Red Snapper (*Lutjanus campechanus*) Associated with a Small Artificial Structure in the Mississippi Sound, a Northern Gulf of Mexico Estuary

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ABSTRACT

During September 1994 - 1997, opportunistic sampling of red snapper (*Lutjanus campechanus*) at a small, artificial structure in the Mississippi Sound estuary provided information on age, reproductive biology, diet and behavior of juvenile and adult red snapper from inshore habitat. The study represents the first detailed account of adult red snapper from a northern Gulf estuary. Red snapper (n = 302) collected from the study site ranged in size from 229 - 714 mm TL; 172 were retained for laboratory examination, and 130 were tagged and released. Age estimates for some specimens (n = 36; 326 - 713 mm TL) ranged from 2 - 5 years. Histological assessment of gonads from a small sample of fish (n = 13) collected primarily during late summer and fall (near the end of the spawning season) revealed sexually mature males (n = 5; 390 - 520 mm TL) and females with regressed ovaries (*n* = 5; 326 - 662 mm TL) or immature ovaries (n = 2; 326 and 330 mm TL). However, ovaries from a single female collected during July (during the peak of the spawning season) contained oocytes in the final oocyte maturation (FOM) stage, an indication of imminent spawning. This finding was of great interest since red snapper are reported to spawn only in offshore waters. Snapper diet consisted of fish, crustaceans and cephalopods. Anchovies (*Anchoa hepsetus* and *A.* sp.) and hardhead catfish (*Arius felis*), were the dominant prey in the diet and occurred in 54 % of stomachs. Gulf crab (*Callinectes similis*), other portunid crabs, and penaeid shrimps were the primary crustaceans in the diet. Tag-recaptures (n = 32) were from the site of tag-release only and extended from 1 - 373 days-at-large. Recaptures documented growth for fish, primarily juveniles and young adults, at the study site and suggested site fidelity and overwintering for some fish. Aspects of the perennial occurrence of adult red snapper in the Mississippi Sound estuary are discussed.

KEY WORDS: *Lutjanus campechanus*, estuarine habitat, Mississippi Sound

Asociacion del Pargo Rojo (*Lutjanus campechanus*) con una Pequeña Estructura Artificial en Mississippi Sound, un Estuario al Norte del Golfo de Mexico

Durante Septiembre 1994 - 1997, el muestreo oportuno del pargo rojo (*Lutjanus campechanus*) en una pequeña estructura artificial en el estuario de Mississippi Sound proporcionó información sobre la edad, biología reproductiva, dieta y comportamiento del pargo rojo (juvenil y adulto) en el habitat costero. Este estudio representa la primera valoracion detallada del pargo rojo adulto en un estuario al norte del Golfo. El pargo rojo (n = 302) colectado en el sitio del estudio fluctuo en tamaño entre 229 - 714 mm LT; 172 fueron conservados para ser examinados en el laboratorio, y 130 fueron marcados con etiquetas y liberados. Las estimaciones de edad para algunos especímenes (n = 36; 326 - 713 mm LT) fluctuaron entre 2 - 5 años. La examinacion histológica de las gónadas en una muestra pequeña de pescados (n = 13) colectados primordialmente a finales del verano y otoño (cerca del final de la estaciòn de desove) revelò a los machos sexualmente maduros (n = 5; 390 - 520 milímetros TL) con el esperma en los lóbulos y en el conducto espermatico y las hembras con los ovarios en regrecion (n = 5; 326 - 662 mm LT) o los ovarios inmaduros (n = 2; 326 - 330 mm LT). Sin embargo, los ovarios de una sola hembra colectada en julio (durante el pico de la estación de desove) contenia los oocitos en su etapa final de maduración (FOM), una indicación del desove inminente. Este descubrimiento fue de gran interes, particularmente debido a que el desove del pargo rojo es descrito solamente en aguas alejadas de la costa. La dieta del pargo consistió en pescados, crustàceos y cefalópodos. Pescados, sobre todo anchoas (*Anchoa hepsetus* y *A.* sp.) y el siluro de cabeza dura (*Arius felis*), fueron la presa dominante y ocurrieron en el 54 % de los estòmagos. El cangrejo azul (*Callinectes sapidus*), otras jaibas (portunidae) y camarones (penaeidae) fueron los crustàceos dominantes en la dieta. El calamar contribuyò muy poco en la dieta. Recapturas (n = 32) fueron establecidas solamente en el sitio de liberacion y fluctuo entre 1 - 373 dias de liberacion. Recapturas documentan el crecimiento de cada pez (juveniles y adultos jovenes) y sugiere no solamente coneccion a largo plazo con el sitio sino su permanencia durante el invierno. Los aspectos de la ocurrencia perenne del pargo rojo adulto en el estuario de Mississippi Sound son discutidos.

PALABRAS CLAVES: Pargo rojo, *Lutjanus campechanus*, estructura artificial

INTRODUCTION

Red snapper occur from the mid-eastern coast of the United States through the Gulf of Mexico (Gulf) to the Yucatan (Hoese and Moore 1998) and support valuable commercial and recreational fisheries throughout their range. The red snapper fishery is the most economically valuable fishery of the snapper/grouper

complex in U.S. waters of the Gulf.

The biology, ecology and behavior of red snapper from the Gulf have been recently studied by Comyns and Lyczkowski-Shultz (1993) - larvae; Render (1995), Collins et al. (1996), Woods et al. (in press) - reproduction; Szedlmayer and Shipp (1994) - habitat; and Wilson et al. (2001), Patterson (1999) and Fischer (2002) - age/growth. Life history studies of red snapper typically focused on associations with offshore artificial reefs and petroleum platforms.

Juvenile red snapper are occasionally collected in research trawl hauls and beam plankton net hauls associated with fisheries assessment and monitoring studies in the Mississippi Sound, a shallow ($\bar{x}$ depth = 3 m) northern Gulf estuary, and are collected from (1) from sea grass flats (shoal grass, *Halophia* sp.), (2) over sand-mud bottom, and (3) from Dog Keys Pass at Horn Island (IFMAP, 2001). Hastings (1979) observed that adult red snapper rarely move into coastal Gulf waters, and adult red snapper have not been reported from the Mississippi Sound.

In September 1994, we encountered an aggregation of large red snapper at a small, isolated, artificial structure within the Mississippi Sound. The inshore occurrence of large red snapper was considered uncharacteristic for this species within the region and prompted us to periodically visit the site to investigate biological and behavioral aspects of red snapper associated with the structure. Although the Mississippi Sound estuary is not considered essential habitat for red snapper, our small-scale study documented the seasonal occurrence of adult and large juvenile red snapper within inshore coastal waters of the northern Gulf.

MATERIALS AND METHODS

Study site

During fisheries sampling activities conducted September 1994 - September 1997, we investigated red snapper associated with a small artificial structure (approximately 2 m^2 in size) which we opportunistically discovered in the Mississippi Sound on 24 September 1994. The structure was located in six meters of water at Lat. 30° 14'N and Long. 88' 30°W, 3 km north of Petit Bois Island and 8 km south of the mainland (Figure 1). The structure lay on the sloping bank of a 14m-deep navigation channel, the Pascagoula Ship Channel. The structure was tentatively identified as a metallic object, however, its exact composition, profile and size were not determined. We did not dive on the site, nor did we deploy underwater cameras to photo the structure. The substrate at the site was a mixture of sand and mud. Hydrological data were recorded during research activities.

Specimen Collection

All specimens were caught by hook-and-line gear using natural and artificial baits. Two research teams (including one consisting of the authors and colleagues) participated in opportunistic field collections and the tagging of red snapper from the study site during the four year study. The authors did not have access to the

overall catch of snapper for purposes of biological sampling, but we did obtain field collection data and size data for all specimens.

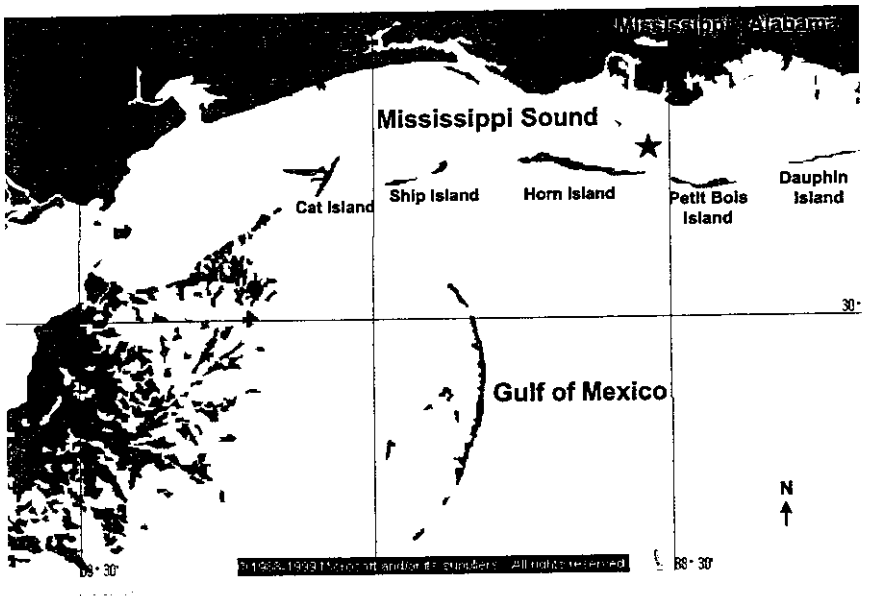

Figure 1. Map of the study area showing the Mississippi Sound and the study site location (shown by star).

Laboratory Processing and Sample Analyses

Most fish examined and sampled in the laboratory were measured (nearest 1.0 mm total length, TL), weighed (nearest 1.0 g., TW) and sexed. The gonads of some specimens were removed by other researchers prior to examination by the authors, and those fish were not sexed. All lengths are reported as TL.

Reproductive Biology — Macroscopic (gross) observations of whole gonads were recorded for a few specimens. During the summer of 1995 and late summer and fall of 1996, gonads were removed from a small number of large specimens and weighed, and a small portion of gonad tissue was placed in 10 % buffered formalin for histological assessment following Brown-Peterson et al. (2001).

Age Estimation — Sagittal otoliths were removed from a small number of specimens caught during late summer and fall of 1997. The left sagitta was processed for ageing following Franks et al. (1999). Opaque bands were counted as annuli from the core of the otolith to the edge (distal margin) of the otolith in the ventral lobe. The first opaque mark (smudge) was counted as the Age-1 mark, a decision based in part on recent red snapper research by Wilson and Nieland (2001).

Diet—Specimens collected during October and November 1994 were examined for stomach contents. Snappers were placed on ice to minimize digestive activity, and in the laboratory the contents were sorted, identified to the lowest possible taxonomic level, counted and measured volumetrically to the nearest 0.1ml by water displacement in a graduated cylinder. Bait was not included in the analyses. Prey were pooled for all stomachs and were represented as percent numeric abundance (%N), percent volume (%V), and percent frequency of occurrence (%F). Empty stomachs were excluded from calculations.

Tag-release

From October 1994 - December 1996 juvenile and adult red snapper were tagged and released by study personnel. Fish were tagged with individually numbered (1) Hallprint polypropylene dart tags with an attached streamer which contained the laboratory's phone number and mailing address, or (2) individually numbered T-bar anchor tags. Tagging date, fish length (mm, TL), condition of fish prior to release and any pertinent comments were recorded on individualized tag-release data cards. Tagged fish were re-captured during subsequent visits to the study site, and the recapture date and fish length were recorded.

Two coded acoustic tags (Sonotronics, Inc., model CT-82-3, 40-day life) were used to examine short-term movements and site fidelity. One transmitter was attached externally to an adult snapper (521 mm TL) on 9 December 1994, and another was implanted into an adult (483 mm TL) on 1 December 1995. Acoustic scans for the fish were conducted during follow-up visits to the study site.

RESULTS

From September 1994 - September 1997, 302 red snapper were collected from the study site (does not include tag-recaptures). Twenty-one (21) of 24 total visits (88 %) to the site produced red snapper. The number of fish caught during individual trips ranged from 1 - 42. The amount of time each research team spent during visits to the site varied from 0.5 - 6 hours. We did not calculate CPUE.

Red snapper caught at the site ranged from 229 - 714 mm. Of the 302 specimens collected, 172 were retained for laboratory examination, and 130 were tagged and released (see section below). Specimens retained for laboratory examination/sampling ranged from 252 - 714 mm ($\bar{x}$ = 524 mm) and 300 - 5,221g TW ($\bar{x}$ = 2,088 g). Sex was determined for 89 of those 172 specimens: males (n = 56; 326 - 713 mm, $\bar{x}$=498 mm); females (n = 33; 380 - 696 mm, $\bar{x}$=532 mm).

The majority of specimens (75 %) were caught during September (n = 54; 279 - 711 mm), October (n = 136; 229 - 714 mm) and November (n = 37; 262 - 686 mm), and others were collected during January (n = 4; 300 - 310 mm), May (n = 11; 252 - 432 mm), June (n = 7; 330 - 381 mm), July (n =12; 300 - 559 mm), August (n = 16; 287 - 622 mm) and December (n = 25; 287 - 483 mm). The largest fish were caught from August - November.

Surface and bottom water temperature at the study site ranged from 15.2 - 24.1^0

C and 16.4 - 24.2^0 C, respectively. Surface and bottom salinity ranged from 17.6 - 30.0 ‰. and 24.6 - 34.0 ‰., respectively. Water clarity (visibility) ranged from < 0.5 m (turbid) to 3.0 m (blue-green). Tide condition (i.e., flooding, high, ebbing or low) did not seem to affect the catch of red snapper.

Reproductive Condition

Gross assessments — Macroscopic assessments of gonads from snapper >430 mm collected primarily during late summer (August and September), fall and winter revealed females with small, reddish-purple, partially flaccid ovaries which appeared spent and males with small, white testes which produced small amounts of milt when squeezed. Numerous females between 275 - 430 mm had ovaries that were small and reddish in color and appeared immature (ovaries of the largest specimens may have been spent), and males between 330 - 430 mm had testes that were gray in color and appeared immature. The ovaries of one specimen (559 mm; 2,111.3g TW) caught in July 1995 appeared well developed and yellow in appearance and weighed 192.5 g. (~9 % of total body weight).

Histological assessments — Male red snapper (n = 5; 390 - 520 mm) sampled for histological assessment were caught in September (n = 1; 390 mm) and October (*n* = 4; 466 - 520 mm), 1996. All five males were sexually mature. Four of the five fish exhibited spermatogenic activity and showed spermatozoa in the lobules and the sperm ducts. One fish caught in late October had spermatozoa in the ducts, but spermatogenic activity had ceased and the testes appeared almost spent. The age of the September fish (390 mm), the only one of these males examined for age, was estimated to be two years.

Female red snapper (n = 8; 326 - 622 mm) sampled for histological assessment were collected in 1995 (July, n = 1, 559 mm; August, n = 1, 662 mm; and September, n = 4, 326 - 483 mm) and 1996 (October, n = 1, 430 mm; and December, n = 1, 330 mm). Ovaries from the July fish were well developed and exhibited final oocyte maturation (FOM), an indication of imminent oocyte hydration and spawning. However, there were no indications of recent spawning by this fish, i.e. we found no postovulatory follicles (POF). Ovaries from the August fish, the largest female examined for reproductive condition during the study, were found to be regressed and exhibited considerable atresia as did the ovaries from the September and October specimens, with the exception of the small September fish (326 mm) which may have been immature. The December female (330 mm) appeared regressed, but since there was no evidence of atresia, may have been immature. The age of the largest September fish (483 mm), the only one of the eight females examined for age, was estimated to be four years.

Age Estimates

Although the overall sample of fish from the study site consisted of specimens which ranged from 229 -713 mm, we collected sagittal otoliths from only a few fish

(n = 40; 326 - 713 mm). Of the 40 otoliths processed for ageing, 33 (88 %) were considered readable (18 males, 15 females), and two readers agreed on the number of opaque bands for those sagittae. Estimated age was assigned as follows: Age-2 (males, n = 2, 326 - 390, $\bar{x}$ = 352 mm; females, n = 1, 430 mm), Age-3 (males, n = 5, 443 - 548 mm, $\bar{x}$ = 481 mm; females, *n* = 2, 380 -601 mm, $\bar{x}$ = 491 mm), Age-4 (males, n = 80, 433 - 675 mm, $\bar{x}$ = 599 mm; females, n = 9, 483 - 610 mm, $\bar{x}$ = 540 mm), Age-5 (males, n = 3, 574 - 713 mm, $\bar{x}$ = 632 mm; females, n = 3, 581 - 696, $\bar{x}$ = 651 mm).

Diet

Stomachs of 54 red snapper which ranged from 360 - 681 mm ($\bar{x}$ = 535 mm) and 0.9 - 5.2 kg TW ($\bar{x}$= 2.66 kg) were examined. Forty-one (76 %) of the 54 stomachs contained a total of 151 prey items. The diet was comprised of fish, crustaceans and cephalopods.

Fishes occurred in 37 (90 %F) of the stomachs and represented 79 % of the total number of prey and 70 % of the total volume of prey. Anchovies were predominant among identified fishes in the diet and were represented by *Anchoa hepsetus* (striped anchovy) (n = 10) (7 %N, 2 %V, 12 %F) and *Anchoa* sp. (n = 52) (34 %N, 5 %V, 24 %F). *Arius felis* (hardhead catfish) (n = 9), ranked first in %V (31) in the diet. Other fishes, due to various states of digestion, could be identified only to genus (*Anchoa* sp., *Hippocampus* sp.), family (Clupeidae and Bothidae), order (Pleuronectiformes) or unidentified fish remains, which ranked first in %F (63) and second in %N (29) and %V (26).

Crustaceans ranked second in importance, numerically (19 %N) and volumetrically (30 %V), in the diet, and occurred in 54 % of the stomachs. Decapods were the primary crustacean prey, and *Callinectes similis* (Gulf crab) (n = 9) was the dominant crustacean in the diet (8 %N, 13 %V, 22 %F). The iridescent swimming crab (*Portunus gibbesii*) and other decapods identifiable only to *Penaeus* sp. (shrimp) and *Callinectes* sp. (crab), combined, accounted for only 3 %N and 2 %V. Decapod remains (1 %V) were categorized as being either those of shrimp or crab and occurred in 20 % of the stomachs. Cephalopods (n = 3) were identified as squid remains and were present in 7 % of the stomachs.

Tag-release

From October 1994 - December 1996, 130 juvenile and adult red snapper were tagged and released at the study site. Tag-released fish ranged from 230 - 660 mm ($\bar{x}$ = 376 mm). Fish were tagged during January (*n* = 4, 300 - 310 mm), May (n = 7, 318 - 432 mm), June (n = 7, 330 - 381 mm), July (n =11, 300 - 432 mm), August (n =15, 287 - 483 mm) September (n = 16, 279 - 389 mm), October (n = 40, 229 - 660 mm), November (n = 7, 262 - 579 mm) and December (n = 23, 287 -483 mm). The amount of predation on tagged juveniles was unknown. Twenty-four (24) of the 130 tagged fish were recaptured; four of those were recaptured twice (double recapture) and two were recaptured three times (triple recapture), for a total of 32 recaptures. All recaptures were made at the study site. Most

recaptures were re-released, all at the study site.

Recaptures occurred during January, July, August, September, October and December. Recaptured fish ranged from 285 - 610 mm. Time-at-large for recaptures ranged from 1 - 373 days ($\bar{x}$=80 days). The "greatest" time-at-large (373 days) was recorded for a fish which measured 305 mm at tag-release (September) and 419 mm at recapture (September). The fish had grown114 mm (0.31 mm/day). The second greatest time-at-large was 300 days recorded for 2 fish: (1) 420 mm at tag-release (October), 508 mm at recapture (August), growth = 88 mm (0.29 mm/day); (2) 506 mm at tag-release (October), 610 mm at recapture (August), growth = 104 mm (0.35 mm/day).

Follow-up acoustic scans for the two fish (sex unknown) fitted with acoustic transmitters were positive only for the external tag. Signals indicated the fish was actively swimming around the study site during December 1994 and January 1995.

DISCUSSION

Our first encounter with red snapper at the study site occurred while cleaning fish remains from the deck of the nine meter research vessel *R/V Seiche* as it drifted along the eastern border of the Pascagoula Ship Channel. We observed approximately 100 red snapper, predominantly large individuals, feeding in a frenzied action on the remains at the surface of the water. Using hook-and-line gear, 20 red snapper (457 - 711 mm) were landed within a period of 0.5 hours.

Our study represents the first investigation of adult red snapper from Mississippi estuarine waters, and apparently is the first such study in the northern Gulf. Bortone et al. (1994) reported *L. campechanus* as a component of the fish assemblage at an artificial reef sited in 6.5 m of water in the Choctawhatchee Bay, Florida estuary, but the size of red snapper observed was not reported and no specimens were reported as collected.

Other species of fish, including small baitfishes (anchovies and menhaden), were also associated with the study site structure, and the following 18 species were caught by hook-and-line: *Dasyatis sayi, Carcharhinus limbatus, Rhizoprionodon terraenovae, Rachycentron canadum, Scomberomorus maculatus, Arius felis, Mycteroperca microlepis, Caranx crysos, Sciaenops ocellatus, Pogonias cromis, Mircopogonius undulatus, Archosargus probatocephalus, Lutjanus griseus, Lagodon rhomboides, Orthopristis chrysoptera, Chaetodipterus faber, Paralichthys lethostigma* and *Opsanus beta*. With the exception of *A. felis, C. crysos, S. ocellatus, M. undulatus, L. griseus, L. rhomboides, O. chrysoptera*, and *O. beta*, the above species were caught only once and were considered transients at the site. The above fishes comprise an interesting mix of species, most of which occur in both Mississippi's estuarine and offshore waters.

Our study prompted numerous questions, including:

i) Did Horn Island Pass and the associated Pascagoula Ship Channel serve as the primary conduit for the ingress of snapper emigrating into the estuary from offshore juvenile and adult red snapper habitat;

ii) Were the size and shape of the bottom structure critical;
iii) What were the factors driving the "ingress and egress" of the snapper;
iv) Why did adult red snapper congregate and persist at the inshore site, i.e., what were the environmental and/or habitat characteristics of the site and adjacent area that attracted and retained adults;
v) Did adult red snapper spawn at the site (only one female specimen gave such indication);
vi) Were juveniles (age-1, age-2) at the site merely "strays" that for some reason failed to remain offshore with the rest of their cohort;
vii) Did snapper reach adulthood at the site;
viii) Could the protection and abundance of food provided by estuarine habitat enhance juvenile growth rates and survival rates relative to that characteristic of offshore habitats; and
ix) Did our collections reflect the size distribution of snapper at the study site.

It is not known if estuarine residency is an integral part of the early life history of some juvenile red snapper. Also, it is not known if adult red snapper are perennial residents of the Mississippi Sound, however, anecdotal information provided by local anglers indicates that large red snapper (~8 kg) congregate during each month of the year at small, unmarked (clandestine), inshore artificial structures located near navigation channels within the Mississippi Sound. Despite a high degree of fidelity demonstrated by some individuals as shown by tag recaptures, there were definite fluctuations in numbers of snapper caught at the site over the study period. This may have been related to seasonality of snapper occurrence, periodic influx of individuals to the site, behavioral changes, harvest by anglers, lack of appropriate food source, or environmental variables.

Lowest bottom temperature at our site was 16.40° C in January, and the highest bottom temperature was 24.20° C in August, both within the acceptable range of temperature and salinity reported for red snapper (Bullis and Jones 1976). Highest bottom salinity recorded was 34.0 ‰, and the lowest bottom salinity recorded was 24.6 ‰., probably the result of freshwater inflow into the estuary during a period of heavy rainfall and subsequent river flushing into the eastern Mississippi Sound.

Age estimates (Age 2 - 5) assigned a small number of fish n = 33) in our sample fall within the range of age estimates reported for red snapper of similar size in recent studies (Wilson and Nieland 2001, Fischer 2002), and red snapper in our study exhibited a large variability in age at a given TL, as reported by Wilson and Nieland (2001) for red snapper from Louisiana. Length-at-age information for Gulf red snapper (Wilson and Nieland 2001, Fischer 2002), size data from our study, estimated age for a few of our specimens, and reproductive assessments (Render 1995, Collins et al. 1996, and this study), showed that numerous fish in our sample were adults.

Red snapper spawning season in the Gulf extends from May to October (Collins et al. 1996), and peak spawning occurs between June and August (Render 1995).

Males sampled for gonad histological assessment (n = 5; 390 - 520 mm; September and October) were sexually mature, although spermatogenic activity was declining in most fish. The female (559 mm) collected in July was ripe (FOM stage) which provided evidence that spawning might have occurred at or near the study site, a tantalizing revelation. Females collected in late summer and fall were regressed and most exhibited considerable atresia.

Our histological assessments of ovaries from fish caught during the spawning season were limited to eight specimens, and only one of those indicated near-term spawning. What are the environmental cues and requirements to trigger estuarine spawning of red snapper? What would be the fate of the fertilized eggs and larvae?

Our finding that fish were the dominant prey of red snapper generally reflects that of others who examined the diet of Gulf red snapper (Bradly and Bryan 1975). Snapper at the study site most likely fed on organisms which occurred at or very near the study site.

Since the mean depth at the study site was six meters, there were no obvious negative effects from the capture and retrieval of fish to be tagged. Tag-recaptures provided the opportunity to examine behavioral aspects of snapper associated with the study site. None of the fish tag-released at the site were caught (or reported caught) at any inshore bottom structures or any offshore artificial reefs or petroleum platforms within the area.

Recaptures of tagged fish suggested that some individuals (juveniles and adults) resided at the site for long periods of time and some apparently overwintered there. The age of the 3 tagged fish which were recaptured in our study after 300 (n = 2) and 373 (n = 1) days-at-large was not known, and it is not known if those fish remained at the tag-release site throughout their entire period at liberty. However, sacrifice of the specimen which was at large for 373 days (September recapture) revealed a female with extremely small, regressed ovaries. The fish was 419 mm at time of recapture (and was likely 3 year old), suggesting that at 305 mm at time of tag-release, it was likely a two year-old, immature fish. Did this fish occupy the study site for it's entire time-at-large and spawn there?

Our study terminated in 1997 when maintenance dredging of the Pascagoula Ship Channel resulted in the removal of the study site. Use of side scan sonar (Edgetech, model 560A) verified the absence of the structure.

Although our work was based in opportunism, opportunistic discovery has often led to more extensive study. Identifying and monitoring estuarine habitat utilized by red snapper could improve the ability to assess and manage productive substrate and provide additional indicators of juvenile red snapper recruitment to estuaries. The study site reported here probably would not qualify as a "reserve" in the truest sense of the word, but the creation of a small network of similar, surreptitious sites within the Mississippi Sound, perhaps within the safety of the "regulated buffer zone" of the Gulf Islands National Seashore, might serve to provide undisturbed study sites to evaluate the effectiveness of "small estuarine reserves" as red snapper habitat. Studies at such sites could provide greater insight into environmental and biotic factors associated with the recruitment, growth and survivorship of young red

snapper associated with estuarine habitat.

Study findings provided here, albeit limited, pertain to the utilization of estuarine habitat by red snapper and contribute information on the biology and behavior of red snapper from the northern Gulf, including the simultaneous occurrence of large juveniles and adults at an inshore artificial structure, indications of long-term site fidelity and possible overwintering at estuarine habitat, and indications of spawning within a northern Gulf estuary.

ACKNOWLEDGMENTS

Great appreciation is extended to USM College of Marine Sciences colleagues D. Barnes and C. Nicholson for their tremendous participation during field sampling activities aboard the *R/V Seiche*. Thanks go to B. Comyns, N. Jordan, J. Peterson and J. Steckler for access to red snapper they collected from the study site. A. Garber, M. Griggs and D. Gibson helped process and analyze otoliths and stomach contents. Valuable counsel on the assessment of gonad histology was provided by N. J. Brown-Peterson. We thank the Mississippi Department of Marine Resources (MDMR) for the use of their side scan sonar, and we extend our appreciation to MDMR fisheries biologists K. Cuevas, J. Ledoux and W. Devers who operated the side scan sonar during the study site survey. C. Crowder, Louisiana State University School of Veterinary Medicine, did the gonad histological preparations. This study was supported in part by funding through Federal Aid in Sport Fish Restoration Project No. F-120 awarded the USM College of Marine Sciences by the Mississippi Department of Marine Resources, Biloxi, Mississippi and the U.S. Fish and Wildlife Service, Atlanta, Georgia.

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