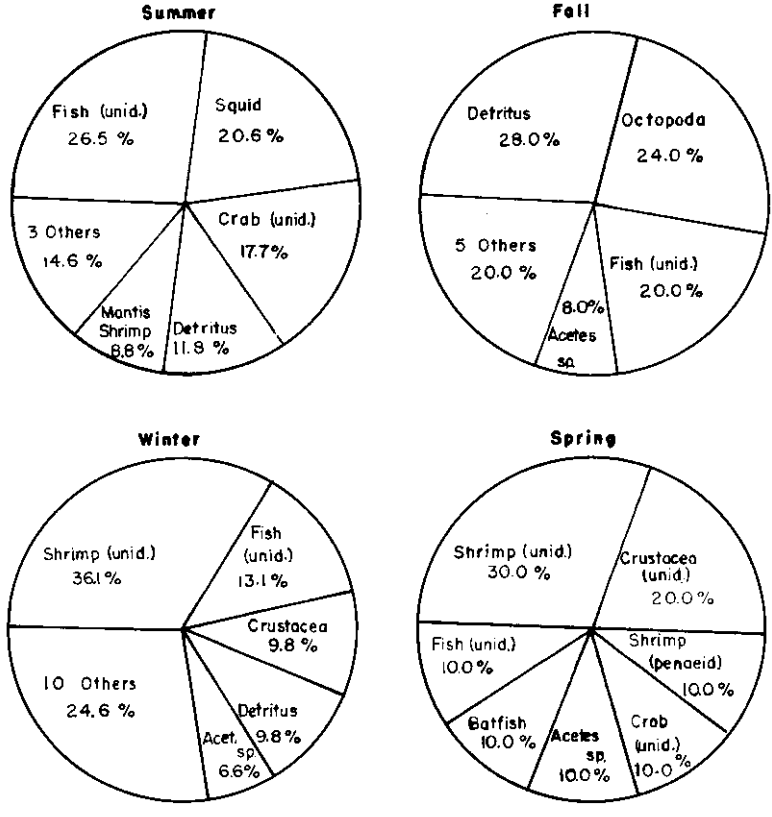

Fig. 9. Food preferences of juvenile *L. campechanus* (Frequency by percent), 1972.

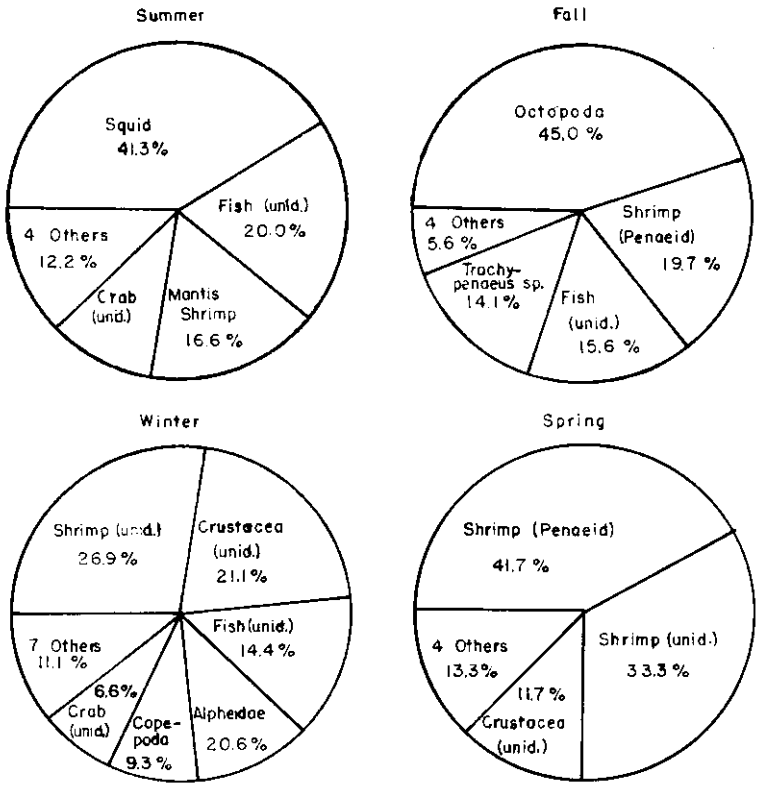

Fig. 10. Food preferences of juvenile *L. campechanus* (Volume by percent), 1972.

pendency upon vertebrates as the fish grow larger. Those fish smaller than 51 mm and larger than 225 mm were not taken in numbers large enough to give a good estimation of the ratio of vertebrates to invertebrates in their diet.

The data agree with those of Camber (1955) who found small shrimp in 14 of 15 juvenile stomachs examined, and of Moseley (1966) who found that juvenile red snappers were polyphagous, but that they depended mostly on crustaceans for food.

Amphipods, copepods, *Lucifer* sp., *Acetes* sp., leptocephalus larvae, fish larvae, and other members of the zooplankton were found in snappers up to 150 mm long. Between 101 and 150 mm, the small red snappers apparently go through a transition period in which food emphasis is shifted from zooplankton to juvenile forms of crustaceans and other fishes. By the time the snappers have grown larger than 150 mm, planktonic forms are no longer in the diet and have been replaced by a wide variety of juvenile vertebrates and invertebrates.

Adult red snapper which were examined utilized the greatest variety of foods in summer and the least in winter (Fig. 11). Fish were found to make up the highest percentage by volume for every season but summer, when *C. danae* made up

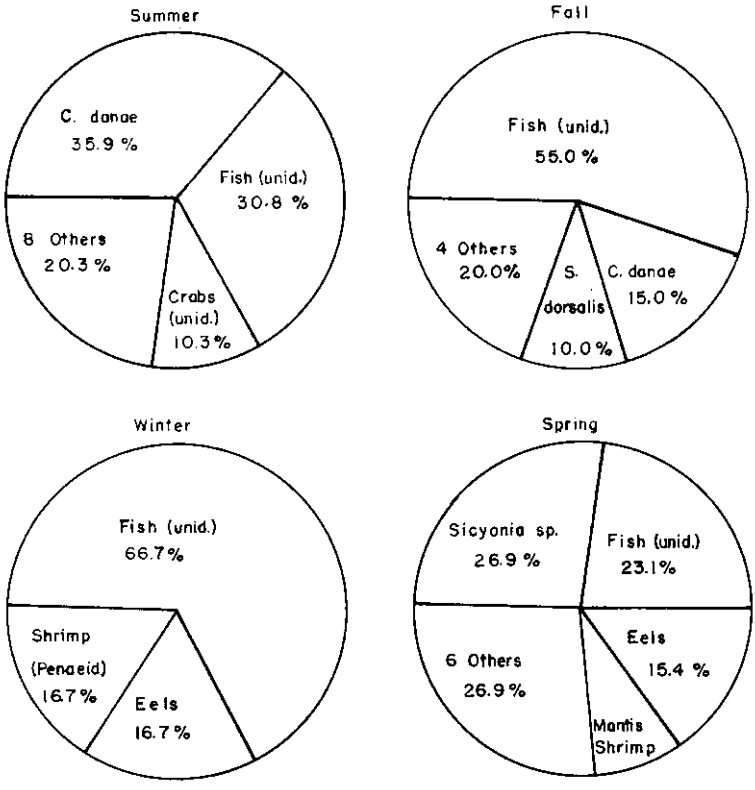

Fig. 11. Food preferences of adult *L. campechanus* (Frequency by percent), 1972.

39.2% of the catch (Fig. 12). Fish constitute the primary food item throughout the year. Seasonal primary food items included the following: spring—eels, mantis shrimp and *Sicyonia* sp.; summer—*C. danae* and *Sicyonia dorsalis*; winter—eels. The key factor involving the utilization of these items was probably availability of the organisms at various times during the year.

Predation

Red snappers are probably preyed upon by numerous organisms. One snapper (80 mm) was found in the stomach of a lizard fish (*Synodontidae*) caught in a trawl and another (340 mm) was found in the stomach of a 13.6 kg (30 lb) dolphin (*Coryphaena hippurus*) caught near a reef. Sharks probably also prey upon snappers. At times they would strike fish being brought up by hook and line and it appeared that when sharks were numerous in the area, the snapper catches would decline.

Morphology

Camber (1955) noted two different body shapes in red snapper caught from the Campeche banks. A straight line extended from the tip of the nostril through the

tip of the opercle would go through the tail on some fish and above the tail on others. We examined 392 snappers in this manner during the study. In 57% of the fish, the line went through the tail, 34% went above the tail, and 9% below the tail. In any given sample or size of fish there was a variation in the angle of the line.

Shape of body was compared with weight (Fig. 13). Up to about 350 mm all three types were similar in size. Beyond 350 mm the fish with the line running above the tail were heavier, and those with line below the tail lighter than the fish in which the line ran through the tail.

Commercial snapper fishermen claimed that some fish of a given size weighed more than others at the same size. They called these fish "blackbacks" because they were darker dorsally and had a distinctly different body shape. They stated that these fish were found in different locations and at different times of the year than the "normal" snappers. A commercial catch was examined that contained this type fish, but unfortunately no weights could be taken. However, the line from

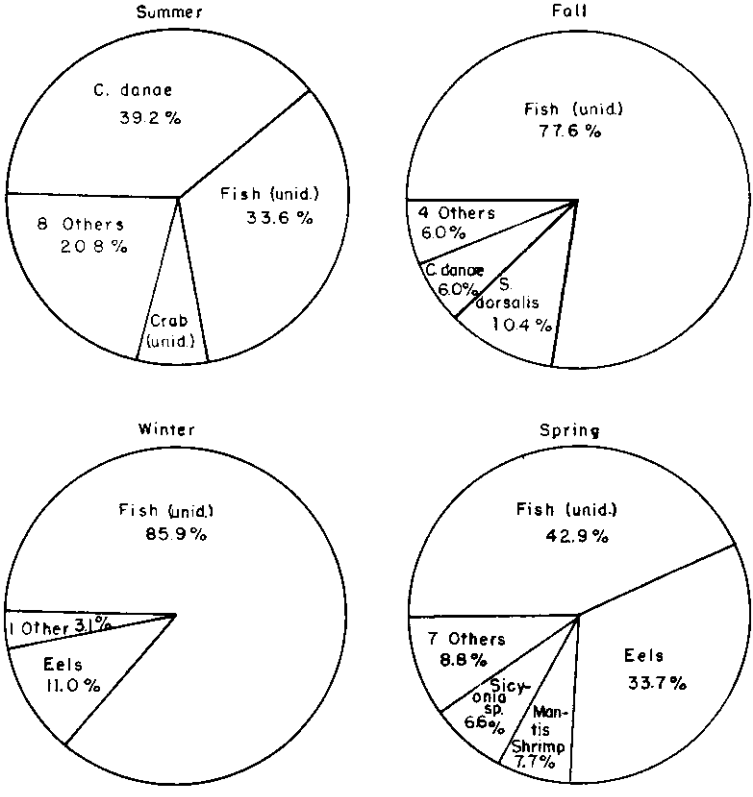

Fig. 12. Food preferences of adult *L. campechanus* (Volume by percent), 1972.

the snout through the opercle on those examined varied as it did in the rest of the populations examined.

More taxonomic work is needed on the species. Clarification of its taxonomy would aid in studies of its life history, especially in the area of age and growth.

Table V. Stomach contents of juvenile red snapper, 1972
(Listed by size of red snappers in 25 mm increments)

Fork length (mm)	Contents	Volume (cc)	Depth (fm)	% Vertebrates, Invertebrates Frequency
25-50	(2)Fish	.10	12	
	Shrimp	0.07	12	V-50
	Amphipoda	TR	16	I-50
51-75	Crustacea	2.0	15	
	Copepoda	0.25	15	
	(5)Shrimp	0.75	15.5	
	Squid	1.00	18	
	Octopus	0.75	22	
	Penaeidae	1.40	22	
	Crab	0.10	22	V-8
	Fish	0.20	23	I-92
76-100	Lucifer sp.	0.10	15	
	Eel (leptocephalus)	0.05	15	
	Crustacea	0.30	15	
	(1)Shrimp	0.30	15	
	(7)Shrimp	0.62	15.5	
	Fish	0.08	15.5	
	(1)Shrimp	0.15	16	
	Acetes sp.	0.10	18	
	Crustacea	0.50	18	
	(4)Octopus	2.2	22	
	Fish	0.25	22	
	Copepoda	0.80	23	
	Acetes sp.	TR	24	
	Fish	0.10	27	
	Acetes sp.	0.05	27	
	(2)Alpheidae	1.1	28	
	(1)Shrimp	0.12	28	
	(1)Shrimp	0.01	28	
	Squid	0.07	28	
	Copepoda	TR	28	
	Crustacea	0.01	28	V-12
	Crustacea	0.05	33	I-88

Table V. (Continued)

101-125	(1)Shrimp	0.40	15	
	Polychaeta	0.09	15.5	
	(2)Shrimp	.25	15.5	
	Sicyonia sp.	0.40	15.5	
	Acetes sp.	0.05	15.5	
	Ogcocephalidae	0.20	17-18	
	Fish	1.00	18	
	Sicyonia sp.	1.00	18	
	Fish	0.25	22	
	Octopus	0.25	22	
	Crustacea	0.03	23	
	Lucifer sp.	0.03	28	
	Alpheidae	0.10	28	
	(2)Shrimp	.40	28	
	(2)Fish	.02	28	
	Trachypenaeus sp.	1.00	32	
	Acetes	TR	33-36	V-29
	Fish	0.25	40	I-71
126-150	Crab	0.30	17-18	
	(1)Shrimp	0.70	17-18	
	(2)Crab	2.7	21-22	
	(2)Sicyonia sp.	3.75	22-23	
	Mantis Shrimp	1.00	22-23	
	(1)Shrimp	TR	28	
	Fish	0.15	28	
	Mysidae	TR	28	
	Isopoda	TR	28	
	(2)Shrimp	1.30	29	
	Acetes sp.	0.10	33	V-13
	Fish	TR	33-36	I-87
151-175	Mantis Shrimp	2.10	8	
	(2)Squid	4.80	17-18	
	Fish	0.90	17-18	
	(1)Shrimp	6.00	21-22	
	Crab	5.10	21-22	
	Trachypenaeus similis	1.70	21-22	
	(4)Sicyonia sp.	4.3	22-23	
	Crab	0.20	22-23	
	Synodus sp.	1.00	22-23	
	Penaeidae	2.50	27	
	Fish	0.20	27-32	V-19
	Crustacea	0.20	29	I-81
176-200	Squid	9.40	17-18	
	Crab	0.70	17-18	
	Squid	13.80	17-18	

Table V. (Continued)

	(2)Batrachoididae	12.0	21-22	
	Sicyonia sp.	5.6	21.23	
	Crab	1.50	27	
	Fish	1.00	33	V-30
	Crab	0.75	33	I-70
201-225	(2)Squid	17.2	21-22	
	Crab	2.00	21-22	
	(2)Fish	2.1	22-23	V-33
	Callinectes sp.	0.50	22-23	I-67
226-250	Batrachoididae	7.10	21-22	V-50
	Mantis Shrimp	2.90	21-22	I-50
251-275	Diplectrum sp.	4.00	22-23	V-100
276-300	No specimens taken			
301-325	Mantis Shrimp	13.50	21-22	V-0 I-100%

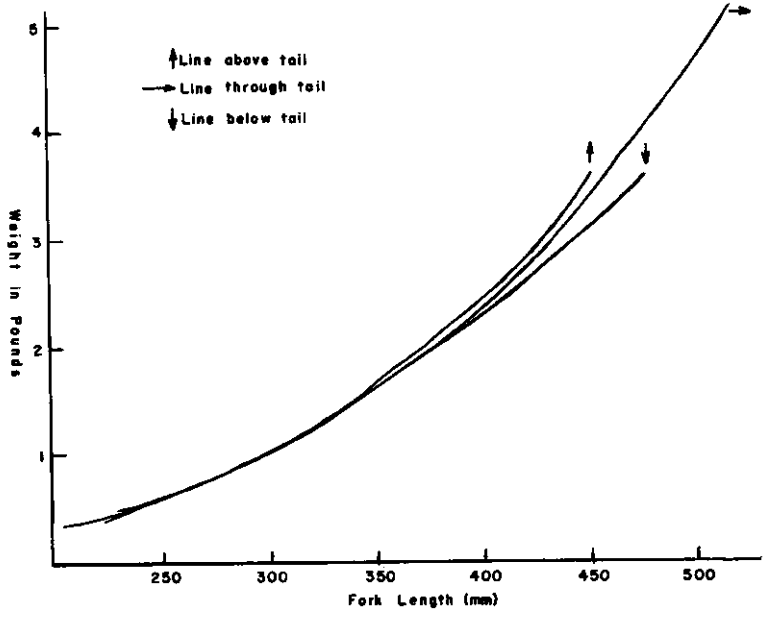

Fig. 13. Comparison of length-weight relationship between three different body shapes of *L. campechanus*.

The Red Snapper Fishery

Sports and commercial fishermen were interviewed along the coast for information pertaining to the fishery. Trips were taken on party boats and, if possible, measurements of fish were obtained monthly at various fish houses. Many of the dealers and fishermen expressed concern over the apparent decline in the fishery.

Relatively few boats were involved solely in commercial fishing for the species. As far as could be ascertained in 1972, there were seven boats working out of Port Isabel, three out of Port Mansfield, and one part-time boat from the Port Arthur area. At least two, and perhaps three, of the boats from Port Isabel limited their fishing to waters off Mexico.

The commercial snapper boats fished with a small crew (two to four) using powerful electric reels. They would cruise known productive areas using depth recorders to find schools of snapper. When a school was found each man fished with two lines with about 30 hooks per line to capture the fish. They would alternate use of the lines so that while fish were being removed from one and it was being rebaited, the other was always fishing. Generally the "bites" lasted for only a short time and the fishermen would continue the search for new schools of snappers. A fisherman related that searching for fish took 95% of the time, while actual fishing time was about 5%.

It was difficult to ascertain the catch rates of commercial boats, but fishermen stated that prior to 1965 they averaged about 454 kg (1,000 lb) a day, while in recent years they felt fortunate to catch 227 kg (500 lb) per day. Their estimate of about 50% decline corresponds with commercial landings during the same period (Table VI).

The fish houses, especially in the Galveston area, also relied upon catches made by shrimpers, fish sold to them from party boats, and snappers landed by out-of-state commercial fishermen. At times shrimp fishermen would fish for snapper by hook and line during slack shrimping periods and would also sell the larger ones caught in the trawls.

When fish were brought to the fish house in Port Isabel, they were graded into three sizes designated "baby" (less than a pound), "medium" or "store size" (one pound to 4½ lb), and "large" (above 4½ lb). A catch of 1902 kg (4,200 lb) examined in June had a weight ratio of 10% "large," 13% "small," and 77% "medium."

There were approximately 11 party boats involved in snapper fishing; 4 in Galveston, 4 in Port Isabel, 2 in Freeport, and 1 in Port Aransas. At least one of the boats was able to handle 100 persons fishing one reel with two hooks, while the smaller boats took 12 persons. Besides the large party boats, there were charter vessels that took small individual parties to the snapper banks and sportsmen that fished for snapper from their own craft.

In 1970, catch rates (weight per 15 hooks per hour) from larger boats ranged from 4.5 kg (9.9 lb) to 34.0 kg (75 lb) per hour and averaged 21.1 kg (46.6 lb) per hour. The highest catch rates were between October and December.

Commercial landings of snappers have fluctuated greatly since statistics have been collected (Table VI). Camber (1955) and Carpenter (1965) listed some of the factors influencing production as market conditions, war, size and efficiency of the fishing fleet, labor-management relations, labor shortage, and weather.

Table VI. Historical catch statistics of *L. Campechanus* landed on the Texas coast* (thousands of pounds)

Year	Quantity	Year	Quantity
1887	75	1950	1,233
1888	65	1951	1,117
1889	22	1952	1,523
1890	5	1953	1,101
1897	465	1954	1,345
1902	2,068	1955	1,262
1908	2,252	1956	1,534
1918	1,243	1957	1,443
1923	1,009	1958	1,399
1927	1,237	1959	1,665
1928	1,055	1960	1,153
1929	804	1961	1,829
1930	930	1962	1,742
1931	691	1963	2,169
1932	985	1964	2,250
1934	635	1965	2,212
1936	907	1966	1,653
1937	1,141	1967	1,409
1938	1,279	1968	1,128
1939	1,156	1969	925
1940	1,233	1970	916
1945	288	1971	1,082
1948	1,324	1972	1,238
1949	1,055	1973	781

*Source—Fishery Statistics of the United States, 1965-71 & Texas Landings

The highest period of production in recent years was 1964 when 2¼ million pounds were landed. From that period to 1969, landings steadily decreased to less than a million pounds per year. Total production was highest in 1964, but in 1963 the catch per effort had dropped by 50% (Table VII). The number of hooks used in the fishery steadily increased from the 1940's, until 1963, when the effort more than doubled. When catches declined the effort began to decline and in 1969 the number of hooks used decreased by about 40% of the number used in 1973. The catch per effort also declined by about 40% during the same period.

Production of fish captured with otter trawls also fluctuated greatly from year to year (Table VII). As gross tonnage of shrimp vessels increased there appeared to be a general increase in landings of trawl-caught snappers and a decrease in hook and line catches (Fig. 14).

Carpenter (1965) noted that total production was higher than in previous years, but that the catch per vessel had declined. He attributed the decreased catches to heavy pressure exerted on snapper populations. More effort was expended by Texas fishermen in the mid-sixties, but both effort and catch per effort have declined since then.

Table VII. Texas commercial landings of *L. campechanus* captured with hook and line and otter trawl, 1950-1971*

Year	Pounds captured with hook and line	Number of hooks fished	Pounds per year per hook	Pounds captured with trawls
1950	1,224,000	540	2,267	8,900
1951	1,105,800	404	2,737	600
1952	1,514,300	414	3,658	1,600
1953	1,100,500	462	2,382	200
1954	1,235,400	725	1,704	109,300
1955	1,205,100	1,186	1,016	56,600
1956	1,453,500	1,005	1,446	80,000
1957	1,404,300	1,085	1,294	38,700
1958	1,341,900	1,103	1,217	57,100
1959	1,630,500	1,264	1,290	34,600
1960	1,140,700	1,424	801	13,700
1961	1,799,100	1,741	1,033	29,800
1962	1,708,600	1,871	913	33,700
1963	2,115,500	4,643	456	53,200
1964	2,133,500	4,740	450	116,300
1965	2,127,700	4,487	474	84,100
1966	1,566,400	4,496	348	86,700
1967	1,297,300	4,474	290	111,300
1968	1,046,000	3,039	344	81,500
1969	776,700	2,762	281	148,000
1970	776,700	1,451	535	139,700
1971	925,300			157,100

*Source — Fishery Statistics of the United States 1950-1971.

Sports fishing has increased in recent years (Carpenter, 1965, and Moseley, 1966) and this may have offset the decrease in pressure exerted by commercial fishermen. Data from our study show that large numbers of juvenile snappers (50-160 mm) are probably caught in trawls and discarded. Apparently the combination of these factors has exerted too much pressure on the fishery, thus the decline in commercial landings.

In April 1973, a new project was initiated with one of the objectives being to determine the discard practices of the commercial shrimping fleet. Samples were taken with the fleet from June 1973 through January 1974 and June through August 1974. This project will not be completed until June 1975, but some results pertaining to juvenile red snappers have been obtained.

Results to date indicate that juvenile red snappers did not begin to enter fleet samples significantly until the latter part of August when about 19 per hour were captured with one net (Table VIII). The catch increased until a high was reached

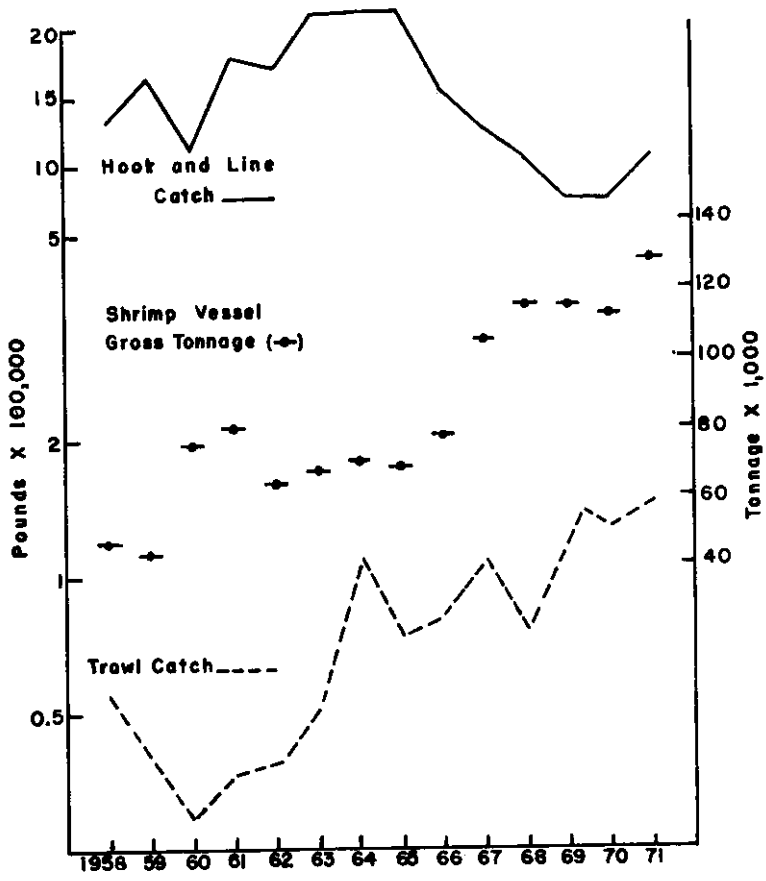

Fig. 14. Comparison of commercial hook and line catch, trawl catch of *L. campechanus* and gross shrimp vessel tonnage, 1958-71. 1958 and 1959=Net Tonnage. Source: Fishery Statistics of U.S.

in November then decreased sharply in December. The average catch was about 15 per hour and snappers were captured between 16.5 m and 54.9 m (9 and 30 fm). The high catches in November may be misleading because fewer samples were obtained, but the data indicate the numbers of young snappers captured by the shrimping fleet and are in general agreement with our findings in 1970-72 (Fig. 3).

The size of shrimp vessels and trawling techniques may have had more effect than the increase in the number of vessels alone. Hildebrand (1954) reported relatively few snappers in his samples. Most of the boats during that period were using large (90-120 ft) trawls and engines with relatively low horsepower. Since that time more efficient trawling methods have been developed using larger and more powerful vessels. It is probable that increased trawling speed and more efficient trawls are capturing more young snappers than in the past.

Table VIII. Catch of juvenile red snappers (*L. campechanus*) while trawling with commercial shrimping fleet June 1973 through January 1974, June through August 1974

Month	Hours trawled	Number snapper caught per hr.	Depth sampled (fm)	Depth of capture (fm)	Mean number of boats in fleets sampled	% of samples containing snapper
June	10.50	0.2	4-15	13	22	20
July	20.60	2.5	4-16	9	27	6
Aug.	14.50	19.2	10-20	10-15	26	50
Sept.	2.25	41.3	4-18	16-18	11	25
Oct.	5.50	58.0	10-23	10-23	16	100
Nov.	.50	154.0	22-23	22-23	9	100
Dec.	2.00	12.5	25	25	14	100
Jan.	1.00	2.0	27-30	27-30	16	100
Totals	56.85					32

Many of the snapper fishermen believed that the discarding of young snappers was the cause of the decline in the fishery. Moe (1963) reported similar sentiments from fishermen in Florida. However, before making a final judgment more data are needed on populations and life history studies dealing with fecundity, larvae, and mortality. It is possible that the numbers of juveniles captured in the trawls are small in relation to the total population.

If the capture and discarding of young snappers by the shrimping fleet is affecting the commercial red snapper fishery, the most apparent solution to the problem would be the development of more selective fishing gear—trawls that catch less "trash" with the shrimp. This would curtail the capture of young snappers and benefit the shrimper by shortening sorting time and allowing longer tows.

It is our view that the red snapper on the Texas coast is in no immediate danger of complete depletion though there has been a decrease in commercial landings. There are still areas that are not trawlable and serve to protect young snappers from the trawls. The problem exists mainly in the commercial fishery, which requires large catches per effort to be profitable. If the numbers of young snappers captured in the trawls could be reduced, perhaps the commercial snapper landings would increase.

SUMMARY

Juvenile snappers were captured on level, trawlable bottom from off Galveston to off Port Isabel. Few were caught within 18 m (10 fathoms) or beyond 64 m (35 fm). The highest catch per effort was in 29.3-45.7 m (16-25 fm) off the Freeport-Galveston area.

Reefs ranging in depth from 13.7-146.3 m (7½ to 80 fm) were sampled and red

snappers were captured by hook and line at all sites. Fishermen stated, and trawl landings of snappers showed, that large snappers were captured on level bottom and are not confined to reef or rough bottom areas.

The smallest snappers were caught by trawl in the summer. As the season progressed, the snappers grew larger and moved offshore to deeper water. During the spring, trawl catches declined and there was a movement of the larger juveniles back inshore. The offshore movement began before the water cooled, so movement may have related to food availability.

Catches of adult snappers on reefs and on smooth bottom are seasonal and may indicate a movement off the reefs during the warm spawning season and back to the reefs during the colder months. In general, fishing on the reefs was most productive from sunset to midnight.

The major period of spawning was June and July with a probable smaller spawn occurring in fall. Examination of gonads indicated that spawning may have extended from May through January. Commercial landings of snappers were highest in March, April, and August. The larger catches in the spring may have been due to increased feeding prior to spawning and those in August to post-spawning feeding activity and to recruitment into the population from the previous years' spawn. No spawning grounds were found, but data from commercial fishermen indicated that at least some activity took place on level bottom within 20 fathoms.

Juvenile snappers feed on invertebrates and adults on vertebrates, but both will eat the most available food. The food items of young snappers appear to change from planktonic to juvenile forms when they reach about 150 mm. Snappers are preyed upon by lizard fish, the dolphin-fish, sharks, and probably other species.

Total Texas commercial snapper landings and catch per effort have declined considerably in recent years. Effort by commercial fishermen has also decreased, while sports fishing for the species has increased. Shrimp vessels which are more numerous and efficient than in the past also apply pressure to the fishery, not only by catching snappers for market, but by discarding the juveniles captured in trawls. Our samples indicate that areas where the young snappers are abundant coincide with the brown shrimp (*Penaeus aztecus*) shrimping grounds. The period of highest catches of trawl-caught small snappers was from late August through November.

If fishing gear are developed that will catch less "trash" with the shrimp, it will benefit both the shrimp and red snapper fisheries. The shrimper's catch will be easier to sort and it will allow longer trawl tows. If the trawl catch of small snappers is decreased it should allow more of them to enter the hook-and-line fishery.

LITERATURE CITED

Adams, A.C. and W.C. Kendall. 1891. Report upon an investigation of the fishing grounds off the West Coast of Florida. Bull. U.S. Fish. Comm. 9:289-312.

American Fisheries Society. 1970. A list of common and scientific names of fishes from the United States and Canada. Special Publication No. 6, Third Edition. 150 pp.

Anderson, W.D. Jr. 1967. Field guide to the snapper (Lutjanidae) of the Western Atlantic. Bur. of Comm. Fish. Cir. 252:1-14.

Baughman, J.L. 1943. The lutjanid fishes of Texas. Copeia: 212-215.

Beaumariage, Dale S. 1964. Returns from the 1963 Schlitz Tagging Program. Tech. Ser. Fla. St. Bd. Conserv. No. 43:1-34.

_____ and A. C. Whittich, 1966. Returns from the 1964 Schlitz Tagging Program. Tech. Ser. Fla. St. Bd. Conserv. No. 47:1-50.

Camber, C. I. 1955. A survey of the red snapper fishery of the Gulf of Mexico, with special reference to the Campeche Banks. Tech. Ser. Fla. St. Bd. Conserv. No. 12:1-64.

Carpenter, James S. 1965. A review of the Gulf of Mexico red snapper fishery. Bur. of Comm. Fish., Cir. 208:1-35.

Collins, J. W. 1887. Report on the discovery and investigation of fishing grounds made by the Fish Commission Steamer Albatross during a cruise along the Atlantic Coast and in the Gulf of Mexico, with notes on the Gulf fisheries. Rep. U.S. Commnr. Fish. 13:217-311.

Food and Agriculture Organization of the United Nations. 1960. Manual of field methods in fisheries biology. Rome, Italy. Prov. Ed. No. 1. 152 pp.

Hildebrand, H. H. 1954. A study of the fauna of the brown shrimp (*Peneaus aztecus* Ives) grounds in the western Gulf of Mexico. Publs. Inst. Mar. Sci. Univ. Tex. 4:170-232.

Gunter, Gordon. 1945. Studies on Marine Fishes of Texas. Publs. Inst. Mar. Sci. Univ. Tex. 1(1):9-120.

Jarvis, N. D. 1935. Fishery for red snappers and groupers in the Gulf of Mexico. Invest. Rep. U.S. Bur. Fish. 26:1-29.

Lyles, Charles H. 1967. Fishery statistics of the United States. 1965. Bur. Comm. Fish. Stat. Dig. No. 61:59-364.

Miller, J. M. 1965. A trawl survey of the shallow Gulf fishes near Port Aransas, Texas. Publs. Inst. Mar. Sci. Univ. Tex. 10:80-105.

Moe, M. A., Jr. 1963. A survey of offshore fishing in Florida. Prof. Pa. Ser. Mar. Lab. Fla. No. 4:1-117.

_____, D. S. Beaumariage, and R. W. Topp. 1970. Return of tagged Gag, *Mycteroperca microlepis*, and Caribbean red snapper, *Lutjanus campechanus*, after six years of freedom. Trans. Am. Fish. Soc. 99(2):428-429.

Moseley, F. N. 1966. Biology of the red snapper, *Lutjanus aya* Bloch, of the Northwestern Gulf of Mexico. Publs. Inst. Mar. Sci. Univ. Tex. 11:90-101.

Rivas, L. R. 1966. Review of the *Lutjanus campechanus* complex of red snappers. Quart. J. Fla. Acad. Sci., 29(2):122.

Smith, R. O. 1948a. Experimental fishing for red snapper. I. The use of hoop nets. Comm. Fish. Rev. 10(2):1-10.

_____ 1948b. Experimental fishing for red snapper. II. The use of mechanical reels. Comm. Fish. Rev. 10(3): 6-7.

Smith, H. M. 1885a. Report to the division of statistics and method of the fishing. Rep. U.S. Commr. Fish. 18:183-184.

_____ 1885b. Report of the division of statistics and method of the fishing. Ibid. 19:68-70.

Stearns, S. 1884. On the position and character of the fishing grounds of the Gulf of Mexico. Bull. U.S. Fish. Comm. 4:289-290.

_____ 1885. The fisheries of Pensacola, Florida. Bull. U.S. Fish. Comm. 5:245-247.

Texas Landings. 1969. U.S. Dept. Comm., N.O.A.A., Nat. Mar. Fish. Ser. C.F.S. No. 5232:1-7.

_____ 1970. U.S. Dept. Comm., N.O.A.A., Nat. Mar. Fish. Ser. C.F.S. No. 5616:1-7.

_____ 1971. U.S. Dept. Comm., N.O.A.A., Nat. Mar. Fish. Ser. C.F.S. No. 5923:1-7.

_____ 1972. U.S. Dept. Comm., N.O.A.A., Nat. Mar. Fish. Ser. C.F.S. No. 6124:1-8.

_____ 1973. U.S. Dept. Comm., N.O.A.A., Nat. Mar. Fish. Ser. C.F. S. No. 6394:1-2.