

# Estimate of the Catch of Red Snapper, *Lutjanus campechanus*, by Shrimp Trawlers in the U.S. Gulf of Mexico

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## Introduction

Red snappers, *Lutjanus campechanus*, have been the object of intense commercial fishing in the Gulf of Mexico. Average annual landings of red snapper from 1965 to 1982 were: 1965-71, about 11 million pounds; 1972-76, 800,000 pounds; and 1978-82, 549,000 pounds. Recreational catches of snappers caught in the Gulf of Mexico were substantially higher than commercial catches. Recreational snapper catches for 1965 and 1970 were 44 and 15 million pounds, respectively (Nakamura, 1976). Marine recreational fishing surveys indicated that about 75 percent of the reported snapper catch was red snapper (Thompson, 1979). The recreational take of snappers is substantial and should be considered in management decisions (Prochaska and Cato, 1975; Nakamura, 1976).

Extensive efforts have been expended documenting both the fishery (Ginsburg, 1930; Captiva and Rivers, 1960; Carpenter, 1965; Allen and Tashiro, 1976) and the taxonomy (Rivas, 1966, 1970; and Anderson, 1967) of snappers. Fewer reports, however, address the life history of these species (Camber, 1955; Moseley, 1966; Bradley and Bryan, 1976; Futch and Bruger, 1976).

Commercial and recreational fishermen repeatedly have had to increase travel distances to locate profitable fishing grounds because of declining catch rates in traditional areas. Commercial

fishermen who used to fish profitably in the U.S. Gulf of Mexico now often travel to the Caribbean Sea for good catches. Increases in party boat size and in the number of large private craft have made offshore reefs, rock piles, and oil platforms, once exploited only by commercial interests, available to recreational anglers.

The commercial shrimp fishery has been suggested as a possible cause of declining U.S. Gulf snapper landings (Bradley and Bryan, 1976). This suggestion was addressed in the Gulf of Mexico Fishery Management Council Fishery Management Plan for reef fish resources (GMFMC, 1980) but remained unresolved because existing analyses were insufficient.

This paper, utilizing available commercial by-catch and resource assessment data provides a more precise estimate of the catch of juvenile red snapper by shrimp trawlers than that reported in the GMFMC (1980) Reef fish Management Plan. In addition, the information provided may be useful for estimating the timing of first exploitation of red snapper by the shrimp fishery.

## Materials and Methods

Fishing catch data were obtained from two sources: The commercial shrimp fleet and National Marine Fisheries Service (NMFS) resource assessment cruises. Commercial data were obtained from three Gulf of Mexico shrimp fleet monitoring projects of the NMFS Mississippi Laboratories: 1) the Domestic Observer Program; 2) the Sea Turtle Incidental Catch Project; and 3) the Shrimp Fleet By-Catch Study. In all projects,

data were collected from commercial vessels using standard shrimp trawls aboard trawlers operating in the northern Gulf.

Resource assessment data were collected on NMFS bottomfish surveys including several Southeast Area Monitoring and Assessment Program (SEAMAP) cruises. Northern and western Gulf (Fig. 1, statistical subareas 10-21) bottomfish cruises employed a stratified random sample design with samples generally taken using a standard SEAMAP 42-foot shrimp trawl with 8-foot  $\times$  40-inch doors. Infrequently, 55-foot and 70-foot nets with 10-foot  $\times$  44-inch doors also were used.

Samples were processed similarly for both data sources. At least 10 percent of the total live weight of the catch was sampled; it was then sorted and weighed by species, individuals of each species counted, and the data recorded on uniform data sheets for subsequent key-punching and computer processing. Collected data also included date, position, depth of capture, trawl headrope length, minutes fished, and time of day.

Data analysis was restricted to juvenile red snapper, as defined by Futch and Bruger (1976). These were specimens less than 1 year old (weighing less than 114 g or 1/4 pound and measuring less than 200 mm FL) and sexually immature.

Fish were not weighed individually. A mean weight per individual was computed for each sampling site by dividing total species weight by the number of specimens. This technique may occasionally be misrepresentative because juveniles caught with many large fish may not have been counted, and some adults

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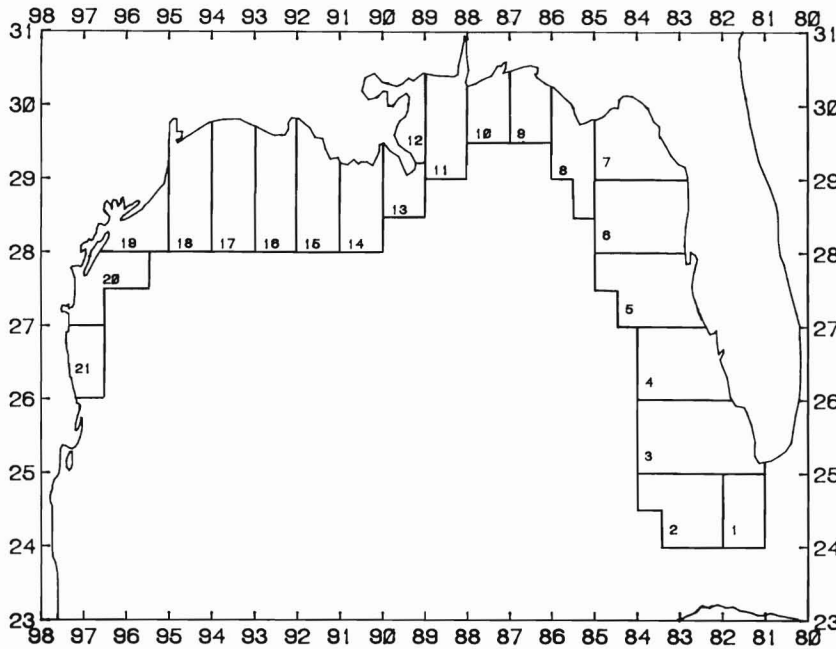


Figure 1.—Statistical subareas in the U.S. Gulf of Mexico used for reporting shrimp landings and effort (in Patella, 1975, after Kutkuhn, 1962).

taken with many juveniles may have been included inadvertently. Frequency of this type misrepresentation remains unknown but was probably not substantial, as catches usually consisted of one size class.

Two estimates were computed to indicate relative abundance: 1) Number of fish per hour of trawling and 2) number of fish per hectare. The number of fish per hour of trawling was determined by dividing the number of fish caught by the number of hours fished. This method assumes a linear relationship between the number of fish caught and number of hours fished (i.e., in a given location, twice as many fish are caught in a 2-hour tow as a 1-hour tow with the same net). The number of fish per hectare was determined by dividing the number of fish caught by the number of hectares swept by the trawl. The number of hectares swept was computed using a modification of the method of Roe (1969):

$$ha = \frac{6,076.12 K \times H \times 0.67 L}{107,640}$$

where  $K$  is the vessel speed in knots

(6,076.12 feet = 1 n.mi.);  $H$  is the number of hours fished;  $L$  is the headrope length in feet, 0.67 is a constant (an average horizontal trawl opening is about 67 percent of the headrope length<sup>1</sup>); and a hectare ( $ha$ ) = 107,640 square feet. This formula assumes an equal catchability coefficient for snapper regardless of trawl size.

Data were analyzed similarly for both sources. Indices of relative abundance were summarized by depth, month, year, time of day, and statistical subareas. These subareas were those used in reporting Gulf Coast Shrimp Data (GCSD) and are illustrated in Figure 1 (Patella, 1975). Surface area in hectares for statistical subareas have been computed and reported by Patella, 1975.

Mean numbers of fish per hour and hectare were multiplied by shrimping effort and area in hectares, respectively, to develop catch estimates. Effort data published in GCSD represent interviewed craft only and do not reflect total effort. As about one-third of the shrimp fleet

was interviewed<sup>2</sup>, the number of days fished was multiplied by three to represent total fleet days fished.

The number of hours fished was estimated by multiplying days fished by 24. Where effort data were not available for subareas, months or depths, effort was estimated from available landings and effort information in adjacent subareas. Effort data by statistical subareas were then used as the base effort estimate for computational purposes. These effort data were used because of their similarity to the effort data reported in the GMFMC Shrimp Management Plan, October 1979 (4,717,368 hours, effort summation by statistical subarea vs. 4,596,307 hours, effort reported in GMFMC Shrimp Management Plan, October 1979).

No adjustments were made to compensate for differences in the size of trawl nets used by the commercial shrimp fleet. Relating catch per unit effort (CPUE) to a standard trawl net size would not provide useful information because the CPUE reported in GCSD Report is not similarly standardized. Since commercial data for this study were obtained from the shrimp fleet, we assumed the various net sizes sampled adequately represented those of the entire fleet. The estimated number of fish per hectare does compensate for net size as headrope length was included in the formula for the area swept by the trawl.

## Results

Commercial data for 1972 through 1981 included a 10-year total of 2,856 stations, fished for 11,665.3 hours (Table 1). Fishing effort for 1972, 1973, 1974, and 1979 was less than 100 hr yearly, while all other years ranged from 401.3 to 4,821.9 hr, with a mean of 1,926.7 hr (Table 1). Monthly commercial fishing effort ranged from 345.0 to 2,681.7 hr (Table 2) and hourly data ranged from 139.2 to 1,143.9 hr (Table 3). Depths to 50 fm were fished, with 98% of the commercial effort at less than 30 fm (Table 4). Data were also separated into statistical subareas (Table 5),

<sup>1</sup>John Watson, NMFS Pascagoula Laboratory, Pascagoula, Miss. Personal commun.

<sup>2</sup>Guy Davenport, Fishery Information Management Division (FIMD), NMFS Miami Laboratory, Miami, Fla. Personal commun.

with only subareas 5, 9, and 10 showing no commercial fishing effort. Fewer than 100 hours were fished in subareas 6, 7, and 8, and effort in the other subareas ranged from 102.2 to 2,198.8 hours.

Resource assessment data for 1972 through 1983 included a 12-year total of 17,589 stations, fished for 3,630.5 hours (Table 1). Total hours fished per year ranged from 125.6 to 817.0 hours, by

month from 42.2 to 817.0 hours (Table 2), and by hour from 94.0 to 225.7 (Table 3). Depths from 5 to 50 fm were sampled, with 81 percent of the effort expended at depths of 30 fm or less (Table 4). Effort data by statistical subareas for resource assessment cruises are listed in Table 5 and show most effort expended between Mobile Bay, Ala. (subarea 11) to Morgan City, La. (subarea 15).

Data collected from both commercial and resource assessment cruises indicated red snapper was the major snapper species caught by trawls in the U.S. Gulf of Mexico (Table 6). The gray snapper, *L. griseus*, was the only other shallow-water snapper captured by commercial shrimp trawlers. Lane snappers, *L. synagris*, were generally taken by trawlers outside the depth range of juvenile red snapper. They were most frequently caught between Tampa and Tortugas, Fla., on live sponge bottom areas which were not extensively fished by the commercial shrimp fleet. Other snappers infrequently caught included the yelloweye, *L. vivanus*, and blackfin, *L. buccanella*, but they were caught in deep water well outside the depth range of juvenile red snapper.

Some data from the Shrimp Fleet By-Catch Study were judged questionable because of small sample size. From 1972 to 1974, and in 1979, little fishing occurred, with only 6, 29, 69 and 1 hours fished in each year, respectively. Annually, juvenile red snapper were caught by commercial shrimpers at a mean rate of 8 percent of the stations sampled per year (range, from 0 to 19 percent of the stations). The resource assessment data provided a better picture of the susceptibility of juvenile red snapper to trawling gear, probably because of the survey's random selection of stations rather than the directed sampling of the commercial fleet. Juvenile red snapper were caught at a mean rate of 20 percent of the resource assessment stations sampled per year (range, from 8 to 41 percent of the stations).

Initial total annual estimates of juvenile red snapper caught by the U.S. Gulf shrimp fleet were highly variable among years, ranging from 2.2 to 44.2 million

Table 1.—Annual summary statistics of juvenile red snapper captured in the Gulf of Mexico by NMFS resource assessment surveys from 1972 to 1983 and by commercial shrimp trawlers from 1972 to 1981.

Year	No. of stations	Hours fished	Frequency of occurrence	No. of individuals	Wt. (kg)	No. per hour	Kg per hour	No. per hectare	Mean wt. per individual (g)	Mean length of head-rope (ft)
Resource survey data										
1972	700	125.6	287	4,224	100.2	33.622	0.798	6.942	23.6	42.7
1973	1,184	204.9	229	1,341	41.3	6.544	0.201	1.400	30.8	41.2
1974	2,398	464.5	190	1,266	39.0	2.725	0.084	0.601	30.8	40.0
1975	2,300	508.6	317	2,383	71.2	4.686	0.140	0.945	29.9	43.7
1976	2,368	543.2	280	2,273	85.7	4.184	0.158	0.895	37.6	41.2
1977	1,346	383.4	272	2,439	88.4	6.362	0.231	1.361	36.3	41.2
1978	1,094	182.3	137	2,803	146.5	15.379	0.804	3.388	52.2	40.0
1979	765	127.8	157	829	15.9	6.485	0.124	1.429	19.1	40.0
1980	1,627	324.5	439	3,631	83.0	11.190	0.256	2.465	22.7	40.0
1981	1,636	338.2	396	3,688	117.3	10.905	0.347	2.403	31.8	40.0
1982	1,505	293.2	370	3,210	132.0	10.949	0.450	2.412	41.3	40.0
1983	666	134.3	79	420	26.4	3.127	0.196	0.689	62.6	40.0
Commercial data										
1972	11	5.9	0	0	0.0	0.000	0.000	0.000	0.00	45.5
1973	27	29.2	4	274	22.7	9.384	0.776	1.838	82.5	45.0
1974	99	68.8	13	138	8.2	2.007	0.119	0.395	59.0	44.8
1975	119	401.3	7	186	15.4	0.464	0.038	0.071	83.0	57.5
1976	395	1,436.4	27	2,943	190.1	2.049	0.132	0.401	64.4	45.0
1977	316	1,419.2	20	1,197	0.0	0.843	0.000	0.000	0.0	53.9
1978	1,049	4,821.9	34	2,459	113.1	0.510	0.024	0.076	45.8	57.2
1979	2	1.0	0	0	0.0	0.000	0.000	0.000	0.0	40.0
1980	598	2,357.2	66	3,867	142.2	1.640	0.060	0.208	36.7	69.5
1981	240	1,124.4	46	2,509	144.3	2.231	0.128	0.273	57.6	72.2

Table 2.—Monthly summary statistics of juvenile red snapper captured in the Gulf of Mexico by NMFS resource assessment surveys from 1972 to 1983 and by commercial shrimp trawlers from 1972 to 1981.

Year	No. of stations	Hours fished	Frequency of occurrence	No. of individuals	Wt. (kg)	No. per hour	Kg per hour	No. per hectare	Mean wt. per individual (g)	Mean length of head-rope (ft)
Resource survey data										
Jan.	1,098	185.6	133	1,073	42.6	5.781	0.230	1.274	39.9	40.0
Feb.	253	42.2	34	229	6.2	5.420	0.146	1.196	26.8	40.0
Mar.	1,492	302.0	204	1,859	79.5	6.156	0.263	0.166	42.6	40.3
Apr.	1,957	339.7	257	1,448	63.0	4.263	0.186	0.842	43.5	44.6
May	319	71.6	59	378	10.0	5.278	0.139	1.163	26.3	40.0
June	1,737	380.5	153	1,815	65.9	4.770	0.173	1.048	36.3	40.1
July	1,066	255.9	87	757	46.8	2.958	0.183	0.634	61.7	41.1
Aug.	932	208.5	72	503	11.3	2.413	0.054	0.532	22.7	40.0
Sept.	724	353.1	254	3,393	69.9	9.610	0.198	1.942	20.4	43.6
Oct.	3,016	571.2	797	9,022	327.2	15.794	0.573	3.446	36.3	40.4
Nov.	4,626	817.0	1,048	7,744	218.4	9.478	0.267	2.083	28.1	40.1
Dec.	369	103.2	55	286	6.4	2.770	0.062	0.576	22.2	42.4
Commercial data										
Jan.	64	345.0	0	0	0.0	0.000	0.000	0.000	0.0	63.2
Feb.	122	589.2	2	12	0.5	0.020	0.001	0.003	45.4	63.1
Mar.	67	354.7	4	49	3.0	0.138	0.009	0.018	62.1	68.7
Apr.	103	597.9	0	0	0.0	0.000	0.000	0.000	0.0	59.0
May	142	588.9	4	127	5.6	0.216	0.010	0.034	44.5	55.2
June	200	724.8	4	68	3.4	0.094	0.005	0.014	50.8	59.8
July	317	800.0	34	1,782	104.5	2.227	0.131	0.338	58.5	58.1
Aug.	203	741.9	36	1,476	87.2	1.989	0.117	0.328	59.0	53.5
Sept.	488	1,623.0	33	2,065	52.9	1.272	0.033	0.188	25.6	59.5
Oct.	563	2,681.7	49	4,216	163.9	1.572	0.061	0.236	39.0	58.8
Nov.	373	1,728.3	28	2,553	166.6	1.477	0.097	0.224	65.3	58.0
Dec.	214	890.0	23	1,225	48.2	1.376	0.054	0.226	39.5	53.7

**Table 3.—Hourly summary statistics of juvenile red snapper captured in the Gulf of Mexico by NMFS resource assessment surveys from 1972 to 1983 and by commercial shrimp trawlers from 1972 to 1981.**

Time of day	No. of stations	Hours fished	Frequency of occurrence	No. of individuals	Wt. (kg)	No. per hour	Kg per hour	No. per hectare	Mean wt. per individual (g)	Mean length of head-rope (ft)
<b>Resource survey data</b>										
0100	816	211.2	143	1,270	35.2	6.014	0.166	1.287	27.7	41.2
0200	795	196.9	159	1,825	72.2	9.269	0.367	1.988	39.5	41.1
0300	736	170.1	153	1,366	42.8	8.031	0.252	1.730	31.3	40.9
0400	750	159.5	155	1,264	30.7	7.924	0.192	1.716	24.0	40.7
0500	769	147.2	157	1,527	52.4	10.374	0.356	2.252	34.5	40.6
0600	691	123.5	129	1,029	28.3	8.335	0.229	1.804	27.7	40.7
0700	714	121.3	110	714	20.3	5.885	0.167	1.275	28.6	40.7
0800	709	121.9	116	719	19.9	5.898	0.163	1.284	27.7	40.5
0900	650	110.3	108	702	20.7	6.363	0.188	1.382	29.5	40.6
1000	678	114.9	105	1,714	91.9	14.915	0.800	3.238	53.5	40.6
1100	688	120.1	119	754	30.0	6.277	0.249	1.359	39.9	40.7
1200	657	113.6	98	573	19.0	5.045	0.167	1.090	33.1	40.8
1300	643	113.5	88	980	41.5	8.637	0.366	1.874	42.2	40.6
1400	644	111.3	95	680	19.5	6.108	0.175	1.320	28.6	40.8
1500	676	118.4	110	575	14.6	4.856	0.123	1.049	25.4	40.8
1600	671	118.7	116	809	29.6	6.814	0.249	1.479	36.7	40.6
1700	523	94.0	89	545	15.4	5.797	0.164	1.259	28.1	40.6
1800	786	148.9	140	1,311	36.8	8.807	0.247	1.883	28.1	41.2
1900	728	153.2	125	971	47.8	6.340	0.312	1.362	49.4	41.0
2000	847	225.7	161	1,628	40.3	7.215	0.179	1.524	24.9	41.7
2100	886	209.5	175	1,810	49.2	8.640	0.235	1.848	27.2	41.2
2200	876	218.5	181	2,001	61.5	9.159	0.282	1.954	30.8	41.3
2300	855	223.7	180	2,279	91.1	10.188	0.407	2.174	39.9	41.3
2400	801	184.8	141	1,461	36.1	7.907	0.195	1.695	24.9	41.1
<b>Commercial data</b>										
0100	133	655.4	17	1,791	86.8	2.733	0.132	0.427	48.5	56.4
0200	187	790.5	16	1,606	69.9	2.032	0.088	0.348	43.5	51.5
0300	124	466.9	4	160	1.9	0.343	0.004	0.051	11.8	59.5
0400	76	221.0	6	67	2.5	0.303	0.011	0.045	37.2	59.6
0500	37	139.2	1	22	0.0	0.158	0.000	0.021	0.0	67.2
0600	128	472.4	12	378	15.0	0.800	0.032	0.112	39.5	62.9
0700	250	871.9	9	271	11.9	0.311	0.014	0.045	44.0	60.8
0800	126	527.1	8	251	11.1	0.476	0.021	0.072	44.0	58.4
0900	90	323.2	4	116	3.7	0.359	0.011	0.053	32.2	59.5
1000	96	342.0	1	10	0.4	0.029	0.001	0.004	45.4	57.0
1100	86	336.8	4	42	2.9	0.125	0.009	0.018	68.0	59.9
1200	104	422.9	0	0	0.0	0.000	0.000	0.000	0.0	62.0
1300	88	350.3	3	242	15.0	0.691	0.044	0.104	64.0	58.7
1400	62	213.7	4	576	12.1	2.695	0.056	0.420	20.9	56.6
1500	49	197.3	0	0	0.0	0.000	0.000	0.000	0.0	58.5
1600	30	145.1	2	241	2.1	1.661	0.014	0.240	8.6	61.1
1700	64	358.7	3	62	5.0	0.173	0.014	0.023	81.2	65.2
1800	134	800.3	19	1,890	100.9	2.362	0.126	0.364	53.5	57.2
1900	163	875.8	20	1,127	57.6	1.287	0.066	0.202	51.3	56.2
2000	269	1,143.9	33	2,297	130.3	2.008	0.114	0.297	56.7	59.6
2100	207	737.2	22	1,473	62.9	1.998	0.085	0.333	42.6	52.9
2200	91	258.4	11	393	27.8	1.521	0.108	0.235	70.8	57.1
2300	99	297.1	6	319	7.3	1.074	0.024	0.167	22.7	56.6
2400	163	718.3	12	239	8.3	0.333	0.012	0.047	34.9	61.9

**Table 4.—Depth summary statistics of juvenile red snapper captured in the Gulf of Mexico by NMFS resource assessment surveys from 1972 to 1983 and by commercial shrimp trawlers from 1972 to 1981.**

Depth in fathoms	No. of stations	Hours fished	Frequency of occurrence	No. of individuals	Wt. (kg)	No. per hour	Kg per hour	No. per hectare	Mean wt. per individual (g)	Mean length of head-rope (ft)
<b>Resource survey data</b>										
0-10	5,227	948.0	460	4,279	147.5	4.513	0.156	0.990	34.5	40.2
11-20	5,728	1,230.7	1,681	16,898	517.9	13.731	0.421	2.874	30.6	42.1
21-30	3,424	771.7	805	5,857	212.7	7.589	0.276	1.652	36.3	40.5
31-40	2,181	498.8	179	1,381	65.8	2.768	0.132	0.604	47.6	40.4
41-50	1,027	180.9	28	92	3.2	0.508	0.018	0.111	34.8	40.3
<b>Commercial data</b>										
0-10	1,752	6,951.8	62	3,213	114.3	0.462	0.016	0.065	35.6	62.6
11-20	786	3,399.1	132	8,918	457.3	2.624	0.135	0.462	51.3	50.1
21-30	258	1,096.8	23	1,442	64.4	1.315	0.059	0.212	44.7	54.7
31-40	58	216.9	0	0	0.0	0.000	0.000	0.000	0.0	60.1
41-50	2	0.7	0	0	0.0	0.000	0.000	0.000	0.0	55.0

individuals. These estimates were calculated by multiplying the mean annual shrimping effort (4,717,368 hours) by the lowest (0.46) and highest (9.38) annual CPUE values from the commercial discard data (Table 1). This variability probably resulted from different levels of fishing effort within specific areas in the Gulf. Less variable estimates of the catch were obtained by calculating estimates separately for each state before combining them into a total estimate (Table 7).

Fewer juvenile red snapper were caught from January through June, with most taken from September to November (Table 2 and Figure 2). More juvenile red snapper were caught during resource assessment cruises throughout the year than on commercial shrimping trips. This difference probably reflected methodology differences in (random sampling vs. directed fishing) rather than seasonal distribution patterns.

Juvenile red snapper were captured in all months except January and April on commercial shrimp trawlers. The greatest catches by both commercial shrimpers and during resource assessment cruises were from September through November (Table 2 and Figure 2). The frequency of monthly juvenile red snapper captures from the commercial shrimp discard data ranged from 0 to 18 percent of the stations occupied with a mean of 6 percent. Resource assessment data, however, indicated a broader distribution of juveniles, with frequency of capture ranging from 8 to 35 percent of the stations occupied, and a mean of 16 percent.

Estimated monthly catches of juveniles are shown in Table 8, with means summed to obtain an annual estimate. Monthly captures based on commercial shrimp discard data were highest from July through November, and lowest from January through April (Table 8).

Analysis of the commercial shrimp trawler data by statistical subarea showed most captures off Texas and least off the west coast of Florida (Table 5 and Figure 3). Although considerable effort was expended in subareas 1 through 4, representing 93 percent of the total Florida commercial shrimping effort, few juve-

**Table 5.—Summary statistics by subarea of juvenile red snapper captured in the Gulf of Mexico by NMFS resource assessment surveys from 1972 to 1983 and by commercial shrimp trawlers from 1972 to 1981.**

Stat. subarea	No. of stations	Hours fished	Frequency of occurrence	No. of individuals	Wt. (kg)	No. per hour	Kg per hour	No. per hectare	Mean wt. per individual (g)	Mean length of head-rope (ft)
<b>Resource survey data</b>										
1	0	0.0	0	0	0.0	0.000	0.000	0.000	0.0	0.0
2	42	33.7	1	10	0.0	0.297	0.000	0.047	0.0	55.2
3	39	6.5	0	0	0.0	0.000	0.000	0.000	0.0	40.0
4	39	6.5	0	0	0.0	0.000	0.000	0.000	0.0	40.0
5	49	8.2	0	0	0.0	0.000	0.000	0.000	0.0	40.0
6	85	14.1	0	0	0.0	0.000	0.000	0.000	0.0	40.0
7	50	8.3	0	0	0.0	0.000	0.000	0.000	0.0	40.0
8	25	4.5	0	0	0.0	0.000	0.000	0.000	0.0	40.0
9	67	14.1	2	6	0.4	0.424	0.032	0.093	75.7	40.0
10	413	70.7	65	349	8.6	4.935	0.122	1.088	24.5	40.0
11	6,095	1,165.6	1,543	15,059	447.2	12.919	0.384	2.731	29.5	41.7
12	208	34.5	3	5	0.1	0.145	0.003	0.032	18.1	40.0
13	2,061	363.3	201	1,266	38.4	3.485	0.106	0.766	30.4	40.1
14	4,081	727.8	610	5,872	263.5	8.069	0.362	1.756	44.9	40.5
15	2,740	784.2	331	2,152	51.5	2.744	0.066	0.588	24.0	41.1
16	421	77.3	104	728	26.3	9.418	0.340	2.075	36.3	40.0
17	288	83.0	59	519	19.2	6.253	0.231	1.378	37.2	40.0
18	269	64.0	81	1,138	46.4	17.777	0.726	3.918	40.8	40.0
19	147	37.8	43	512	14.2	13.533	0.375	2.984	27.7	40.0
20	127	38.1	57	481	12.2	12.608	0.321	2.782	25.4	40.0
21	217	55.9	42	371	18.1	6.639	0.325	1.462	49.0	40.0
<b>Commercial data</b>										
1	36	102.2	0	0	0.0	0.000	0.000	0.000	0.0	67.5
2	125	490.5	1	9	0.0	0.018	0.000	0.003	0.0	57.0
3	24	115.0	0	0	0.0	0.000	0.000	0.000	0.0	57.9
4	81	194.1	6	164	0.0	0.845	0.000	0.139	0.0	53.6
5	0	0.0	0	0	0.0	0.000	0.000	0.000	0.0	0.0
6	16	43.5	0	0	0.0	0.000	0.000	0.000	0.0	60.0
7	4	5.6	0	0	0.0	0.000	0.000	0.000	0.0	43.0
8	15	18.0	0	0	0.0	0.000	0.000	0.000	0.0	45.7
9	0	0.0	0	0	0.0	0.000	0.000	0.000	0.0	0.0
10	0	0.0	0	0	0.0	0.000	0.000	0.000	0.0	0.0
11	162	502.4	12	273	21.0	0.543	0.042	0.077	77.1	62.2
12	62	187.1	2	17	1.0	0.091	0.005	0.010	58.5	82.2
13	209	579.8	30	1,350	56.8	2.328	0.098	0.357	42.2	57.4
14	113	385.4	3	129	7.3	0.335	0.019	0.032	56.2	61.2
15	295	957.7	6	188	4.0	0.196	0.004	0.028	21.3	61.3
16	188	921.6	15	263	13.6	0.285	0.014	0.038	51.7	66.6
17	172	746.5	8	421	36.2	0.564	0.048	0.079	86.2	63.2
18	514	2,198.8	17	1,459	100.8	0.664	0.046	0.095	68.9	61.6
19	344	1,637.5	43	2,772	142.2	1.693	0.087	0.246	51.2	60.7
20	348	1,847.3	51	4,148	184.3	2.245	0.100	0.461	44.4	42.9
21	140	740.3	23	2,380	68.7	3.379	0.097	0.662	29.0	45.0

**Table 6.—Species of snapper captured by NMFS resource assessment surveys, 1972-83, and by commercial shrimp trawlers in the Gulf of Mexico, 1972-81.**

Species	Commercial		Resource	
	No. of individuals	Percent of total	No. of individuals	Percent of total
Red snapper, <i>L. campechanus</i>	45,487	98	115,168	91
Lane snapper, <i>L. synagris</i>	942	2	10,788	9
Gray snapper, <i>L. griseus</i>			336	

**Table 7.—Mean annual estimate of juvenile red snapper caught by commercial shrimpers in the U.S. Gulf of Mexico from 1972 to 1981. Estimates are based on (NMFS, FIMD) reports of average hours fished off identified states, multiplied by the mean number caught per hour by the commercial fleet operating off the respective states.**

State	Total hours fished	Mean catch (no./hr.)	No. of individuals caught
Florida	707,605	0.096	67,390
Alabama/Miss.	330,215	0.211	69,676
Louisiana	2,169,989	0.742	1,610,132
Texas	1,509,558	1.995	3,011,568
Total	4,717,368		4,759,306

nile red snapper were caught.

Across the Gulf within statistical subareas, the frequency of red snapper occurrence in commercial catches ranged from 0 to 16 percent. Mean frequency of occurrence by state area was as follows: Florida, 0.9 percent; Alabama and Mississippi combined, 3.4 percent; Louisiana, 6.5 percent; and Texas, 11.7 percent. Florida (subareas 1 to 9), in which 15.0 percent of the total commercial shrimping effort was expended, yielded only 1.4 percent of the juvenile red snapper catch, probably reflecting the paucity of suitable trawling areas. Total effort and juvenile red snapper catch from commercial shrimp trawlers was also low off

**Table 8.—Mean monthly estimates of juvenile red snapper caught in the U.S. Gulf of Mexico by commercial shrimp trawlers from 1972 to 1981. Estimates were calculated using mean number caught per hour of trawling multiplied by the reported interviewed shrimping effort (NMFS, FIMD). Shrimp days were based on interviewed craft; therefore, final estimates were multiplied by 3 to reflect total effort and catch.**

Month	Inshore (0-20 fm)		Offshore (20+ fm)		Total		Estimated numbers	
	Shrimp days	Percent effort	Shrimp days	Percent effort	Shrimp days	Percent effort	Mean number red snapper per hour	Number caught
January	1,298	2.3	746	8.2	2,044	3.1	0.00	0
February	1,298	2.3	818	9.0	2,116	3.2	0.02	1,016
March	1,580	2.8	646	7.1	2,226	3.4	0.14	7,479
April	2,144	3.8	446	4.9	2,590	4.0	0.00	0
May	6,320	11.2	464	5.1	6,784	10.3	0.22	35,820
June	8,407	14.9	246	2.7	8,653	13.2	0.09	18,690
July	6,094	10.8	500	5.5	6,594	10.1	2.23	352,911
August	6,658	11.8	1,073	11.8	7,731	11.8	1.99	369,232
September	6,884	12.2	1,137	12.5	8,021	12.2	1.27	244,480
October	7,335	13.0	891	9.8	8,226	12.6	1.57	309,956
November	5,586	9.9	1,073	11.8	6,659	10.2	1.48	236,528
December	2,821	5.0	1,046	11.5	3,867	5.9	1.38	128,075
Total	169,275		27,258		196,533			5,112,561
Percent	86		14					

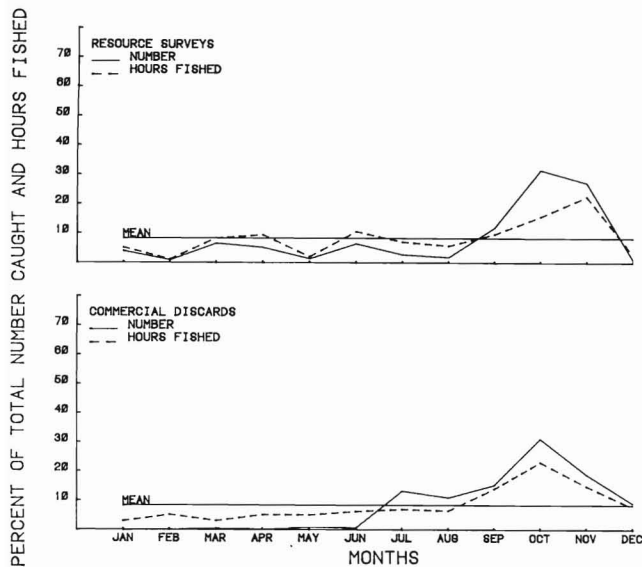


Figure 2.—Monthly catch of juvenile red snapper and sampling effort expressed as percentage of the total number caught and hours fished for commercial discard and resource assessment data; mean value represents average percent of total number caught for all months.

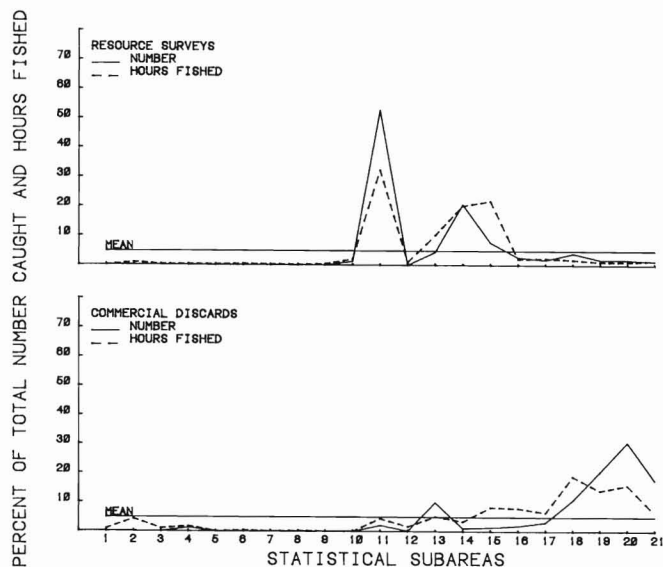


Figure 3.—Catch of juvenile red snapper and sampling effort by statistical subareas expressed as percentage of the total number caught and hours fished for commercial discard and resource assessment data; mean value represents average percent of total number caught for all statistical subareas.

Table 9.—Mean inshore-offshore estimates of juvenile red snapper caught within statistical subareas by commercial shrimp trawlers in the U.S. Gulf of Mexico from 1972 to 1981. Estimates were calculated using mean number caught per hour of trawling multiplied by the reported interviewed shrimping effort (NMFS, FIMD). Shrimp days were based on interviewed craft; therefore, final estimates were multiplied by 3 to reflect total effort and catch.

Statistical subarea	Inshore (0-20 fm)			Offshore (20+ fm)			Combined in-offshore
	Shrimping days	No. of red snapper/hr	Total no. caught	Shrimping days	No. of red snapper/hr	Total no. caught	Total no. caught
1	243	0.00	0	2	0.00	0	0
2	4,003	0.02	1,921	452	0.02	217	2,138
3	2,255	0.00	0	27	0.00	0	0
4	930	0.85	18,972	28	0.85	562	19,534
5	554	0.00	0	4	0.00	0	0
6	544	0.00	0	0	0.00	0	0
7	549	0.00	0	7	0.00	0	0
8	439	0.00	0	11	0.00	0	0
9	51	0.00	0	2	0.00	0	0
10	555	0.00	0	16	0.00	0	0
11	2,487	0.54	32,232	68	0.54	885	33,117
12	1,266	0.09	2,735	5	0.09	13	2,748
13	5,140	2.33	287,403	1383	2.33	77,313	364,716
14	7,601	0.34	62,027	490	0.34	4,001	66,028
15	6,982	0.20	33,514	855	0.20	4,102	37,616
16	3,544	0.29	24,668	810	0.29	5,639	30,307
17	3,292	0.56	44,241	36	0.56	488	44,729
18	5,020	0.66	79,520	830	0.66	13,140	92,660
19	6,456	1.69	261,868	1,219	1.69	49,449	311,317
20	2,461	2.25	132,890	1,332	2.25	71,950	204,840
21	2,054	3.38	166,616	1,516	3.38	122,974	289,590
Total	169,728		3,445,821	27,279		1,052,199	4,498,020
Percent	77			23			

Alabama and Mississippi. In this area, 7 percent of the Gulf commercial shrimp-

ing effort was expended but only 1.5 percent of the juveniles were caught. Com-

mercial shrimping effort east of the Mississippi River delta represented 22.0 percent of the total Gulf effort, but yielded only 3.0 percent of the juvenile red snapper catch.

West of the Mississippi Delta, juvenile red snapper were taken primarily in subareas 13 (Louisiana) and 19 to 21 (Texas) by commercial shrimp trawlers (Fig. 3). Commercial shrimping effort off Louisiana represented 46 percent of the total Gulf effort, where 34 percent of the juvenile red snappers were caught. Texas shrimpers caught 63 percent of the juveniles, but expended only 32 percent of the total shrimping effort (Tables 7 and 9). Resource assessment data also showed that the highest densities of red snapper (mean number of juveniles per hectare) were west of the delta, primarily off Texas (Table 5 and Figure 4).

Within subareas, differences also were noted between inshore (0-20 fm) and offshore (20+ fm) depths (Table 9). The highest inshore and offshore estimates of juveniles were off Texas (56 and 73 percent, respectively, of the total estimated numbers caught). Juvenile red snapper

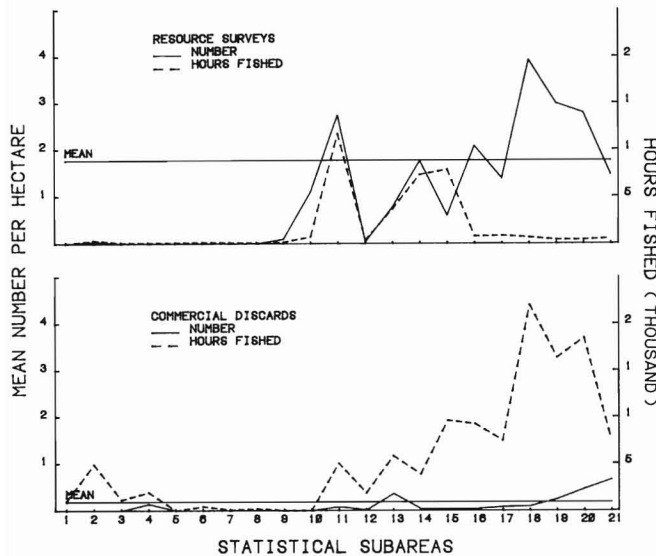


Figure 4.—Catch of juvenile red snapper and sampling effort by statistical subareas expressed as mean number per hectare (density) and hours fished for commercial discard and resource assessment data; mean catch represents average number caught for all statistical subareas.

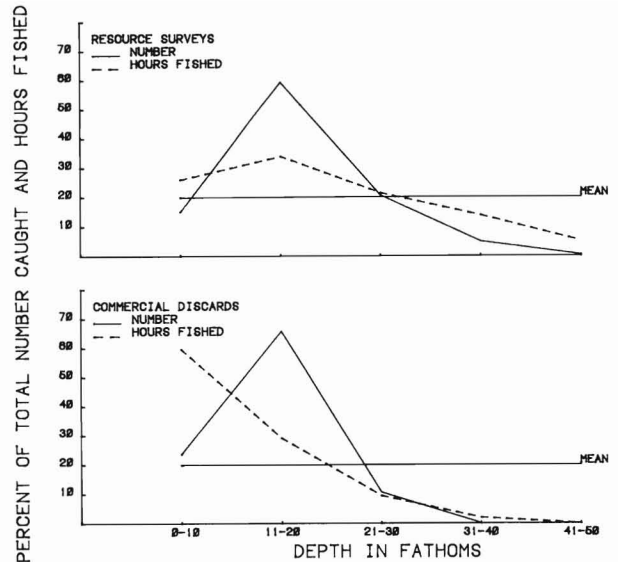


Figure 5.—Catch of juvenile red snapper and sampling effort by depth expressed as percentage of the total number caught and hours fished for commercial discard and resource assessment data; mean catch represents average percent of total number caught for all depths.

abundance by depth zone was greatest in 11-20 fm in both commercial shrimp discards and resource assessment data (Table 4 and Figure 5). Juveniles were not caught at depths greater than 31 fm by commercial shrimp vessels, and at these depths they represented only 5 percent of the total resource assessment catch. Commercial shrimp discard data showed 66 percent of the snapper were caught in 11-20 fm, but only 29 percent of the effort was expended in this stratum. Resource assessment data showed a similar pattern, with 59 percent of the individuals and 34 percent of the effort expended in 11-20 fm. Both commercial shrimp discard and resource assessment data showed the highest frequency of occurrence in the 11-20 fm depth range with the second highest in 21-30 fm, followed by the 0-10 fm range. Few juveniles were caught at other depths.

Hourly captures of juveniles based on resource assessment data were fairly uniform throughout the day. Commercial hourly catches, however, were larger at night (Table 3) due in part to hourly differences in fishing efforts (Figure 6). Fre-

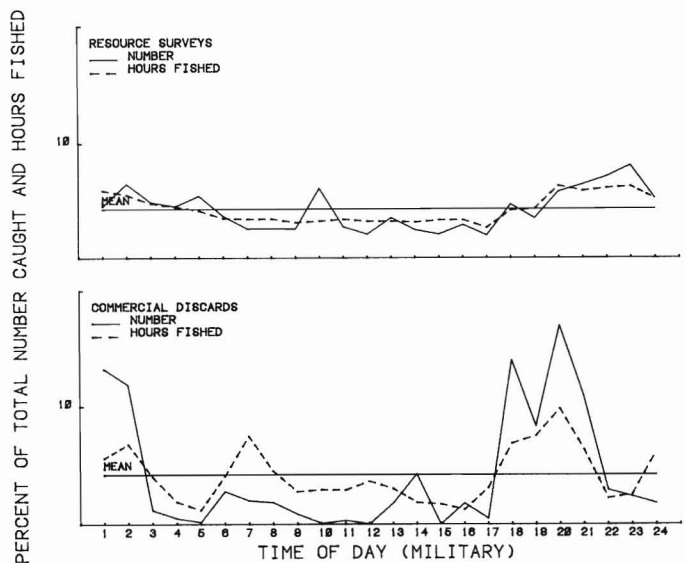


Figure 6.—Catch of juvenile red snapper and sampling effort by hour expressed as percentage of the total number caught and hours fished for commercial discard and resource assessment data; mean catch represents average percent of total number caught for all hours.

quency of occurrence for hourly catches of juvenile red snapper ranged from 14 to 21 percent, with a mean of 18 percent in the resource assessment data; whereas, the commercial shrimp discard data showed a range from 0 to 14 percent, with a mean of 6 percent.

### Discussion

Results of this study generally agree with previous estimates of the catch of juvenile red snapper in the Gulf of Mexico. Bradley and Bryan (1976) noted that lower catch rates were recorded by commercial trawlers than by resource assessment cruises, with the mean size of red snapper on commercial trawlers seldom exceeding 200 mm FL. Juveniles were caught along the entire Texas coast, with few taken inside 10 fm or outside 35 fm. Red snapper caught on NMFS resource assessment cruises were also principally juveniles (<200 mm FL) and associated with commercial shrimping depths. This is in agreement with Bradley and Bryan's (1976) conclusion that areas of young snapper abundance coincide with shrimping grounds. Trawl surveys conducted along the Texas and Louisiana coasts (Gunter, 1945; Miller, 1965; Chittenden and McEachran, 1976; Ragan et al., 1978) recorded few, if any, red snapper taken inside 10 fm.

Juvenile red snapper appear to move offshore in colder months, returning inshore in warmer months. This pattern was noted in both the commercial shrimp discard and resource assessment cruise data (Table 10), with the most pronounced difference occurring between spring and summer cruises. During spring and fall cruises, 86 percent of the captures occurred from 11 to 30 fm, which was similar to that reported by Bradley and Bryan (1976). In summer months, 93 percent of the captures occurred at depths to 20 fm (Table 10).

Juvenile red snapper were captured during all months as reported in previous studies. The capture of juveniles 34-70 mm SL off Texas in January, March, June through October, and December (Bradley and Bryan, 1976); 60-70 mm FL off Louisiana and Mississippi in March/April; and 30-40 mm FL in October/November in this study indicates a

**Table 10.**—Juvenile red snapper caught on resource assessment surveys in the U.S. Gulf of Mexico (1972-1983) by depth. Numbers and percentages are composites from several surveys and represent fish less than 200 mm FL.

Depth (fm)	Spring		Summer		Fall	
	No.	Pct.	No.	Pct.	No.	Pct.
0-10	24	3	397	37	135	10
11-20	336	42	604	56	664	49
21-30	355	44	62	6	508	37
31-40	82	10	12	1	57	4
41-50	11	1	0	0	1	0
0-20	405	45	1,001	93	1,552	62
20+	503	55	74	7	923	38

more protracted spawning period throughout the U.S. Gulf of Mexico than reported by Mosely (1966) and Futch and Bruger (1976). Spawning peaks reported in July/August by Mosely (1966) and August/September by Futch and Bruger (1976) coincide with our capture of the highest numbers of juveniles taken from September through November (Table 2).

Estimates of the number of juvenile red snapper caught by commercial shrimp trawlers based on the commercial discard data are listed in Tables 7 to 9. Inshore catches were considerably higher than offshore catches, which agrees with the depth distribution of juvenile red snapper (Table 4). Annual catches of juvenile red snapper by the commercial shrimp trawlers were highly variable, ranging from 0.46 to 9.38 individuals per hour of trawling (Table 1). This variation was possibly due to changes in either the distribution of snapper juveniles or environmental conditions.

July through December were months of highest catch rates of juvenile red snapper on the commercial trawlers, but greatest catches on resource assessment cruises were made from September to November (Table 8 and Figure 2). Few juveniles were caught between January and April on either commercial trawlers or during resource assessment activities, but more were taken in all months during resource assessment cruises. Increased capture rates were probably a reflection of the random station selection. Similar monthly trends were reported by Bradley and Bryan (1976).

All inshore estimates of abundance,

based on CPUE, were at least 1.35 times higher than offshore estimates (Table 9). These higher inshore estimates agree with the findings of Bradley and Bryan (1976).

The only reported estimate of total juvenile red snappers captured by the U.S. commercial shrimp fleet was in the Fishery Management Plan for reef fish resources of the Gulf of Mexico (GMFMC, 1980). This estimate suggested a mean annual catch of 78 million red snapper per year and was based on NMFS resource assessment cruises off Texas, during which about 15 juvenile red snapper were caught per hour of trawling (Table 5). The CPUE value of 15 per hour was the same as that reported by Bradley and Bryan (1976) for the 16-25 fm depth range off Texas during a Texas Parks and Wildlife Department study of northwestern Gulf of Mexico marine fisheries from 1970 to 1973. However, the mean estimate for all depth ranges in that study was only 5.98 individuals per hour of trawling.

Average Texas catch rates should not be used for the entire U.S. Gulf, as they were considerably higher than for other Gulf states. Mean catch rates of individuals per hour of trawling from resource assessment data for the Gulf were: Florida, 0.08; Mississippi/Alabama, 6.00; Louisiana, 5.99; and Texas, 12.64. Resource assessment data consistently showed higher density and CPUE values than the commercial shrimp discard data (Tables 1 to 5). Mean catch rates of individual juvenile red snapper per hour of trawling from commercial discard data were: Florida, 0.096; Mississippi/Alabama, 0.211; Louisiana, 0.742; and Texas, 1.995.

Estimates of the juvenile red snapper catch reported in this paper were based on the commercial discard data which more realistically represents the commercial shrimpers catch of juvenile red snapper throughout the Gulf than that presented in the GMFMC (1980) Reefish Management Plan. A similarity between overall estimates computed by year (4.8 million individuals, Table 7), month (5.1 million, Table 8) and statistical subarea (4.5 million, Table 9), and similar inshore-offshore ratios was noted.



Large numbers of snapper are caught by sport and commercial interests off Florida; however, shrimp vessels cannot operate extensively within this habitat, and the impact of the shrimp fishery on red snapper mortality is probably minimal. The maximum impact of commercial shrimping on red snapper stocks appears to be off Texas where 63 percent of the total juvenile captures occurred. The effect of this pressure on adult populations of Gulf red snapper is unknown.

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