The Distribution of Early Juvenile Groupers Around South Caicos, Turks and Caicos Islands

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ABSTRACT

Groupers are important components of fisheries throughout tropical seas. However, little is known of their early life histories. This study aimed to investigate habitat use by early juvenile (< 12 cm TL) groupers around the south coast of South Caicos, Turks and Caicos Islands. From May to August 2007, a 530,000 m^2 shallow (< 5m) area was systematically sampled on snorkel covering a range of habitats extending from a fringing reef crest into a harbour and sheltered bay. Species, size, GPS position, and habitat of all epinepheline groupers observed were recorded. *Epinephelus striatus* (n=209), *E. guttatus* (n = 15), *E. adscensionis* (n = 9), *Cephalopholis fulva* (n = 396), and *C. cruentatus* (n = 4) were found to have overlapping but substantially different distributions: 87% of *E. striatus* and 73% of *E. guttatus* were found in seagrass areas which covered < 30% of the study area; *C. fulva* favoured rubble/rock areas (57%); and all *E. adscensionis* were found within 10m of land. *E. striatus* were found sheltering predominantly in two structures: discarded conch shells (44% of individuals) and ledges formed by the roots and rhizomes of seagrass in blowout walls (33% of individuals). Whilst previous studies have emphasized the importance of macroalgal beds in tidal creeks as early juvenile *E. striatus* habitat, around South Caicos, seagrass habitats cover large areas and may contribute more individuals to local populations than alternative habitats.

KEY WORDS: Juvenile grouper, *Epinephelus striatus*, seagrass, *Strombus gigas*, blowout

La Distribución de los Meros más Jóvenes del Año Alrededor de South Caicos, Turks and Caicos Islands

Los meros son componentes importantes de pesquerías tropicales. Sin embargo, se sabe poco de su etapa temprana de crecimiento. Este estudio se propuso investigar el uso del hábitat por los meros más jóvenes del año (< 12 cm LT) alrededor de la costa del sur de South Caicos, Turks and Caicos Islands. De mayo hasta agosto 2007, un área superficial (< 5 m) de 530,000 m^2 fue estudiada sistemáticamente en esnórquel. Esta área incorpora varios hábitats y se extiende desde una cresta de una barrera coralina hasta un puerto y una bahía. La especie, el tamaño, la posición de GPS y el hábitat de todos meros observados de la subfamilia Epinephelinae fueron registrados. *Epinephelus striatus* (n = 209), *E. guttatus* (n = 15), *E. adscensionis* (n=9), *Cephalopholis fulva* (n = 396), y *C. cruentatus* (n = 4) fueron encontrados superpuestos pero su distribución era substancialmente diferente: 87% de *E. striatus* y 73% de *E. guttatus* fueron encontrados en áreas de pastos marinos que cubrieron <30% del área de estudio; *C. fulva* prefirió áreas de escombro/piedra (57%); y todos los *E. adscensionis* los hábitats a menos de 10m de la costa. Los *E. striatus* se refugiaron predominantemente en dos estructuras: desechos de caracola (44% de individuos) y los salientes formados por las raíces y rizomas de pastos marinos en paredes alrededor de parches sin vegetación (33% de los individuos). Los estudios previos acentuaron la importancia de camas de macroalgas en riachuelos de la marea como hábitat para los *E. striatus* más jóvenes del año. Sin embargo, alrededor de South Caicos, los pastos marinos cubren grandes áreas y pueden aportar más individuos a la población local que los hábitats alternativos.

PALABRAS CLAVES: Juveniles de mero, *Epinephelus striatus*, pastos de mero, *Strombus gigas*, blowout

INTRODUCTION

Groupers are important food fishes in tropical seas (Heemstra and Randall 1993). However, many are at risk of overexploitation due to high demand coupled with life history characteristics (e.g. large size and age at first maturity) and behaviours (e.g. migrations and formation of spawning aggregations), that limit their populations' resilience to harvest (see Coleman *et al*. 2000 and references therein). As adults, many species are found inhabiting coral reefs, but juveniles may utilize a succession of off-reef habitats: for example, in Palau, squaretail coral grouper, *Plectropomus areolatus*, settles into coral rubble in tidal channels before moving to reefs as larger juveniles (Tupper 2007), and in the Bahamas, Nassau grouper, *Epinephelus striatus*, has been observed settling into coral clumps covered in macroalgae before moving to patch reefs at 12 to 15 cm TL (Dahlgren and Eggleston 2001, Eggleston 1995). However, for many species, there is little information available on early juvenile habitat use.

Despite the importance of off-reef habitats to grouper populations, most management and conservation concern is focused on adults, their reef habitats and in particular their spawning aggregations (see Sadovy and Eklund 1999). However, the maintenance of populations of grouper is also dependent on early juvenile habitats. Many of these habitats may be as vulnerable as those used by adults: they are often found at shallow depths close to land and are thus exposed to human activities on land and at sea (e.g. dredging, Tupper 2007).

The Turks and Caicos Islands (TCI) appears to have relatively healthy populations of grouper (Brightman Claydon Unpubl. data). For example, the Nassau grouper is regionally endangered (Cornish and Eklund 2003) but this species is found in the TCI at some of the highest densities recorded in its range (Tupper 2002). Historically, fishing activities have largely concentrated on queen conch, *Strombus gigas*, and spiny lobster, *Panulirus argus* (Rudd 2003), and the healthy populations of grouper may

be a reflection of the generally low fishing pressure on reef fishes in the TCI. However, the interest in groupers, snappers, and other reef fishes, which was once restricted to by catch in lobster traps, or other opportunistic or infrequent harvesting (Rudd 2003), has been growing over the last decade (Rudd and Tupper 2002) and is now the primary focus of some commercial fishermen (Brightman Claydon Pers. observ.). As fishing pressure increases, so does the need for effective management and initial steps are being taken by the TCI government to regulate this fishery more closely, especially with regard to Nassau grouper (Kathy Lockhart, Scientific Officer, TCI Department of Environment and Coastal Resources, personal communication).

The aim of this study was to investigate the distribution and habitat use of early juvenile groupers around South Caicos, Turks and Caicos Islands. The onset of Nassau grouper's migration away from early juvenile habitats starts at around 12 cm TL (Eggleston 1995). Similar data from other species of grouper in the study area are limited. Therefore, for the purposes of this study, early juveniles are defined as all individuals < 12 cm TL. A more complete understanding of habitat use by groupers throughout ontogeny is essential for more informed and thus more effective management.

MATERIALS AND METHODS

The study was performed on the south coast of South Caicos (N 21°29' W71°31'), Turks and Caicos Islands. The study area covered 0.53 km^2 and extended from a fringing reef crest into a harbour and into a sheltered bay (see Figure 1). This area included fringing reef, rubble, seagrass, patch reef, sand, gorgonian plain and macroalgal dominated habitats, at depths from 1 to 4 m. In previous studies documenting all sizes of groupers around South Caicos, seven species had been observed: coney (*Cephalopholis fulva*) were the most abundant followed by Nassau grouper (*Epinephelus striatus*), and then red hind (*E. guttatus*), with graysby (*C. cruentata*), rock hind (*E. adscensionis*), tiger grouper (*Mycertoperca tigris*), and yellowfin grouper (*M. venenosa*) being relatively uncommon (Brightman Claydon Unpubl. data).

The study was conducted from 20th May to 23rd August 2007. This time period was chosen in order to optimize the number of early juvenile groupers (individuals < 12 cm TL) that would be observed. Earlier in the year, recently settled Nassau grouper are cryptic and thus hard to observe (until they have grown to 5 to 6 cm TL), and later in the year Nassau grouper outgrow the early juvenile habitat (at around 12 cm TL) and begin to migrate to patch reefs (Eggleston 1995). Data on other species were unavailable.

It was deemed inappropriate to sample using transects placed representatively in different habitats because this approach would be unlikely to reveal all of the spatial patterns displayed by the early juvenile groupers. The preferred approach adopted in this study was to attempt to sample the entire area systematically. This was carried out on snorkel, subdividing the study area into manageable units and sampling each of these using systematic search patterns. Whilst it is probable that some of the study area was not sampled, these overlooked areas are likely to be minimal, and effort was distributed evenly across the entire study area. The species, size, habitat, microhabitat, and location (recorded with a handheld GPS unit) of all early juvenile groupers were recorded. Microhabitat was defined as the structure (biogenic or otherwise) in, around, under or on top of which the individual was found (*e.g.* discarded conch shell, coral head, artificial structure, *etc*.). No attempt was made to quantify the availability of habitats or microhabitats in the study area beyond calculating the area of seagrass and reef (estimated from ground-truthed satellite imagery as covering 28% and 15% of the study area respectively).

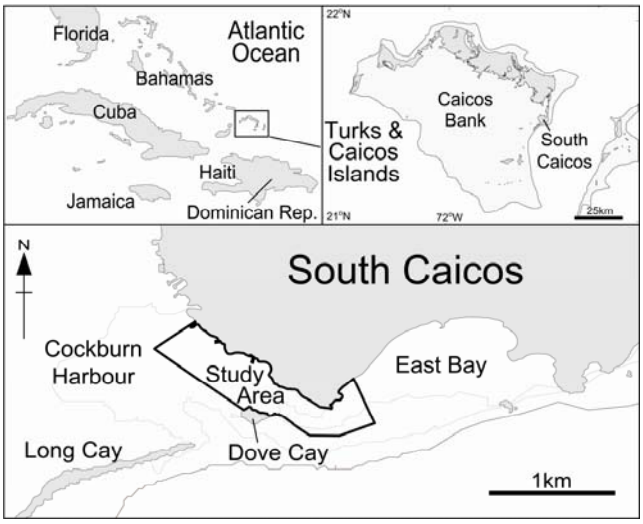

Figure 1. Study area on the southwest coast of South Caicos, Turks and Caicos Islands.

RESULTS

A total of 633 early juvenile groupers were observed in the study area: 396 coneys, 209 Nassau grouper, 15 red hind, 9 rock hind, and 4 graysbys. Neither tiger grouper nor yellowfin grouper were seen in early juvenile size classes during the study period. For all groupers (except graysbys), habitat and microhabitat associations are shown in Figure 2 and the spatial distribution of individuals within the study area is shown in Figure 3. Early juveniles were observed throughout most of the study area and were found in seagrass, reef, rubble/rock and gorgonian plain habitats, but none were found in macroalgal or sand dominated habitats. There was also a conspicuous absence of early juveniles on the exposed reef on the southern margin of the study area. Details for each species are summarized below.

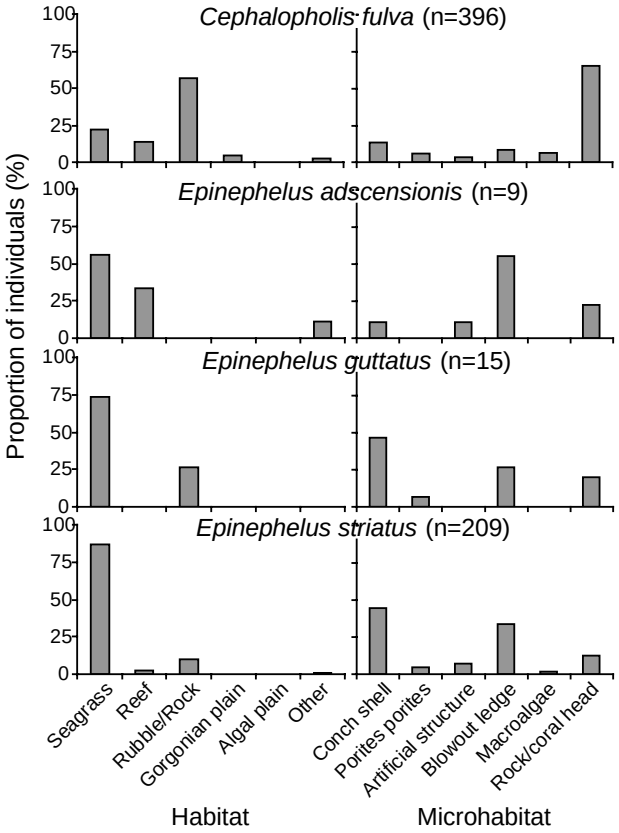

Figure 2. The habitat and microhabitat associations of early juvenile (< 12 cm TL) coney (*Cephalopholis fulva*), rock hind (*Epinephelus adscensionis*), red hind (*E. guttatus*), and Nassau grouper (*Epinephelus striatus*) in the study area.

Coney — Over half (57%; n = 225) of the early juvenile coneys were observed in rubble/rock habitat, 22% (88) in seagrass, 14% (n = 54) in reef and 5% (n = 20) in gorgonian plain. The majority (65%; n = 258) used rock/coral heads, with 14% (n = 54) using discarded queen conch shells (*Strombus gigas*), 8% (n = 33) using blowout ledges (the ledges formed by exposed roots, rhizomes and sediment in eroded areas of seagrass), 7% (n = 26) using macroalgae (*Neogoniolithon* spp.), 6% (n = 24) using live finger coral (*Porites porites*) and 3% (n = 13) using artificial structures including concrete blocks, PVC and steel pipes, steel cable, and steel mesh from discarded lobster traps. Coneys were distributed throughout the study area with highest densities in the back reef rubble/ rock habitat in the south.

Nassau grouper — Eighty-seven % (n = 181) of Nassau groupers were found in seagrass and 10% (n = 21) in rock/ rubble habitat. Discarded conch shells were used by 44% (n = 93) and 33% (n = 70) used blowout ledges as microhabitat. Rock/coral heads, artificial structures (*e.g.* PVC and steel pipes, cement blocks, a glass bottle, and an abandoned lobster trap), live finger coral, and macroalgae were also used by 12% (n = 26), 7% (n = 15), 4% (n = 9), and 1% (n = 3) individuals, respectively. The highest densities of Nassau grouper were found in the seagrass bed in the northern half of the study area. All individuals were either found in seagrass beds or in close proximity to (i.e. within 20 m of) seagrass areas.

Red hind — Most of the early juvenile red hinds (73%; n = 11) were found in seagrass and 27% (n = 4) in rubble/rock

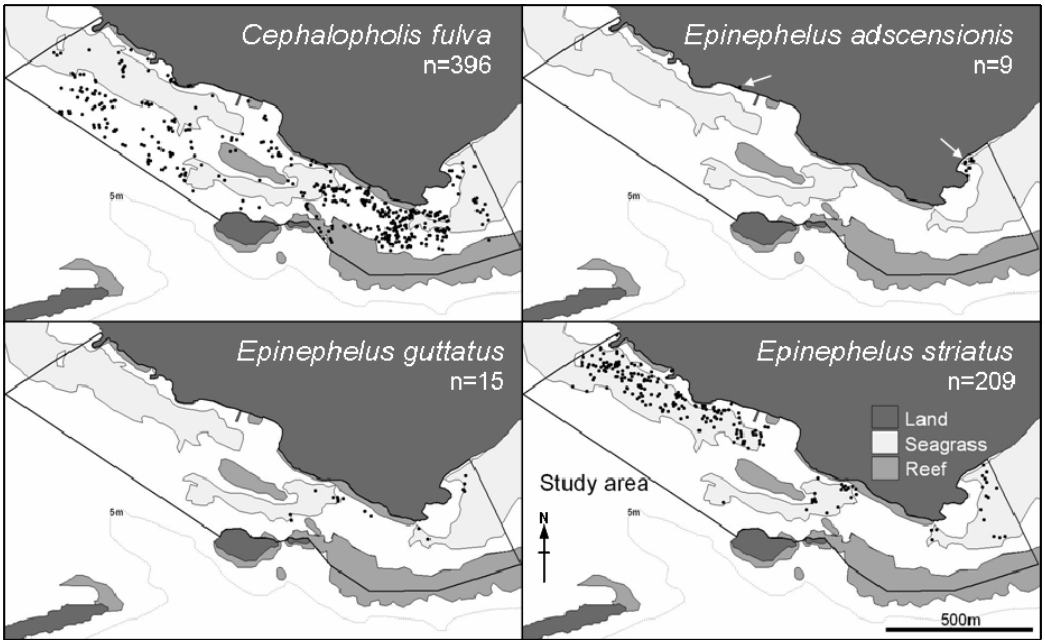

Figure 3. The location of early juvenile groupers (< 12 cm TL) within the study area. The systematically searched study area is delineated in black. Black dots represent sightings of early juveniles, and white arrows assist in displaying the locations of *Epinephelus adscensionis*.

habitat. As microhabitat, 47% (n = 7) used conch shells, 27% (n = 4) used blowout ledges and 20% (n = 3) used rock/coral heads. Red hind were only found in the southern half of the study area and not in areas further into the harbour.

Rock hind — Fifty-six % (n = 5) of the rock hinds were found in seagrass and 33% (n = 3) were found on reefs. All individuals found in seagrass also used blowout ledges as microhabitat. Rock/coral heads (n = 2), a discarded conch shell (n = 1), and an artificial structure (n = 1) were also used as microhabitat. All early juvenile rock hind were found in relatively turbulent areas within 10m of shore with one found sheltering in a crevice on the submerged base of a cliff. All but one were found in a cluster at the western end of East Bay.

Graysby — Three out of four individuals were found on reefs, the remainder found in rock/rubble habitat. Three used rock/coral heads as microhabitat and one was found under the ledge formed by a steel plate in a wreck. There was no discernible pattern to their spatial distribution.

DISCUSSION

Early juveniles of the five species of grouper observed in this study showed distinct but overlapping patterns of habitat use and spatial distribution. Coneys were found throughout the study area in a range of habitats, but had a preference for rock and rubble habitat. All three species of *Epinephelus* (Nassau grouper, red hind and rock hind) were most commonly found in seagrass. However, seagrass was not used evenly throughout the study area, nor was it used equally by the three species. Densities of Nassau grouper were highest within seagrass areas in the northern half of the study area further into the harbour, but all of the red hind were found in the southern half of the study area closer to the reef, and all the rock hind were found within 10 m of land.

Despite sightings of adults nearby, no early juvenile tiger or yellowfin grouper were found in this study. The absence of these congeners may be a result of (1) their scarcity (reflected by low densities of adults J.A.B.C unpublished data), (2) possible cryptic behaviour that prevented detection, or (3) preference for habitats not sampled in the present study. Data on habitat preference of *Mycteroperca* spp. are mostly limited to gag, *M. microlepis* (see Casey *et al*. 2007), a species not found around the TCI, and early juvenile tiger and yellowfin groupers may prefer the expansive deeper reef or shallow mangrove areas that were not surveyed in this study.

Coneys were often recorded swimming above the substratum and did not always seek shelter when approached by observers. However, the early juveniles of all other groupers were seen sheltering in structures, resting a few centimeters away from shelter and/or sought shelter within structures shortly after being disturbed by observers. For the three species most commonly found is seagrass, the two of the most important structures used as microhabitat were discarded conch shells and blowout ledges. Individuals were rarely seen in open seagrass habitat without concentrating movements around a specific structure or sheltering within it.

Early juvenile coneys appear to use habitat in a similar way to conspecific adults and, although only four individuals were observed in this study, early juvenile graysbys also appear to use the same habitat as adults (see Nagelkerken 1981 for description of adult habitats). As congeners, this may be a pattern consistent with *Cephaplopholis* spp.. This, in turn, may be a reflection of the fact that these species mature at smaller sizes than other groupers found around South Caicos. Indeed, the term early juvenile may not be appropriate to some of the coneys observed in this study: coneys are likely to reach sexual maturity at sizes smaller than 16 to 25 cm TL stated by Thompson and Munro (1978), as is evident from no juveniles being found in a sample of over 900 individuals in Bermuda that ranged to as small as 15cm TL (Trott 2006) and small individuals of possibly smaller but unconfirmed sizes have been observed spawning (Brightman Claydon Unpubl. data).

In the Bahamas, early juvenile Nassau grouper have displayed a strong preference for macroalgal habitats, in particular areas where *Laurencia* spp. covers dead finger coral, *Porites porites* (Dahlgren and Eggleston 2001, Eggleston 1995). Such habitat may not be as important to Nassau groupers around South Caicos: in the present study no Nassau groupers were found in this habitat. This could be explained by the limited coverage of macroalgal beds in the study area. However, in a separate study focusing on macroalgal beds at alternative sites around South Caicos, surveys also revealed surprisingly few early juveniles (Brightman Claydon Unpubl. data). The apparent differences between early juvenile habitat in the two locations may be a reflection of location specific habitat requirements. Alternatively, the characteristics preferred by settling larvae may be the same in both locations, and these unknown characteristics correspond to areas more likely to be covered by macroalgae in the Bahamas and more likely to be covered by seagrass in South Caicos.

The use of discarded queen conch shells as habitat for fish (including Nassau grouper) has been observed in other studies (Colin *et al*. 1997, Shulman 1984, 1985, Wilson *et al*. 2005). However, in a previous experiment assessing use of discarded conch shells around South Caicos, only one Nassau grouper was found using this microhabitat (Wilson *et al*. 2005). The present study shows a far stronger association between early juvenile Nassau grouper and conch shells and the reason for the discrepancy is unclear. Wilson *et al*s.' (2005) observations were made later in the year (October to January *versus* May to August) when many Nassau groupers may have outgrown and migrated away from early juvenile habitat (Dahlgren and Eggleston 2001, Eggleston 1995). However, a relatively

high density of Nassau grouper have been observed using conch shells in the study area from October to December (Brightman Claydon Unpubl. data).

Wilson *et al*.s' (2005) observations were made in a range of habitats including seagrass, and where conch shells were abundant. However, the sites surveyed may have been avoided by Nassau grouper. In the present study, early juvenile Nassau grouper were largely absent from the area of seagrass to the north of Dove Cay despite the abundance of conch shell and blowout microhabitat and despite the habitat appearing similar to the seagrass habitat in the north of the study area that housed the highest densities of this species (*i.e.* dense mixed stands of *Thalassia testudinum* and *Syringodium filiforme*). Similarly, around Mona Island, Puerto Rico, 19,800 m^2 of shallow back reef habitat were surveyed, but all sightings of early juvenile Nassau grouper were made within 200 m of each other and this included observations made five years apart (Aguilar-Perera *et al*. 2006). Thus, the nursery function of habitats of superficially similar characteristics may differ considerably. To some extent this may correspond to the ingress of larvae and differential post-settlement processes (see review by Jones 1991). However, in this study, the three species that were found most commonly in seagrass habitats displayed very different spatial distributions that are also likely to correspond to subtleties in habitat preference.

Fishermen around South Caicos usually dispose of conch shells in piles (middens) away from areas in which the live conch were harvested. This practice stems for at least three reasons:

i) There is a widespread belief amongst fishermen that discarded conch shells will scare away live conch from an area (Gisele Magnusson, NOAA Unpubl. data),
ii) It may be more convenient for a boat to knock conch *en masse* at sheltered sites, and
iii) Fishermen have been encouraged to dispose of conch shells in this fashion because it creates habitat used by a variety of fishes, many of which may be harvested (Wilson *et al*. 2005).

Although these data were not specifically collected, early juvenile Nassau grouper appeared to prefer solitary conch shells rather than middens. Early juveniles prefer to seek shelter away from other fish, and fish (especially *Stegastes* spp.) were found on all middens studied by Wilson *et al*. (2005), but not all solitary conch shells were colonized and thus represent a microhabitat more favourable for Nassau grouper. Solitary conch shells were also used as microhabitat by other fishes and juvenile spiny lobsters (Kroetz and Brightman Claydon Pers. observ.). A strategy to enhance the nursery function of seagrass habitats in the TCI could include the deployment of solitary conch shells in suitable areas around the islands. This strategy could complement the current practice of creating middens and be of benefit to two important fisheries in the TCI.

CONCLUSION

The shallow seagrass, reef, rubble and rock habitats surveyed around South Caicos housed high densities of early juvenile groupers. These habitats are threatened by their close proximity to land and the activities of large vessels. This is particularly the case for the seagrass area to the north of the study area, some of which lies along the route taken by container ships heading to and leaving from the nearby dock. This area appears to be especially important for the regionally endangered Nassau grouper and may represent essential habitat that supplies many of the adults found in deeper reef areas outside of the harbour. A successful management strategy for groupers must also account for the early juvenile stages of these species and offer protection to their often vulnerable habitats (Tupper 2007).

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LITERATURE CITED

Aguilar-Perera, A., M. Scharer, and M. Nemeth. 2006. Occurrence of juvenile Nassau grouper, *Epinephelus striatus* off Mona Island, Puerto Rico: considerations of recruitment potential. *Caribbean Journal of Science* **42**:264-267.

Casey, J.P.,G.R. Poulakis, and P.W. Stevens. 2007. Habitat use by juvenile gag, *Mycteroperca microlepis* (Pisces: Serranidae), in subtropical Charlotte Harbor, Florida (USA). *Gulf and Caribbean Research* **19**:1-10.

Coleman, F.C., C.C. Koenig,G.R. Huntsman, J.A. Musick, A.M. Eklund, J.C. McGovern, R.W. Chapman, G.R. Sedberry, and C.B. Grimes. 2000. Long-lived reef fishes: the grouper-snapper complex. *Fisheries* **25**:14-21.

Colin, P.L.,W.A. Laroche, and E.B. Brothers. 1997. Ingress and settlement in the Nassau grouper, *Epinephelus striatus* (Pisces: Serranidae), with relationship to spawning occurrence. *Bulletin of Marine Science* **60**:656-667.

Cornish, A. and A.M. Eklund. 2003. *Epinephelus striatus*. In: IUCN 2007. 2007 IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 20 November 2007.

Dahlgren, C.P. and D.B. Eggleston. 2001. Spatio-temporal variability in abundance, size and microhabitat associations of early juvenile Nassau grouper *Epinephelus striatus* in an off-reef nursery system. *Marine Ecology Progress Series* **217**:145-156.

Eggleston, D.B. 1995. Recruitment in Nassau grouper *Epinephelus striatus*: Post-settlement abundance, microhabitat features, and ontogenetic habitat shifts. *Marine Ecology Progress Series* **124**:9-22.

Heemstra, P.C. and J.E. Randall. 1993. Groupers of the world (Family Serranidae, Subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date.: *FAO species catalogue*. FAO Fisheries Synopsis. No. 125, Rome, Italy.

Jones, G.P. 1991. Postrecruitment processes in the ecology of coral reef fish populations: a multifactorial perspective. Pages 294-328 in: P.F. Sale, (ed.). *The Ecology of Fishes on Coral Reefs*. Academic Press, San Diego.

Nagelkerken, W. 1981. Distribution of the groupers and snappers of the Netherlands Antilles. Pages 479-484 in: C.E. Birkeland, R.W. Buddemeier, R.E. Johannes, J.A. Marsh, Jr., R.T. Tsuda and E.D. Gomez, (eds.). *Proceedings of the Fourth International Coral Reef Symposium*. Manila, Philippines.

Rudd, M.A. 2003. Fisheries landing and trade of the Turks and Caicos Islands. *Fisheries Centre Research Reports* **11**:149-161.

Rudd, M.A. and M.H. Tupper. 2002. The impact of Nassau grouper size and abundance on scuba diver site selection and MPA economics. *Coastal Management* **30**:133-151.

Sadovy, Y. and A.M. Eklund. 1999. Synopsis of biological data on the Nassau grouper, *Epinephelus striatus* (Bloch, 1792), and the jewfish, *E. itajara* (Lichtenstein, 1822). NOAA Technical Report NMFS 146, and FAO Fisheries Synopsis 157.

Shulman, M.J. 1984. Resource limitation and recruitment patterns in a coral reef fish assemblage. *Journal of Experimental Marine Biology and Ecology* **74**:85-109.

Shulman, M.J. 1985. Recruitment of coral reef fishes: effects of distribution of predators and shelter. *Ecology* **66**:1056-1066.

Thompson, R. and J.L. Munro. 1978. Aspects of the biology and ecology of Caribbean reef fishes: Serranidae (hinds and groupers). *Journal of Fish Biology* **12**:115-146.

Trott, T.M. 2006. Preliminary analysis of age, growth, and reproduction of coney (*Cephalopholis fulva*) at Bermuda. *Proceedings of the Gulf and Caribbean Fisheries Institute* **57**:385-400.

Tupper, M. 2002. Essential fish habitat and marine reserves for groupers in the Turks & Caicos Islands. *Proceedings of the Gulf and Caribbean Fisheries Institute* **53**:606-622.

Tupper, M. 2007. Identification of nursery habitats for commercially valuable humphead wrasse *Cheilinus undulatus* and large groupers (Pisces: Serranidae) in Palau. *Marine Ecology Progress Series* **332**:189-199.

Wilson, S.K., S. Street, and T. Sato. 2005. Discarded queen conch (*Strombus gigas*) shells as shelter sites for fish. *Marine Biology* **147**:179-188.