Occurrence and Behavior of Juvenile Red Snapper, *Lutjanus campechanus*, on Commercial Shrimp Fishing Grounds in the Northeastern Gulf of Mexico

IAN K. WORKMAN and DANIEL G. FOSTER

Introduction

The red snapper, *Lutjanus campechanus*, one of the most highly prized finfish by recreational fishermen and highly valued by commercial fishermen, has been significantly overfished in U.S. Gulf of Mexico waters. Commercial Gulf landings declined from about 7 million pounds annually between 1964 and the mid 1970's to an average of 3.2 million pounds during 1988–90 (Goodyear and Phares[1]). Efforts to reduce red snapper fishing mortality rates are now in progress (GMFMC, 1981, 1989, 1991, 1992).

In 1993, the Gulf of Mexico Fishery Management Council implemented measures to protect the red snapper by setting the commercial harvest quota at 6.0 million pounds and the recreational bag limit at 7 fish. A minimum size limit of 13 inches total length was implemented in 1984 with a proposed 16–inch limit to be implemented by 1998. The target date for restoring the stock to a 20% spawning potential ratio (SPR) is the year 2009. Accomplishing this will require reducing fishing mortality rates by as much as 50%.

Shrimp trawl bycatch has been identified as a significant source of juvenile red snapper mortality (Bradley and Bryan, 1976; Gutherz and Pellegrin, 1988). Little is known about the occurrence and habits of juvenile red snappers or the effects of environmental factors. Most of what is known has come from trawl studies (Bradley and Bryan, 1976; Gutherz and Pellegrin, 1988). These studies have shown that juveniles are seasonally very abundant on shrimp fishing grounds. They are also highly subject to capture in shrimp trawls, with an estimated 20 million caught incidentally by Gulf of Mexico shrimp trawlers in 1989 (Nichols et al.[2]).

As part of the shrimp trawl bycatch reduction studies being conducted by the NMFS Southeast Fisheries Science Center's Mississippi Laboratories, researchers are studying shrimp and fish behavior. Understanding their behavior on commercial shrimp grounds and in shrimp trawls is helping in the development of methods and mechanisms to exclude finfish from trawl catches without losing shrimp. Due to its commercial and recreational importance and the need to restore its SPR, red snapper is the subject of much of the behavior study effort. Discussed herein are the areas of occurrence identified and aspects of juvenile red snapper behavior observed in a study conducted by NMFS researchers in 1991.

Materials and Methods

The NOAA Ship *Oregon II* was used as a research platform to conduct a study of juvenile red snapper behavior in September 1991. The 53 m research fishing vessel was double-rigged with a single net on each side. The nets were 15 m four–seam semiballoon trawls (Watson et al., 1984) rigged with 2.7 × 1 m trawl doors, 73 m bridles, and tickler chains set 1.1 m shorter than the trawl footropes. One of the trawls was equipped with an experimental finfish excluder and a turtle excluder device (TED). The other was a standard trawl with a TED.

The authors are with the Pascagoula Facility, Mississippi Laboratories, Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA, P.O. Drawer 1207, Pascagoula, MS 39568-1207

ABSTRACT—Red snapper, Lutjanus campechanus, *is subject to significant overfishing in U.S. Gulf of Mexico waters, and regulations are being implemented to reduce fishing mortality and restore them to a 20% spawning potential ratio by the year 2009. One source of mortality that must be reduced to achieve this goal is the incidental capture of juvenile red snappers in shrimp,* Penaeus *spp., trawls. NOAA's National Marine Fisheries Service is conducting research to develop shrimp trawl modifications to reduce the snapper bycatch. An important part of this research is the study of juvenile red snapper behavior on commercial shrimp grounds and in relation to trawling gear.*

An area of high juvenile red snapper abundance was identified off the coast of Mississippi. Most snappers were observed around structures or objects on the bottom which they appeared to use for refuge or orientation. Those ranging over barren bottom had no apparent point of orientation. When encountered by shrimp trawls, most juvenile snappers rose above the trawl footrope and fell back into the trawl. These observations have directed research toward modifying shrimp trawls to release juvenile red snappers after entry, rather than preventing them from entering a shrimp trawl.

[1] Goodyear, C. P., and P. Phares. 1990. Status of red snapper stocks of the Gulf of Mexico, Report for 1990. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southeast Fish. Sci. Cent., Miami Lab. Contrib. (unpubl.) CRD 89/90-05, 64 p.

[2] Nichols, S., A. Shah, G. J. Pellegrin, Jr., and K. Mullin. 1990. Updated estimates of shrimp fleet bycatch in the offshore waters of the U.S. Gulf of Mexico 1972–1989. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southeast Fish. Sci. Cent., Pascagoula Lab., Aug. 1990. Unpubl. rep., 22 p.

To determine an area of red snapper concentration, a trawl survey was conducted. The survey started at a depth of 10 m off the coast of Mississippi in an area where juvenile snappers had previously been caught. It extended offshore and to the east until a zero red snapper capture was reached and southwest to the Mississippi River. The trawls were towed at 2.5–3.0 knots for one hour at each station. After each tow, juvenile snappers were removed from the standard trawl's catch and counted.

Juvenile red snapper behavior was studied using a remotely operated vehicle (ROV) and scuba divers. Operating within the area that snapper were found to occur, the ROV and divers, using diver propulsion vehicles, ran transects along the bottom in search of juvenile red snappers. Three ROV transects were conducted during day and night periods, and one diver transect was completed during a daylight period. When snappers were encountered, the ROV pilot or divers observed and recorded their behavior. Video documentation of snapper behavior was recorded using the ROV's video cameras or a diver-operated 8 mm video camera contained in an underwater housing.

Divers also studied the daytime behavior of juvenile red snappers as they were encountered by shrimp trawls. While hanging onto the footrope of the trawl, divers scanned the area ahead looking for juvenile snappers. Snapper behavior was observed and video–documented as they came under the influence of the trawl. Divers followed some of the captured snappers through the trawl and studied their behavior outside the trawl when they escaped through the finfish–excluder device.

Results

During the trawl survey, a zero red snapper capture rate was reached at an offshore depth of about 55 m and to the east at lat. 30°04'N and long. 87°35'W (Fig. 1). To the southwest, red snapper captures continued to the Mississippi River. An area measuring about 350 km^2 in 18–28 m of water off the Mississippi coast was identified as an area of high juvenile red snapper abundance. The average number of red snappers caught in that area was 153 fish/hour.

Eight ROV and four diver encounters were made along the juvenile red snapper transects (Table 1). The number of snappers occurring at each encounter ranged from one to six. Most were observed in association with structures, objects, or small burrows in the bottom. Five were observed over barren bottom with no apparent structure association. Their behavior was dependent on where they occurred. Those encountered over bottom with no relief swam away as the ROV or divers approached.

Snapper behavior around structures was dependent on structure complexity. Juvenile snappers used the more complex structures for refuge, while simple structures appeared to be used more for orientation. As the ROV or divers approached the simple structures, the snappers would swim away only to return again after a short time. Snappers that fled the ROV or divers did not exhibit a frantic escape reaction. Instead, they swam just fast enough to keep a short distance ahead of their pursuer.

From the trawl, divers observed that juvenile red snappers did little to escape as they were overtaken and captured by the trawl. A few snappers were observed going under the trawl footrope, but most rose above the footrope and fell back into the trawl. In the body of the trawl, they swam just enough to avoid contact with the passing webbing, and, as they passed through the trawl extension and into the codend, they oriented into the direction of the water flow.

In the slower water flow in the trawl codend, juvenile snappers were able to maintain position and exhibited what appeared to be an optomotor response by orienting to the trawl webbing. When experimental fish excluders were installed in the trawls, snappers would position themselves in the slower turbulent flow areas behind parts of the

Table 1.—Juvenile red snapper observed on ROV/diver transects with descriptions of bottom type.

Observer	No. of snapper	Bottom type
ROV	1	Rubble
ROV	1	Rubble
ROV	1	Sand–silt
ROV	1	Sand–silt
ROV	1	Sand–silt with squid eggs
ROV	1	Sand–silt
ROV	1	Sand–silt
ROV	1	Sand–silt with squid eggs
Diver	2	Rubble
Diver	1	Sand–silt with burrow
Diver	1	Sand–silt
Diver	6	Sand–silt with plastic bag

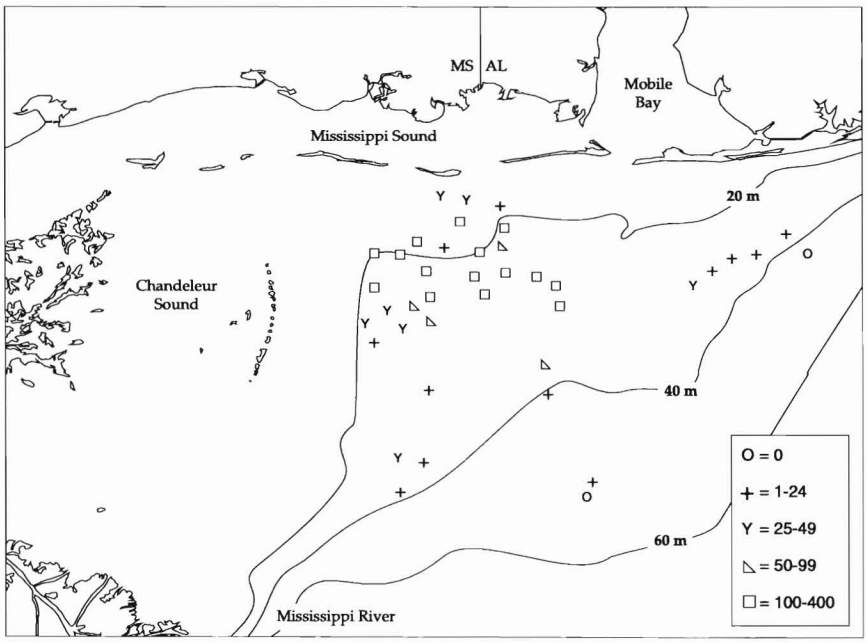

Figure 1.—Trawl survey area with number range juvenile red snappers caught at each station.

excluders. They would exit through the excluder openings if water flow was reduced to between 0.2 and 0.5 m/sec. Most of the snappers that escaped to the outside of the trawl would take up positions in areas of slow water flow such as under the chaffing gear or behind the codend and would remain there until the end of the tow.

Discussion

The area of high juvenile red snapper abundance identified in this study closely corresponds to a center of abundance identified in the northeastern Gulf by Darnell and Kleypas (1987). Their study indicated the central area of abundance was a little deeper and slightly to the east of the area we found them in. Gutherz and Pellegrin (1988) stated that "juvenile red snapper appear to move offshore in colder months, returning inshore in warmer months." This would account for the difference in the centers of abundance identified in our study and by Darnell and Kleypas (1987).

NMFS researchers tried to continue the study of juvenile red snapper behavior in the same study area at the same time of year in 1992 but were not able to find an area of high snapper abundance. This was attributed to the unseasonably low bottom–water temperature (22–24°C) that occurred through September 1992, and it would indicate that spawning success as well as inshore and offshore movements might be dependent on water temperature.

The observed behavior of juvenile red snapper on commercial shrimp grounds was helpful in directing research to reduce shrimp trawl bycatch. One of the early trawl excluder ideas was a low–opening trawl designed to fish under the major concentration of finfish. This design idea was rejected as a means of reducing juvenile snapper because of their observed response to trawling gear and their close proximity to the bottom.

Another concept was to raise the footrope to fish over them, but diver observations showed that, rather than swim downward, most juvenile snapper will rise just above the bottom parts of a trawl. Raising the footrope sufficiently high off bottom to avoid snapper would result in missing many shrimp.

Results of our study have directed research efforts toward developing trawl modifications to exclude juvenile snapper after they enter a shrimp trawl. Observations of snapper behavior in relation to water flow indicate that they will actively exit through trawl excluder openings if water flow is reduced to between 0.2 and 0.5 m/sec. Efforts are now underway to perfect a low water flow finfish excluder that will not affect shrimp production.

Acknowledgments

Special thanks go to John Watson and Charles Taylor for their observations of juvenile snapper behavior and to John Mitchell and Cliff Harper for their part in operating the ROV. Thanks are also due to the officers and crew of the NOAA Ship *Oregon II* and, for their help in reviewing this manuscript, we thank Kim Senseney, John Watson, Wil Seidel, and Scott Nichols. We also appreciate Sally Glynn's help in preparing this manuscript and James Barbour's assistance with drawings.

Literature Cited

Bradley, E., and C. E. Bryan. 1976. Life history and fishery of the red snapper (*Lutjanus campechanus*) in the northwestern Gulf of Mexico: 1970–74. Proc. Gulf Caribb. Fish. Inst. 27:77–106.

Darnel, R. M., and J. A. Kleypas. 1987. Eastern Gulf shelf bio–atlas: A study of the distribution of demersal fishes and penaeid shrimp of soft bottoms of the Continental Shelf from the Mississippi River Delta to the Florida Keys. U.S. Dep. Inter., OCS Study MMS 86–0041, 547 p.

GMFMC. 1981. Environmental impact statement and fishery management plan for the reef fish resources of the Gulf of Mexico. Aug. 1981, 154 p. Gulf Mex. Fish. Manage. Counc., Lincoln Cent., Suite 881, 5401 W. Kennedy Blvd., Tampa, FL 33609.

_____ . 1989. Amendment number 1 to the reef fish fishery management plan. Aug. 1989, 356 p. Gulf Mex. Fish. Manage. Counc., Lincoln Cent., Suite 881, 5401 West Kennedy Blvd., Suite 881, Tampa, FL 33609.

_____ . 1991. Amendment 3 to the reef fish fishery management plan for the reef fish resources of the Gulf of Mexico. Feb. 1991, 38 p. Gulf Mex. Fish. Manage. Counc., Lincoln Cent., Suite 881, 5401 West Kennedy Blvd., Tampa, FL 33609.

_____ . 1992. Draft amendment 5 to the reef fish fishery management plan for the reef fish resources of the Gulf of Mexico. Sept. 1992, 59 p. Gulf Mex. Fish. Manage. Counc., Lincoln Cent., Suite 881, 5401 West Kennedy Blvd., Tampa, FL 33609.

Gutherz, E. J., and G. J. Pellegrin. 1988. Estimate of the catch of red snapper, *Lutjanus campechanus*, by shrimp trawlers in the U.S. Gulf of Mexico. Mar. Fish. Rev. 50(1):17–25.

Watson, J. W., Jr., I. K. Workman, C. W. Taylor, and A. F. Serra. 1984. Configurations and relative efficiency of shrimp trawls employed in the southeastern United States waters. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 3, 12 p.