Fishery independent survey of red snapper *Lutjanus campechanus* in the Gulf of Mexico.

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Abstract

Present abundance estimates of red snapper, *Lutjanus campechanus*, in the northern Gulf of Mexico suggest an overfished stock. However, most estimates are based on landings data which may reflect fishing ability and effort rather than actual stock sizes. In this study we used fishery independent methods to estimate red snapper, *Lutjanus campechanus*, abundance, age frequency, and mortality, off coastal Alabama.

For juvenile estimates of mortality we used the placement of artificial shell nursery habitats and SCUBA surveys. For estimates of fishing mortality we used mark-recapture studies. For estimates of adult populations we used 3 capture methods: fish trap, hook-and-line, and SCUBA visual surveys to estimate red snapper population parameters. All captured fish were weighed, measured, otoliths removed and ovaries weighed and preserved in no-tox.

We built 320 shell/block nursery reefs from 1998 through 2002. We made a total of 649 SCUBA surveys counting age-0 and age-1 red snapper on these reefs. We estimated annual total mortality Z = 2.3, for age-0 to age-1 red snapper from these surveys. From May 1990 to Oct 1991, we tagged and released 1155 red snapper and recaptured 146 red snapper, and estimated annual fishing mortality F = 0.18 $\pm$ 0.19. From 1999 to 2004, we captured 3557 red snapper and aged 3413 fish from 94 different artificial reefs. We estimated total annual mortality Z = 0.54 for red snapper greater than age-1. Growth was fitted to the von Bertalanffy relation where TL = 923 (1 - $e^{-0.17(age+0.79)}$, and Log wt = -0.471 + 2.96 log TL (R^2= 0.98, N = 3451). Using these parameters we estimated SSBR = 0.20, and maximum yield at F = 0.4.

Introduction:

Accurate stock assessment is critical to the management of marine "reef" fish population in the northeast Gulf of Mexico. However, this assessment task often proves difficult with many assumptions that may or may not be valid. The stock assessment of red snapper, Lutjanus campechanus, in the Gulf of Mexico, has proved particularly difficult. This difficulty probably has little to do with assessment effort, i.e., there has been extensive study of this species (Camber 1955; Topp 1964; Moseley 1966; Moe et al. 1970; Bradley and Bryan 1974; Futch and Bruger 1976; Fable 1980; Collins et al. 1980; Holt and Arnold 1982; Nelson and Manooch 1982; Goodyear and Phares 1990; Orbach 1992; Camper et al. 1993; Szedlmayer and Shipp 1994; Workman and Foster 1994; Goodyear 1994; Wilson et al. 1994; Collins et al. 1996; Cuellar et al. 1996; Szedlmayer and Howe 1997; Gold et al. 1997; Schirripa and Legault 1997; Schirripa 1998; Szedlmayer 1998a; Lee 1998; Szedlmayer and Conti 1999). What probably makes red snapper stock assessment more difficult compared to other species, has more to do with life history and "catchability" rather than study effort. One aspect of red snapper stock assessment that needs verification is the reliability of landings data. Does landings data (what commercial and recreational fishers bring back to the dock) reflect the actual population in the Gulf? This problem has been well recognized in the fisheries literature, yet it has received little attention in red snapper management, mainly because fishery independent samples are too costly.

Red snapper are extremely abundant in the shelf waters off coastal Alabama. However, if past catch estimates are valid, red snapper are overfished, (Schirripa and Legault 1999). Thus, despite the dominance of red snapper from this area, abundance estimates from past surveys suggested a stressed population of red snapper. However, these past estimates may have underestimated the actual population, because they were based on landings data.

We can identify some possible explanations that would lead to underestimates of population size from landings. Probably, the most important aspect to consider was the selection of sampling sites. In essence, landings may have originated from well known public reef sites that were heavily fished. However, off coastal Alabama we estimated 15,000 private reefs exist that receive little fishing pressure and these unfished reefs may hold more fish at larger sizes (Tatum et al. 1996; Duffy 1997, 1998, 1999, Minton and Heath 1998). A second consideration that may have caused underestimates may have been sample depth. Shallower depths are within reach of a much larger fishing fleet, and as distance from shore increases fishing pressure decreases.

Our goals were to: 1) develop a fishery independent, stratified random sampling strategy, to estimate the abundance, instantaneous mortality, age frequency distribution, and growth rates (age-length keys) of red snapper in the northeast Gulf of Mexico using three gear types: SCUBA visual surveys, hook-and-line, and fish traps; 2) locate and sample "private" reef sites; and 3) attempt to sample from deeper waters to enhance abundance estimates.

Materials and methods

Nursery habitats and age-0 to age-1 mortality estimates:

From 1998 to 2002 we built 320 shell/ block reefs off coastal Alabama at 15 to 20 m depths. After several trial and error attempts at building these reefs we developed the following protocol. For oyster shell reefs (shell reefs) we filled three 35 gal PVC perforated containers with shell. These were tied together with 3/8 in line. The lids were held closed with rubber tie down straps. An 80 ft, 3/8 in line, was attached to these cans with a orange buoy at the surface. For oyster shell-concrete block reefs (block reefs), we used the same methods as above, but also tied in 4 to 10 concrete blocks. We placed the reefs at 20 m intervals, alternating from shell to block reefs. SCUBA divers set up either a 1x1 or 2x2 m ½ in PVC quadrate on the bottom, and spread the shell and blocks within the quadrate. They would then ascend with the plastic cans on the marker lines. PVC stakes were set up on each reef to estimate trawl effects. Two SCUBA divers counted all fish species and estimated fish sizes on each reef at various time intervals depending on year of deployment.

Mark-recapture:

We used mark-recapture to estimate exploitation rate. We used estimates of tag non-reporting (Denson et al. 2001), tagging mortality (Render and Wilson 1994; Patterson et al. 2001) marked fish depletion (Slipke and Maceina unpubl) and tag retention (Patterson et al 2001). For further details of mark recapture see Szedlmayer and Shipp 1994.

Adult fishery independent survey study area:

In the northeast Gulf of Mexico, off the coast of Alabama, extensive reef building activity has resulted in an estimate of 15,000 total reefs in a 7,338 km2 area (Fig. 1). Depths ranged from 13 to 80 m. These artificial reefs range in size from single cars (3 m) to large ships (100 m). Red snapper, Lutjanus campechanus, are a major faunal component of these artificial habitats, with abundance levels typically as the number 1 or 2 dominant fish species (Szedlmayer 1994).

We randomly sampled 93 individual artificial reefs within this zone (20 to 80 m). Some reefs were from published coordinates (n=11), while most were from unpublished "private" sites (n=82) located by depth sounder (Fig. 1).

Field sampling: Fishery independent sampling methods:

1. Hook and line: After locating a reef site, the first samples were collected by hook & line. The number of fishers varied but was usually 3 individuals, with a fourth individual handling the catch. Hook and line methods were used for 60 min, with standardized gear: 4/0 penn rod and reel, snelled 7/0 double hooks, 60 lb line test, and whole menhaden as bait.

2. Trap set: After hook & line, we deployed a single baited Chevron fish trap (1.2 x 1.5 x 0.6 m; Collins 1990) near the reef structure with an attached line and buoy to the surface. The trap was fished for 15 min intervals. If we failed to catch at least 30 red snapper the trap was redeployed. If a trap set contained more than 30 fish, prior to removal from the water, extra red snapper were released through a trap door.

3. SCUBA visual counts: After other capture methods were completed, two SCUBA divers made visual counts. Divers would make at least 3 counts, and the highest count was used in total reef abundance estimates. In addition, after SCUBA divers completed their visual counts, they attempted to video tape the reef and red snapper with a HI-8 video camera, using an Ikelite housing. No SCUBA surveys were made at depths greater than 35 m.

4. Field handling of red snapper and environmental data: Only the first 30 captured red snapper from each reef site were kept for laboratory analysis. Fish were immediately packed on ice in large coolers. Fish were kept separated by capture method with large plastic bags, then transported back to the lab as quickly as possible for further processing. All subsequently captured fish were counted and released.

Temperature, salinity, dissolved oxygen (YSI meter), reef site, and number of red snapper per method were recorded for each reef site.

Laboratory analysis:

1. Red snapper workup: All red snapper returned to the laboratory were measured to the nearest mm and weighed on one of a series of Ohaus balances, depending on size (CT10 10g max; CT1200 1200 g max; DS4 20 kg max). Gonads were removed and preserved in no-tox solution for later analysis. Sagittal otoliths were removed from all kept fish, cleaned, and stored dry in labeled plastic vials.

2. Otolith preparation: Most otoliths were read whole (all < 6 years), using transmitted light on an Olympus dissecting microscope. While sectioning was required for all older fish (> 5 years).

3. Data analysis: Data were generated on the distribution, abundance, mortality, and age frequency distribution of red snapper from the sampling area off Alabama. We used FAST

statistical program to predict spawning stock biomass ratio (SSBR) and yield curves.

Results:

We built 320 shell/block nursery reefs from 1998 through 2002. We made a total of 649 SCUBA surveys counting age-0 and age-1 red snapper on these reefs (Table 1). We estimated annual total mortality Z = 2.3 for age-0 to age=1 red snapper from these surveys (Fig. 2). From May 1990 to Oct 1991, we tagged and released 1155 red snapper and recaptured 146 red snapper, and estimated annual fishing mortality F = 0.18 + 0.19. From 1999 to 2004, we captured 3557 red snapper and aged 3413 fish from 94 different artificial reefs (Table 2). We estimated total annual mortality Z = 0.54 for red snapper > age-1 (Fig. 3). Growth was fitted to the von Bertalanffy relation where $TL = 923 (1 - e^{-0.17(age+0.79)}$, and Log wt = -0.471 + 2.96 log TL (R^2= 0.98, N = 3451; Fig's. 4 and 5). Using these parameters (Table 3) we estimated SSBR = 0.20, and maximum yield at F = 0.4 (Fig's 6 and 7).

Table 1. Number of reefs and visual surveys of age-0 and age-1 red snapper *Lutjanus campechanus* from artificial shell nursery habitats in the northeast Gulf of Mexico.

Year	Number of Reefs	Visual Surveys
1998	60	60
1999	60	120
2001	100	369
2002	100	100

Table 2. Sample size for the fishery independent survey 1999 to 2004 of adult red snapper *Lutjanus campechanus* from the northeast Gulf of Mexico.

Year	# of reefs	# of red snapper	# aged
1999	25	1144	1082
2000	13	691	611
2001	19	500	499
2002	11	414	414
2003	21	582	581
2004	5	226	226
Totals	94	3557	3413

Table 3. Red snapper mortality estimates that were used in SSBR and yield models.

Class	Z	M	F
age 0	2.3	1.9	0.4
age -1	0.54	0.47	0.07
age 2 - 54	0.54	0.36	0.18

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Figure 1. Study area on the continental shelf off Alabama. Dots show the location of individual reef sites. Sites ranged from 10 to 100 km from the mouth of Mobile Bay.

Figure 2. Age-0 to age-1 mortality estimates for red snapper from SCUBA visual surveys.

Figure 3. Total mortality estimate from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.

Figure 4. Von Bertalanffy growth curve from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.

Figure 5. Length weight relation from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico..

Figure 6. Spawning stock biomass ratio from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico..

Figure 7. Yield model for from fishery independent age frequency distribution of red snapper in the northeast Gulf of Mexico.