Presence of Juvenile Blackfin Snapper, *Lutjanus buccanella*, and Snowy Grouper, *Epinephelus niveatus*, on Shallow-water Artificial Reefs

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ABSTRACT

The inshore environment of Broward County, Florida consists of three reef tracts, each separated by sand substrate, running parallel to the coastline in sequentially deeper water. A wide variety of artificial reef designs have been deployed in Broward County, many lying in sand flats between the reef tracts. From 1995 through 2002, over 1,100 visual fish censuses (predominantly point-counts) were completed on the three natural reef tracts in water depths from 3 m to 30 m and over 1,100 censuses were done on artificial reefs at depths of 7 m to 23 m. Curiously, the juvenile stages of two deeper-water species of the snapper/grouper complex, the blackfin snapper (*Lutjanus buccanella*) and the snowy grouper (*Epinephelus niveatus*), appear to prefer artificial reefs located in the sand flat separating the second and third reef tracts to nearby natural reef areas. Five hundred and forty blackfin snapper have been recorded in 64 visual censuses and nine snowy grouper have been observed in seven counts on artificial reefs. Despite the large volume of visual census data collected thus far, these two species have never been recorded on nearby natural reef tracts. The reasons for this unanticipated observation is unclear but it provides an excellent launch-point for an examination of juvenile habitat requirements, natural availability of these requirements, and the potential for artificial substrate to be used in managing these species

KEY WORDS: Artificial reefs, blackfin snapper, snowy grouper

Presencia de Juveniles del Chillo Oreja Negra (*Lutjanus buccannella*) y Mero (*Epinephelus niveatus*) en Arrecifes Artificiales Someros del Sureste de Florida (Eua)

Entre 1995 - 2002, 1100 conteos de peces fueron llevados a cabo en arrecifes natural (3 -30 m de profundidad) en el condado de Broward, Florida. Así mismo, 1100 conteos de peces también fueron realizados en varios arrecifes artificiales (7 - 25 m de profundidad) en la misma área. A pesar de las numerosas observaciones, *buccanella,* y mero, *Epinephelus niveatus,* se han registrado solamente en los arrecifes artificiales del area. Estos y parecen preferir habitats artificiales a los arrecifes naturales más próximos. La razón de esta preferencia a aun se desconoce pero puede ser debido a la competencia por recursos a la disponibilidad alimento entre los arrecifes naturales y artificiales.

PALABRAS CLAVES: Arrecifes artificiales, chillo oreja negra, mero,

INTRODUCTION

The blackfin snapper (Lutjanidae), *Lutjanus buccanella*, and the snowy grouper (Serranidae), *Epinephelus niveatus*, are economically important deepwater species along the Atlantic coast in the southeast U.S. (Parker and Ross 1986, Parker and Mays 1998). The high demand for these fish combined with naturally slow growth rates make them extremely susceptible to overfishing. Fisheries data have shown a steady decline in catch for both species since the early 1980s, and the snowy grouper has recently been listed as vulnerable by the International Union for Conservation of Nature and Natural Resources (IUCN) (Matheson and Huntsman 1984, Moore and Labisky 1984, Parker and Mays 1998).

Commercially important deepwater fish species are the least studied of all fish supporting a major fishery (Parker and Mays 1998). To properly assess the habitat characteristics and fish assemblages below a depth of 45 m, costly specialized equipment is needed. The costs associated with this type of research continue to limit the information available on deepwater species (Matheson and Huntsman 1984, Moore and Labisky 1984, Parker and Ross 1986, Parker and Mays 1998).

Many juvenile fish species display ontogenetic habitat shifts with growth, maturing and then migrating to deeper waters (Hixon 1991, Perrson et al. 1997, Lindeman 1999, Nagelkerken 2000, Wilbur 2000). However, little is known about juvenile habitat requirements of many commercially important fish species and possible ontogenetic variations in habitat preference. Fisheries managers need to understand juvenile habitat requirements to ensure the survival of juveniles, which may, in turn, increase adult populations (Able 1999). There are only a handful of publications which provide information on blackfin snapper or snowy grouper (Sylvester 1974, Grimes et al. 1977, Matheson and Huntsman 1984, Moore and Labisky 1984, Acero and Garzon 1985, Parker and Ross 1986, Gutherz et al. 1987, Jones et al. 1989, Cuellar et al. 1996, Dodrill et al. 1993, Bohnsack et al. 1994, Tabash and Sierra 1996, Parker and Mays 1998, Wyanski et al. 2000). Most of these studies describe reproductive patterns, or age and growth of adults caught from recreational or commercial fisheries. No studies have been published concerning the juvenile life history stages of either species. Descriptions of juvenile habitat for these two species have been sketchy at best and have generally been described as shallow hardbottom areas. We examined fish distribution data sets from Broward County, Florida USA in order to gain some insight on the distribution of juvenile blackfin snapper and snowy grouper in this area.

METHODS

The inshore environment of Broward County, Florida consists of three reef tracts (inshore, middle, and offshore), each separated by sandy substrate, running parallel to the coastline in sequentially deeper water (Lighty et al. 2001). A wide variety of artificial reef designs have been deployed in Broward County and many lie on the sand flats between reef tracts. During an eight-year period (1995 to 2002) over 1,100 visual censuses were completed on the three natural reef tracts at water depths from 3 m through 30 m, and well over 1,100 counts on artificial reefs at depths of 7 m through 23 m. The data from these censuses are available elsewhere. Portions of these data have been published in various scientific journals (Gilliam et al. 1995, Sherman et al. 1999, Sherman et al. 2001a,b), gray literature (Spieler 1995a,b, Spieler 1998a,b,c, Spieler 2000), theses and dissertations (Gilliam 1999, Sherman 2000, Jordan 2002), or is archived (Spieler 2002), in manuscript (Baron and Spieler in prep.), or in some combination of the preceding.

The census of natural hardbottom consisted of two studies. Between 1998 and 2002, 751 point-counts (Bohnsack and Bannerot 1986) were completed (Ettinger et al. 2001, Spieler 2002). The counts were taken at the edges and crests of all three reef tracts at 0.463 km (0.25 nautical mile) intervals along the entire Broward County shoreline (35.2 km). The counts were completed throughout the year but predominately during summer months. Also, from June to August 2001, 200 30x2x1 m belt transects, 100 point-counts, and 98 rover diver counts were made in the first 30 m of the nearshore hardbottom of Broward County (Baron and Spieler in prep.).

The artificial reef censuses consisted of five studies from Broward County, Florida. From April 1995 to October 1996 a total of 584 fish surveys were completed on 40 small artificial reefs, Gilliam-Spieler modules (aka fish-condo modules), in 7 m of water (Gilliam 1999). Between March 1995 and October 1996 a total of 144 fish counts on 20 Reefball[4] modules were performed at depths of 7 m and 23 m (Sherman et al. 1999). From October 1998 to September 2000 a total of 528 fish counts were also completed in the same shallow inshore area (7 m) of Broward County using various spatial arrangements of 30 Gilliam-Spieler modules (Jordan 2002). An additional study, which began in April 2002, has thus far completed 120 fish counts on Reefballs in 13 m of water (Quinn, unpubl. data). These four studies documented fish species, total number of individuals per species, and estimated total fish length (TL) into five size classes (0 - 2, 2 - 5, 5 - 10, 10 - 20, > 20 cm TL). Lastly, an ongoing study censussing the fish assemblages on seven shipwrecks off Broward County has completed 182 visual point-counts over 19 months (Arena unpubl. data). Data were collected from March 2000 to March 2001 and from March 2002 to September 2002. Six ships were censussed four times during the year, two ships each month and four monthly surveys have been completed on the seventh vessel, which was deployed in April 2002. Total abundance, as well as mean, minimum, and maximum size of each species was recorded at each shipwreck site.

RESULTS

Curiously, juvenile stages of two deepwater species, the blackfin snapper and snowy grouper, appear to prefer artificial reefs located in sand flats separating the reef tracts to nearby natural reef areas.

A total of 586 juvenile blackfin snapper individuals (556 on sunken vessels, 30 on small concrete artificial reef modules) have been recorded in 86 visual censuses and a total of eight juvenile snowy grouper has been recorded in seven counts (Table 1). Although these are not overwhelming numbers, especially for snowy grouper, no individuals of either species have been recorded in fish counts on nearby natural reefs. The majority of blackfin snapper juveniles (95 %) have been recorded on sunken vessels. Snowy grouper juveniles are more evenly dispersed between artificial reef types, but have been seen more often on the small concrete modules (three on sunken vessels and five on small concrete modules).

Table 1. The abundance and size class of snowy grouper. RB = Reefball SV = Sunken Vessel

Date (mo/yr)	Reef Type	N	Size Class (cm)
7/1995	RB	1	5-10
9/1995	RB	2	5-10
11/1995	RB	1	2-5
8/1996	RB	1	2-5
10/2000	SV	1	10-20
1/2001	SV	1	10-20
5/2002	SV	1	10-20

Blackfin Snapper

The minimum size class observed for blackfin snapper on concrete modules was 2-5 cm. The smallest fish observed on a ship was a 4 cm individual, found on a newly deployed vessel. The maximum size observed for blackfin snapper was 40 cm, this was not typical and was observed for only one fish on a sunken vessel. The mean size of blackfin snapper observed on ships was 19 cm. The largest size class observed on the smaller artificial reef modules was >20 cm. The highest abundance of blackfin snapper on ships was found from September to December 2000 (Figure 1). From January to March 2001 the largest mean sizes of blackfin snapper on ships were recorded (Figure 2). Ninety percent of all individuals on ships were between 15 cm and 30 cm and of these fish 60 % were from 15 - 20 cm. The most common size class for the smaller artificial reefs was 5 - 10 cm.

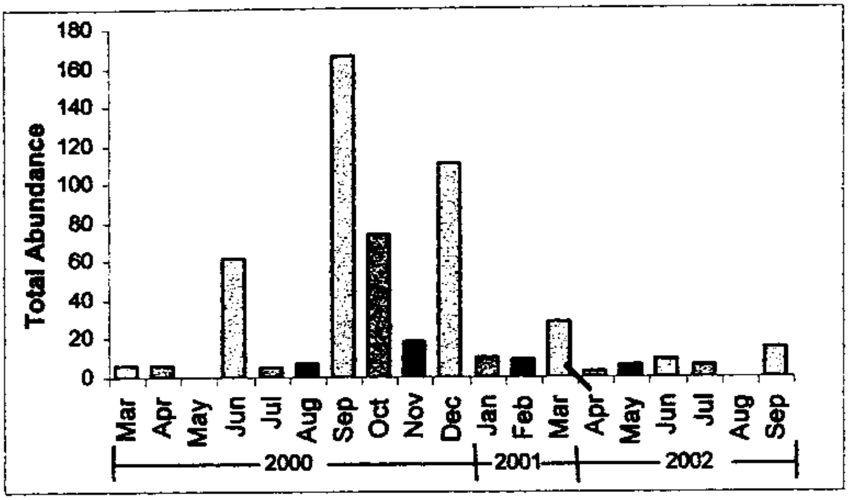

Figure 1. Blackfin snapper monthly abundance on a pair of ships. Bar shades indicate one of three specific pairs of ships, which were censused repeatedly. The oblique line after March 2001 indicates a gap in data collection.

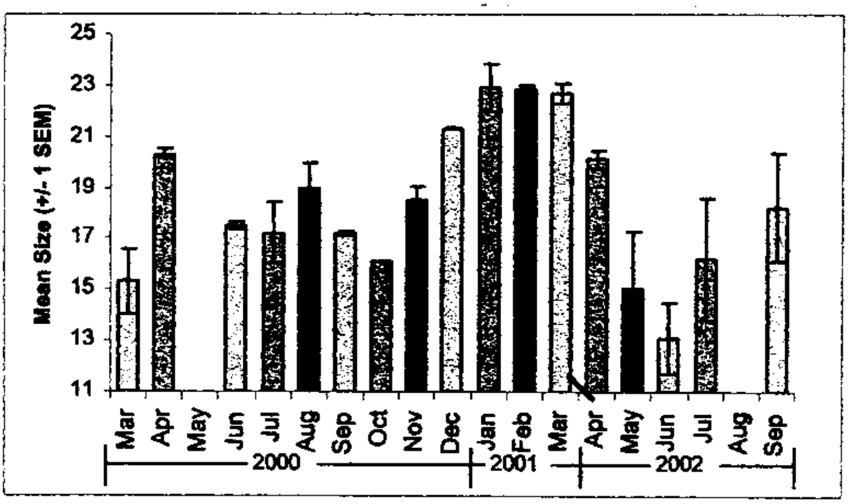

Figure 2. Blackfin snapper monthly mean size (+/- 1 SEM) on a pair of ships. Bar shades indicate one of three specific pairs of ships, which were censused repeatedly. The oblique line after Mar. 2001 indicates a gap in data collection

Snowy Grouper

The minimum size recorded for snowy grouper was 10 cm on a sunken vessel and the 2 - 5 cm size class on the Reefballs. The maximum size observed was 12 cm on a sunken vessel and the 5 - 10 cm size class for the Reefballs. The largest number of individuals seen in any one count was two individuals on the Reefballs (Table 1).

DISCUSSION

The presence of juvenile blackfin snapper and snowy grouper on artificial reefs and their apparent absence from surrounding natural reefs is an unexpected and important observation. This one-sided distribution may be an indication that the artificial structures supply these species with ancillary, possibly unique, nursery/juvenile habitat in water depths of less than 30 m. The importance of juvenile nursery areas to fisheries populations is well established. Many studies have been conducted in commonly known nursery habitats, such as mangroves and seagrasses (Austin 1971, Thayer et al. 1987, Sedberry and Carter 1993). Recently, shallow reefs and nearshore hardbottom areas have also been shown to have nursery potential, and it is now clear that biotope utilization can be very specific for individual species and size classes (Lindeman 1997, Nagelkerken et al. 2000, Wilbur 2000). It has been suggested that juvenile associations with habitat may be based on avoidance of predators, abundance of food, and interception of larvae (Nagelkerken et al. 2000). The presence of the blackfin snapper and snowy grouper on artificial reefs suggest these habitats meet at least some of these criteria.

Blackfin Snapper

Ontogenetic habitat shifts of juvenile fish to intermediate life stage habitats with increasing size have been recorded for many species (Leis 1987, Hixon 1991, Lindeman 1997, 1998, Nagelkerken et al. 2000, Wilbur 2000). Based on the size distribution data of the blackfin snapper, they seem to be utilizing artificial habitats (primarily sunken vessels in 21 - 23 m of water between the middle and offshore reef tracts) as an intermediate or secondary nursery habitat. The majority of blackfin snapper on vessels were in the 15 - 30 cm size range. It appears these fish may be settling elsewhere and when reaching a certain size (approximately 15 cm) they move onto sunken vessels.

Smaller individuals (< 10 cm) were recorded on a recently deployed vessel and smaller artificial reef modules at a depth of 21 - 23 m, as well as on Reefballs on the sand terrace of the middle reef tract in 13 m of water. The sand flats between reef tracts, as well as the sand terrace of the second reef tract, contain small sections of hardbottom and an abundance of small rubble and shell debris patches (authors, personal observation). These structures may be providing microhabitat areas for settling fish. Lindeman (1999) indicates that Lutjanids settle near interfaces of hardbottom structure and sand; this may be the case for settling blackfin snapper as well. The rapid appearance of these smaller juveniles to newly deployed artificial reefs in sand flat areas may be an indication of their presence nearby before reef deployment.

Specific habitats where the juvenile blackfin snapper are settling is still in question, but data collected thus far clearly indicates recruitment of these individuals to artificial reefs at sizes around 15 cm and residency until reaching a larger size (20 - 40 cm). The upper size limit may be related to sexual maturity. Past studies have shown blackfin snapper reach sexual maturity at sizes from 20 - 40 cm (Sylvester 1974, Thompson and Munroe 1974, Grimes et al. 1977, Boardman and Weiler 1980, Froese and Pauly 2002). Blackfin snapper may, therefore, be utilizing the artificial reefs as intermediate nursery habitat, growing to maturity and then migrating to deeper waters.

The data show a high abundance of juvenile blackfin snapper on sunken vessels during winter months (Sep. - Dec. 2000) (Figure 1). There is also an increase in mean size of juveniles toward the end of this period and in subsequent months (Figure 2). This decrease in abundance with increasing mean size may be due to predation, fishing mortality or migration of these larger juveniles/sexually mature adults to deeper waters. Bohnsack and coauthors (1994) found a similar peak in abundance of juvenile blackfin snapper (mean size 4.3 cm) from August to December 1988, on small artificial reef modules in 10 - 12 m of water off Miami, Florida.

The reasons for the association of juvenile blackfin snapper with artificial reefs could involve a number of factors. Lutjanids are known to be voracious predators of newly settled fish (Hixon 1991). Colonization of newly deployed artificial reefs is a rapid process and newly settled juvenile blackfin snapper may benefit from increased food resources as juvenile fish settle to this vacant habitat (Gilliam et al. 1995, Gilliam 1999, Sherman 2000). By reducing foraging distances juvenile blackfin snapper may be conserving energy and maximizing growth (Stephens and Krebs 1986).

Predator susceptibility is another factor that may be structuring the spatial distribution of this species. The artificial reef habitats are all located on sand flats between reef tracts and previous studies have revealed lower predation risks at small distances (< 25 m) away from the reef (Shulman 1985). This habitat may be reducing predation risks because of its off-reef locality.

In addition, artificial reef siting may reduce foraging distances for the blackfin snapper, thereby increasing feeding efficiency and ultimately growth rates. Snappers are known to spend the day on reef and forage among sand flats nocturnally (Leis and McCormick 2002). Providing habitat close to food resources increases the optimal value of the habitat (Stephens and Krebs 1986).

Deep habitat may also be a factor to consider when trying to understand juvenile distributions of this species in Broward County. The continental shelf of southeast Florida is extremely narrow and drops off quickly to great depths (Chiappone 1996). This deep environment appears to be mainly low-relief habitat with an abundance of fine sediment areas and there seems to be a small percentage of suitable habitat (hardbottom ledges and cliffs) for blackfin snapper (Ken Banks, personal comm.).

Juveniles may be utilizing the shallow artificial environment due to the limited availability of deeper juvenile habitat and increased competition with adults as space requirements overlap (Jones et al. 1989, Hixon 1991).

The apparent absence of blackfin snapper and snowy grouper on shallow natural reefs and their presence on artificial reefs at depths less than 30 m does not appear to be restricted to Broward County. In a study to the south of Broward in Dade County, Florida, 462 fish counts were completed on small artificial reefs and 83 counts on nearby natural reefs (Bohnsack et al. 1994). Blackfin snapper and snowy grouper were observed settling on artificial reef sites at depths of 10 - 12 m, but none were recorded on natural reefs. The authors reported that juvenile blackfin snapper did well and grew at these sites before disappearing, which they suspect was due to an ontogenetic migration to deeper water. Another study in the Florida Keys which censused natural reef fish assemblages off Monroe County, Florida observed one blackfin snapper from a total of 6,673 surveys (Bohnsack et al. 1999). The REEF (Reef Environmental Education Foundation) database was also accessed to compare blackfin snapper distributions (REEF 2002). Their data show all observations of blackfin snappers in Broward County were at artificial reef locations. Interestingly, contrary to Broward, Dade, and Monroe Counties, REEF's database indicates Palm Beach County had an even distribution of blackfin snapper on natural and artificial reefs. The natural reef locations were described as high profile reefs. However, a preference for high profile reefs does not adequately explain the differences in distribution, as there are also high profile areas in Broward, Dade, and Monroe Counties.

Snowy Grouper

Although juvenile snowy groupers were seen less frequently and in lower abundances than the blackfin snappers, they too were only seen at artificial reef sites. Juvenile snowy groupers were observed at several size classes, but no individuals were larger than 12 cm. There appears to be some similarity in habitat selection between juvenile and adult snowy grouper. The larger juveniles (10 cm - 12 cm) were all observed near sunken vessels. All the juveniles seem to prefer two artificial reef types: Reefballs and rock/coral covered burrows near sunken vessels. Both of these artificial reef habitats are similar in structure to reported natural adult habitats. Adults have been reported from deeper areas in habitat consisting of irregular sized boulders (Matheson and Huntsman 1984, Parker and Ross 1986, Gutherz et al. 1987, Parker and Mays 1998). Thus, Reefball structure may be similar to these adult habitats. Groupers (Serranidae) are heavily dependent on habitat structure due to their sedentary behavior (Leis 1987). Reefball complexity may increase the feeding efficiency of the juvenile snowy grouper, aiding in its ambush style feeding behavior (Dodrill et al. 1993). Also, fish settling to these small artificial reefs are presumably easy prey for a juvenile grouper, which may increase available food resources.

Adults, as well as one juvenile have been observed utilizing blueline tilefish (Malacanthidae), *Caulolatilus microps*, burrows as habitat in deeper waters (Parker and Ross 1986, Jones et al. 1989). Similarly, all juvenile snowy grouper on the shallow sunken vessels were observed near burrows in the sand covered by a small rock or coral head and would retreat into the burrow when a diver approached. Adults have also been reported to utilize wreck habitats in deeper waters on the upper continental shelf and slope (Dodrill et al. 1993). The presence of adult and juvenile snowy grouper on sunken vessels may be related to natural habitat preferences, as the vertical relief provided by vessels (~10 m) is comparable to the relief found near natural adult habitats (Parker and Ross 1986, Dodrill et al. 1993, Parker and Mays 1998).

CONCLUSION

The fish census data collected thus far in Broward County on natural and artificial reefs represents a baseline of fish populations for the region. It is clear that blackfin snapper and snowy grouper juveniles prefer artificial substrate to that which is naturally available. The reasons for this unanticipated fact are unclear but provide an excellent launch-point for an examination of juvenile habitat requirements, natural availability of these requirements, and the potential for artificial substrate to be used in managing these species.

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