Important Aspects of the life history of the Yellowfin Grouper, *Mycteroperca venenosa,* with emphasis on populations in the Caribbean

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1 Introduction

Interest in the status of the yellowfin grouper, *Mycteroperca venenosa*, populations off Puerto Rico and the U.S. Virgin Islands prompted the need to review and assemble the available biological and fishery information for this species. Historically this species has been an important component of commercial fisheries of Bermuda (Heemstra and Randall 1993), and the U.S., mainly the U.S. Caribbean Recent data on the landings and stock status of this species is lacking, except for Bermuda and the US Caribbean. Information on the life history and ecology is an integral component of stock assessment evaluations. This report reviews and synthesizes biological information from published and un-published sources with emphasis on yellowfin grouper populations in the U.S. Caribbean for use in stock assessment evaluations. The writer made extensive use of the material referenced in Froese, R. and D. Pauly (2007).

2.0 Species Description and Taxonomy

The yellowfin grouper species is a member of the genus Mycteroperca, family Serranidae (i.e., sea bass family) and commonly occurs in tropical, subtropical, and temperate seas (Figure 1). In general many of the members of this family are notably very colorful, in particular those of the genera Mycteroperca and Epinephelus. Most members of the Serranidae also have the characteristic ability to change colors in response to background. Sutherland et al. (1986) described members of these two families as: " being cosmopolitan in distribution, representing an important food resource, solitary, occurring over a wide depth distribution, inhabiting shallow inshore grass beds as juveniles out to the continental shelf break (adults), preferring hard bottom and offshore reefs that offer hiding niches.

The yellowfin grouper often called the "rockfish" is variably colored, sometimes olive-green with rows of rounded, irregular, dark blotches on its back (Figure 2). The belly is often salmon pink, and the mouth yellow inside and along the corners. The outer 1/3 of the pectoral fin is a brilliant yellow (http://www.boldwater.com/groupergallery.shtml). Specimens taken from depths of 35 m or more often have distinct red body coloration and even darker red blotches over the body (Figure 3). Two color phases were reported for the yellowfin grouper by Smith (1971), one the deep red color observed in the deep water individuals and another, more brownish observed in shallow water inhabitants. Thompson and Munro (1974) noted that juvenile yellowfin grouper were a deeper red than adults captured at comparable depths off Jamaica. These authors hypothesized that the transition from red to more dark brownish color was either a developmental trait or possibly suggests a movement of juveniles from deeper to shallow waters.

Visual similarities between the yellowfin grouper and the black and gag groupers have been noted, particularly in the rows of rectangular spots and blotches and the general dark coloration often observed which, tend to be larger and more defined in the black grouper. Also, the caudal fin of the black grouper tends to be straighter than that of the yellowfin grouper. Clear, distinguishing features include the wide, yellow margin on the pectoral

fins in the yellowfin grouper, usually a narrow, orange outer margin observed on the black grouper pectoral fins.

The name '*venenosa'* is said to be derived from the characteristic toxicity associated found in large specimens in regions where ciguatera occurs. Many members of the Serranidae family are frequently used in the aquarium trade due to the large size and colorful forms (http://zipcodezoo.com/Animals/M/Mycteroperca_venenosa.asp).

3 Distribution

This species occurs in the western Atlantic: Bermuda, Florida, around the Gulf of Mexico to Ilha dos Buzios, Brazil and central and South American coasts to the Guianas (Cervigon, 1966 cited in Brownell and Rainey 1971, Smith 1977 cited in Fishbase 2007 and, Figure 3 for distribution map). Although the distribution of the yellowfin grouper is for the most part continuous along the east coast of Central America within the Caribbean and along the east coast of South America south to Sao Paulo, Brazil, the extent of species occurrence as regards bathymetric range and abundance is not well documented. Some information exists to suggest that historically population concentrations were large throughout the distribution (Heemstra and Randall 1993).

4 Habitat Utilization

The yellowfin grouper is associated most often with irregular rock or coral bottom (Bullis and Thompson, 1965). Juveniles occur in shallow turtle grass beds. Some investigators describe the species as a solitary carnivore, adults known to lurk in wrecks, reef shadows, or ledges and occasionally over mud bottoms. Smith (1961) described the most species of groupers as being "*secretive and occupying crevices, ledges, and caves on reefs and wrecks".*

Brownlee and Rainey (1971) reported this species from trap catches off the Virgin Island occurring in depths from ten feet in shallow reef areas to upwards of 38 m at the shelf edge, and the mean depth of occurrence in the Virgin Islands was about 33 m. These investigators noted the yellowfin grouper as the second most abundant grouper in the Leeward Islands and throughout the Caribbean.

Nelson et al. (1982) reported yellowfin grouper bottom longline catches of about 0.4 kg per 100 hooks at depths of 100-198 m around Puerto Rico (west, northwest and north slope) and the U.S. Virgin Islands (north coast) from deep reef surveys conducted between 1967 and 1982. Later reports from the mid 1980's of bottom and bottom longline and trap surveys (off Puerto Rico and the U.S. Virgin Islands) however indicate yellowfin grouper were not present in longline (bottom or off bottom) catches and only occurred infrequently in traps at depths of 110-120 m (Russell 1984, Russell (1982). During these surveys deep water snappers (silk, queen, wenchman), Epinephelid spp. groupers (snowy, misty, yellowedge), and sharks (slope, Cuban, and smooth dogfish) dominated. Nelson et al. (1982) addressed the difficulties associated with using bottom longlines to sample reef fish in areas of dense coral and sponge habitat. Also,

quantifying the occurrence or abundance of reef species known to be more cryptic or secretive such as the yellowfin grouper using traps, longlines (bottom, off bottom, or visual census counts (point, transect) is not without difficulties. Sylvester and Dammann (1974) also reported the occurrence of yellowfin grouper in deepwater fishery surveys conducted off the Virgin Islands between 1970 and 1972 at depths of 100-300 m and, as with earlier investigators catches were dominated by silk and blackfin snappers. Collazo (1982 or 1983) reported that species

Although the range of depths reported for this species by Froese, R. and D. Pauly (2007) is 2-137 m (FishBase 2007), Roe (1976) from a review of 24 years of exploratory fishing and resource assessment activities in the Gulf of Mexico and Caribbean Sea, reported the bathymetric range for this species to be 9-284 m, widely variable between regions. Roe's tabled data though indicates a single observation at 284, exclusion of this point gives a range of 9 to 95m for these early surveys. Some records reported this species as not frequently observed in the Gulf of Mexico however, Roe (1976) reported the highest catches in the survey data he reviewed occurred off Texas and on Campeche Bank (Mexico). Roe's data included surveys using trawls (shrimp, fish), handlines, traps, gillnets, and bottom setlines and the fish captured ranged from 0.5 lbs to 11.5 lbs.

5 Diet and Parasitism

Randall (1967) described feeding for specimens collected off the US Virgin Islands and Puerto Rico and Siera et al. (2001) described feeding in this species for Cuban fish. Juveniles and adults feed predominantly on fish as do other members of this genus, although sometimes other organisms are utilized (e.g., squid, shrimp).

Groupers are considered to be opportunistic, generalized, top-level carnivores. Smith (1961) suggested that most groupers compete with other large and small carnivores in the same area and, particularly with other groupers and although predation occurs mainly on the younger stages, it does occur on adults (Parrish, 1985). It is worth noting that in general, the body form of the Mycteroperca is more terete (cylindrical and tapering) than that of either the Epinephelus or Cephalopholis families, and the Mycteroperca tend to forage higher above the bottom and appear to be stronger, more agile swimmers (Randall 1967 cited in Parrish 1987). Several studies noted the narrow range of preferred diet (for fish) as well as the tendency for members of this family to forage long distances, and further noted that in general, Mycteroperca spp habitat may be more dependent on shelter rather than on prey distribution. Parrish (1987) noted some of the interesting ecological concerns regarding shifts in prey abundance and availability and resulting impacts on predator abundance. He noted that for the most part the diet of the groupers (and many snappers) was sufficiently broad to allow shifts in feeding between prey groups, however he also pointed out that many of the preferred prey taken by the groupers (and snappers) required hunting, and most importantly that the distribution (and abundance) of these groups are not uniformly or densely distributed. Reductions in predator abundance resulting from intensive fishing could potentially have significant impact on population levels of these prey groups (Goeden 1982 cited in Parrish 1987).

Parasitic isopods have been observed clinging to the nostrils of yellowfin grouper (Thompson and Munro, 1974). Larval tapeworms are known to become encysted in the viscera of this species as well. The ovaries of the yellowfin grouper have been observed to be infected with a reddish-brown nematode (Thompson and Munro); the latter could possibly significantly impact the egg production capability

6 Longevity and Growth

The yellowfin grouper can attain sizes upwards to about 20 pounds and about 40 inches (100 cm TL-males); normally though this species does not reach similar maximum sizes as other member of the Mycteroperca family (e.g., Black, scamp, gag, tiger). Lmax (maximum size) was reported to be 86 cm Puerto Rico (Appledorn et al. 1987) and 91 cm for the Virgin Islands (Randall 1968). Manooch (1987) provided a brief review of the literature for yellowfin grouper.

Munro and Williams (1985) reported growth rate (K) and asymptotic size (L-infinity) information for fish from St. John to be 0.086 and 89.5 cm TL. For fish collected off Jamaica values of 0.10 - 0.17 (range) and 86.0 cm TL were reported for K and L-infinity (n=198, Thompson and Munro, 1974). Thompson and Munro (1974) also examined otoliths for use in age and growth studies for a variety of groupers from the *Epinephelus* and *Mycteroperca* families. These authors reported that those of the *Mycteroperca* were thinner and clear more easily in the fixing process than those of the *Epinephelus* spp.. Also, these authors reported that of all the Mycteropeca spp. examined only ***M. venenosa*** were readable. Thompson and Munro (1974) estimated from the otoliths of 27 individuals "that about 4 years were required for fishes to reach a total length of 46 to 57 cm (average 51 cm TL) and at age 10, a size of about 70 cm (about 3cm per year) would be achieved. If asymptotic size were 86 cm TL then the growth rate parameter K is 0.1.

Published weight length relations and length conversion formulae are presented in Tables 1 and 2 as reported by Pauly and Froese (2007).

7 Maturation, Reproduction, and Fecundity

The yellowfin grouper is believed by many to be a protogynous hermaphrodite, changing from female to male in the latter part of life. However, Tupper (1999) pointed out that only the red hind and coney had been histologically proven to be protogynous and further noted that neither Nassau grouper nor yellowfin grouper has been definitively shown to be protogynous, although both are known to aggregate (Shapiro 1987). As with the tiger and black grouper gametogenesis is classified as "Type A" (see Garcia-Cagide et al. 2001), discontinuous asynchronous, with intermittent spawning. Different batches of occytes mature asynchronously so ovaries carry different sizes and stages of vitellogenic oocytes (Garcia-Cagide et al. 2001). The Type A spawning has the effect of allowing several batches of eggs (possibly up to 7 or 8 – Claro and Lindeman 2003) to be released during one spawning aggregation. This is in contrast to the other type oocytes development process seen in snappers and groupers, Type D, in which oocytes develop all at the same rate but release at different rates and from 4-5 egg batches are released per spawning aggregation (Claro and Lindeman, 2003 and Garcia-Cagida et al. 2001).

Smith (1961) estimated fecundity for a single yellowfin grouper to be 1,425,443 eggs at about 51 cm TL. Eggs and larvae are planktonic, larvae settling out from one week to two or three months (Sutherland et al. 1986 citing the work of Smith 1961).

Taylor and McMichael (1983) reported fecundity estimates for two fish to be 1,994,740 ± 26,734 oocytes (70 cm) and 2,874,665 ≠ 12,966 (72 cm).

7.1 Maturation Size

Taylor and McMichael (1983) observed male yellowfin grouper mature at 54 cm SL in the Florida Keys. Garcia et al (1994) using data from Thompson and Munro (1978) calculated maturation size for females to be 51 cm for Cuban fish. Thompson and Munro (1978) reported sex ratios of mature yellowfin grouper from unexploited oceanic banks off Jamaica, to be M:F = 1.18:1. Tuz-Sulub et al. (2006) microscopically examined yellowfin grouper from Campeche Bank (n=363, range 390 to 920 mm total length). They observed that most specimens (males and females) were reddish in color with rounded dark blotches on the sides of the body and small dark red spots on the ventral head and body (Figure 5). These authors reported no transitional fish.

7.2 Spawning Timing

Yellowfin grouper spawn off Bermuda in July, in the Florida Keys during March, and on the Florida Middle Grounds (off West Florida in the eastern Gulf of Mexico) from March to August (Bullock and Smith 1991, Heemstra and Randall 1993). Tuz-Sulub et al. (2006) observed yellowfin grouper spawning during spring, March to May, off Campeche Mexico.

Spawning occurs during March in the Florida Keys (Taylor and McMichael 1983), and from March and M ay to August in the Gulf of Mexico (Bullock and Smith 1991; Appendix 4) and during July off Bermuda (Smith 1958).

Yellowfin grouper have been reported to spawn from February through April off Jamaica (Chan and Sadovy 2002, Thompson and Munro 1978) and from January through June off Cuba (García-Cagide et al. 1994). Off the Grammanik Bank in St. Thomas, U.S. Virgin Islands spawning occurs from February through April, apparently with peaks occurring in March with full moon (Nemeth 2004).

7.3 Sexual Dimorphism

Tuz-Sulub et al. (2006) documented sexual dichromatism in yellowfin grouper spawning aggregations from Campeche Bank. Male fish were observed to have a bright yellow blotch on both sides of the lower jaw while the majority of spawning females retained a reddish lower jaw (Figure 5.) In their samples, histological examination of the gonads confirmed males were 25% of the total and ranged in size from 390-920 mm (n=90) and females were 75% of the total and ranged from 430-853 mm (Figure 6, Table 3). No transitional fish were observed. Of the 90 males examined histologically, 97% of these (n=87) had the bright yellow blotch on the lower jaw, and ranged in size from 617-

920 mm). The authors noted that all males were sexually active (ripening, ripe-running, or spent) and that 80% of the females were. The remaining 20% of the females were immature or resting, however no further details were provided regarding size of these non-sexually active females.

7.4 Spawning Aggregation (SPAG) Information

Several studies have reported that the yellowfin grouper aggregates at some of the same sites utilized by the tiger, Nassau, and black groupers (Sadovy *et al.* 1994, Beets and Friedlander 1992, Fine 1990). It is worth noting that most of the data relating to yellowfin grouper spawning aggregations has obtained ancillary to field studies being conducted for mainly the Nassau and secondarily more recently from studies of the tiger groupers off Puerto Rico.

7.4.1 US Virgin Islands

Olsen and LaPlace (1978) in their study of the Nassau grouper and red hind aggregation about eight miles off the south coast of St.Thomas (US Virgin Islands) between 1974 and 1978, made a brief mention of the occurrence of yellowfin grouper aggregations on the same site immediately after cessation of spawning by these two species. Although, the Nassau and red hind had apparently been exposed to intense fishing for the previous 25 years, Olsen and LaPlace (1979) suggested that the yellowfin population in that area was 'at near zero fishing effort exposure'. Although, not definitive this information could suggest that the yellowfin grouper population off St. Thomas (US Virgin Islands) was not undergoing intense exploitation in the late 1970's.

Sadovy et al. (1994) also reported that other aggregating sites existed for the yellowfin grouper off the US Virgin islands but had not been fully documented. Since that time, three additional aggregation sites have been documented off the US Virgin Islands and studied scientifically. Sites located north and south of St. Thomas are utilized from February through April. A third site located in the USVI National Park off St. John, USVI, is utilized year-round. Individuals aggregating at that site number about 200 (Rielinger 1999). Nemeth (2004a, b) has been studying grouper (tiger, red hind, yellowfin, and Nassau) spawning aggregations off St. Thomas since 2000

7.4.2 Puerto Rico

RicoYellowfin grouper aggregations have been observed off Vieques Island (Puerto Rico) along with tiger grouper in the El Seco area. The first reports of yellowfin grouper aggregations in this area occurred in the early 1980's from observations made by divers who reported large aggregations of tiger grouper off the eastern end of Vieques (Matos-Caraballo 1997, Sadovy et al., 1994). These concentrations of groupers were undergoing intense fishing as far back as the early1970's.

7.4.3 Cayman Islands

During field studies evaluating Nassau grouper aggregations off the Cayman Islands, Whaylen et al. (2004) observed small groups of yellowfin grouper aggregating (but not spawning) on the same site at night. Divers observed small groups, usually from

2-4 individuals, present at the time as Nassau and tiger grouper, the latter two species observed spawning. The grouper aggregations off the Little Cayman (east end) have been fished since about 1903, intensely in the mid 1980's and since 1995 there was no Nassau aggregation at Little Cayman. Whaylen et al. (2006) reported yellowfin grouper aggregating (but not spawning) on the west end of Little Cayman however, data on abundance of these sightings was not given.

Fine (1990, cited in Sadovy et al. 1994) suggested that yellowfin grouper and tiger grouper used the same sites off Guanaja, Honduras; this writer was unable to corroborate that reference.

7.4.4 Cuba

Claro and Lindeman (2003) provided empirical information on reeffish aggregation sites off Cuba's coast for 21sites where snappers and groupers commonly where reported by scientists and fishers between 1970 and 2000. All of these sites were located at the shelf break in depths of 20-50 m. Claro and Lindeman (2003) noted that published information on spawning sites in that region was unavailable for almost all species on the Cuban shelf. They obtained their data through interviews of commercial fisherman, often made in conjunction with other scientific studies. Only sites with unusually large catches of fishes with running-ripe or enlarged gonads during known spawning peaks were identified as potential spawning aggregation sites. Yellowfin grouper were reported aggregating at nearly all of the 21 sites and spawing aggregations were reported at one site off the southwestern coast (Puntalon de Cayo Guano). Also present with yellowfin grouper were spawning groups of the black and Nassau grouper. These species aggregated there from December to March, spawning with peak spawning occurring at different times for each species. Claro and Lindeman's tabled data indicated that over the 30 year study period, 1970-2000, that qualitatively, general the size of the yellowfin grouper spawning aggregations had declined at the majority of the sites where yellowfin were known to occur. The authors emphasized that the spatial and quantitative information obtained regarding these aggregation was a result of fishing effort and validation effort. Information was presented on location, habitat type at the site, spawning peak by species, time of spawning, lunar period, and gear actively used on the aggregation.

7.4.5. Mexico

Tuz-Sulub *et al*. (2003) presented the first evidence on the formation of aggregations for *M. venenosa* from a spawning site off "Bajos Del Norte" about 137 miles northeast of Progresso Port, Mexico (Campeche Bank). The area is characterized by a range of submarine mountain like reef formations, and ranges from about 5-20 m. The total catch for groupers, done during five days of fishing in February 2001 at this spawning site, reached a total of 2.4 metric tons. Yellowfin grouper were reported spawning there along with the tiger and black groupers and red hind.

7.4.6 Belize

Sala et al. (2001) provided baseline information on the multi-species nature of the grouper spawning aggregations on Glover's Reef (Belize) and emphasized the need for

immediate attention to the other grouper species observed along with the Nassau grouper at these sites. The complex found at Glover's Reef includes the yellowfin, the tiger, and the black groupers as well as a large number of snappers, grunts, jacks and other reef fish species (in all there were over 20 species present). Sala et al. (2001) noted that data for the most part is lacking on the sizes of the grouper spawning aggregations throughout the Caribbean as well as the temporal variability in the aggregation size. These authors reported that historically a minimum of some 13 sites existed off Belize's barrier reefs and offshore reefs where, Nassau grouper and a variety of groupers, snappers, jacks, and grunts were known to aggregate for spawning. Biological and bio-economic studies by Sala et al. (2001) and also researchers at the Wildlife Conservation Society (WCS) since 1999 indicates that more than half of the traditional Nassau grouper spawning sites are now considered extinct, based on the lack of reproduction-size aggregations. In addition, Sala et al.'s study, found that the Nassau grouper spawning aggregation at Glover's reef had declined by 80% since the late 1960's. At the time of the Sala et al. (2001) survey, the estimated grouper aggregation size at Glover's Reef in 2001, was less than 3,000 Nassau and less than 200 black, tiger, and yellowfin groupers each. At one of the most historically productive sites, Cay Glory, one apparently which has been fished since the 1920's during that time period yielding from 1,200-1,800 Nassau grouper per boat per spawning season (or about 2 tons per day), during the 2001 survey by Sala et al., catch per boat averaged about 9 Nassau groupers out of an aggregation of 21 groupers at Cay Glory (Craig 1969, Paz and Grimshaw 2001 cited in Sala et al., 2001). Historically the Cay Glory (Belize) Nassau grouper spawning aggregation approached about 15,000 fish in size (Sala et al, 2001).

In 2002, the Belize government enacted regulations that halted fishing in 11 traditional offshore spawning areas and also established a four-month closed season for grouper fishing (http://news.nationalgeographic.com/news/2003/03/0304_030304_belizefish.html). In addition, off Belizean waters 12 marine protected areas are contained within the reef and seven of these have been designated UNESCO World Heritage status.

During 2003, monitoring of grouper spawning aggregations by Belizean scientists at three of the historically active sites (i.e., Nicholas Caye, Caye Glory (Emily), Rocky point, Sand Bore (Lighthouse Reef) continued as well as one new site was surveyed (Belize fisheries Department, 2005). This research was recommended by the Technical Working Group as an element within the component of **Promoting Sustainable Use of the Mesoamerican Barrier Reef Systems (MBRS)** and the sub-component of **Promoting of Sustainable Fisheries Management under the 2003-2004 MBRS Annual Work Plan** to monitor spawning aggregation sites (Belize Fisheries Dept, 2005). Yellowfin grouper and two other common Mycteroperca groupers known to co-occur with the yellowfin, the tiger and the black grouper were both observed during these dives. Precise estimates of the numbers of yellowfin grouper were not available however; the plotted data suggest that less than 100 individuals were observed at any site.

The Belizean Nassau grouper SPAG evaluation case example is particularly relevant in the examination of the health of the yellowfin grouper in the U.S. Caribbean. To summarize the current status of information on the yellowfin grouper, Domeier et al.

(2002) wrote, "*Mycterperca venenosa - is a large species with poorly know aggregations, uses multi-species sites, exploited in many areas*". Similar spawning aggregation information and additional biological information (abundance, site location, tagging data, emigration rates, socio-economic, etc.) such as obtained in the Belizean studies for the Nassau grouper and in the US Virgin Islands for the red hind, are critically needed to quantify and describe spawning aggregations of the yellowfin, tiger, and black groupers. Interestingly, Whaylen et al. (2006) wrote "the locations of many of the Nassau grouper spawning aggregations have been know for at least a century ", yet information remains lacking for many of the other grouper species. An excellent source of information pertaining to methodology and protocol in use in the Mesoamerican quantifying information on reef fish aggregations can be found at http://www.reefresilience.org/r2spawning/index.htm and also at http://www.scrfa.org/server/home/index.htm.

All of the above examples suggest that throughout the range of the yellowfin grouper, aggregations have declined. An immediate need exists to further quantify the available information from the published and unpublished literature and to conduct new field studies to document and study spawning aggregations of the yellowfin, tiger, and black groupers, including location, duration of aggregation (timing), number of individuals by site locale, size, reproductive condition, sex ratios, biological metrics (individual size or length), depths of aggregation location, periodicity in aggregation timing, social behaviors characteristics of the aggregation, and population removal (extraction) information both historical and present-day, and habitat and environmental conditions (e.g., MBRS 2004, Heyman et al. 2002, Johannes et al. 1994). Although information from throughout the species range is vital to any comprehensive analysis of yellowfin grouper population status throughout the species range, of immediate need to the SEDAR14 and subsequent management process for the US Caribbean resource, would be to quantify such spawning aggregation information for the U.S. Caribbean (Puerto Rico and St. Croix geological platform) yellowfin grouper population.

8 Natural Mortality (M)

Munro and Williams (1985) reported M for fish off Jamaica to be 0.42 per year. Thompson and Munro (1978) reported a range for M to be 0.23-0.61, for yellowfin grouper captured at unexploited oceanic banks off Jamaica, corresponding to the range of values for K of 0.10-0.27. These authors utilized the Beverton and Holt (1956) formulation to calculate M, the latter computes M from the relative abundances of successive length groups. Ault (et al., 2005) calculated M to be 0.20 using the method of Alagaraga (1984), the latter procedure the author indicated was 0.20 based on lifespan.

9 Conservation Issues

The yellowfin grouper is considered, according to the International Union for the Conservation of Nature and Natural Resources (IUCN), as "Near Threatened"[1]. This

[1] Near Threatened: "A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future."

determination was made by the IUCN based on a review of the trends in landings and spawning aggregations throughout the species distribution (range) that included Bermuda, the US (mainly Caribbean), Cuba, Mexico and Belize. Percentage declines of landings of 80% were observed between 1975 and 1981 in Bermuda, and 94% in the US Caribbean from 1990-2001. Off Cuba, Mexico and Belize the size of spawning aggregations declined also. Large declines in commercial landings of this species have been reported, concomitant with increases in fishing intensity throughout the range, however in many regions information is lacking to document spawning aggregations. This species is particularly vulnerable to fishing pressure during spawning aggregation formation. Based on the available information on fishery declines and spawning aggregation information, the IUCN Red List has also identified the yellowfin grouper as close to a "Vulnerable" listing[2] under IUCN criteria A2d, and in addition highlights the need for more data and more effective management. A schematic of the IUCN designation categories and criteria is presented in Figure 5 (http://www.iucnredlist.org/search/details.php/44683/all .

Based on criteria contained within the Sustainable Fisheries Act of the Caribbean Fishery Management Council (CFMC), FMP the yellowfin grouper stock in the U.S. Caribbean is undergoing Overfishing. The CFMC recently enacted regulations to prohibit harvest of any fish from February 1 through April 30, for yellowfin grouper within the Grammanik Bank area off St. Thomas, U.S. Virgin Islands. The Grammanik Bank is an area that has been closed to fishing seasonally since 1990, and permanently since 1999 to protect spawning red hind The recent total harvest regulation was specifically designed to protect known spawning aggregations of the yellowfin grouper in that area. The decline of the yellowfin grouper spawning aggregation in this area was documented to have begun around 2002-2003 (Nemeth 2004b).

Mexico also has responded to concern for the status of this species, with a closure from January 15 to February 15 on the Campeche Bank, a minimum size regulation of 30 cm TL, and an annual catch quota of 1,200 mt for the Cuban fleet of all groupers (SEMARNAP cited in IUCN Red list document).

Largest conservation concerns include spawning stock overfishing and habitat destruction, and the general lack of quantitative information to quantify population status throughout the species range. Possible steps suggested for reversing population declines include incorporating known spawning aggregation sites into management planning, including the development of long term spatially comprehensive monitoring programs. In addition, imposing specific gear restrictions on particularly vulnerable fish populations was recommended (Luckhurst 2003).

The status of the yellowfin grouper has not been assessed relative to the pre-Sustainable Fisheries Act (SFA) definitions of overfished and overfishing. Under these definitions, the stock would be overfished when the transitional SPR is less than 20%

[2] Vulnerable:" A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild."

SPR. Overfishing is defined as a fishing mortality rate in excess of that corresponding to a 20% SPR level (NMFS 2002). This species is managed together with the red, black, misty, yellowedge, and tiger groupers in Grouper Unit 4. The SFA Working Group classified the status of Grouper Unit 4 as "at risk (Final Rule for the Fisheries of the Caribbean, Gulf of Mexico, and South Atlantic; Comprehensive Amendment to the Fishery Management Plans of the U.S. Caribbean, 2005)

The yellowfin grouper is thought by some scientists to have low population resilience, to be very vulnerable to fishing gear, particularly during spawning aggregation period, thus very susceptible to overfishing. In addition, estimates of the minimum population doubling time are from 4.5 to 14 years (Froese and Pauly, 2007).

10 Other Issues of Interest

There have been frequent reports that the yellowfin grouper can cause ciguatera poisoning (Haalstead et al. 1990 cited in Froese and Pauly 2007, Bohlke and Chaplin, 1968 cited in Brownell and Rainey 1971). Although, individuals from the Bahamas and the Virgin Islands have been recognized as ciguateric, this species traditionally was a desirable food fish and even large individuals, 5 to 10 kgs in size, from locales considered safe were sold and consumed. Some researchers consider this species to be more frequently associated with ciguatera poisoning that other groupers (http://research.myfwc.com/gallery/image_details.asp?id=13233).

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Figure 1. Photo of Yellowfin grouper, ***Mycteroperca venenosa.*** From Fishbase 2007. Submitted by Robert A. Patzner.

Figure 2. Yellowfin grouper on cleaning station, showing distinct yellow coloration on the pectoral fin, from the Caymans . [Photograph taken by Jonathan Powel: http://www.reefnews.com/reefnews/news/v06/v06n08/moraygpr.html].

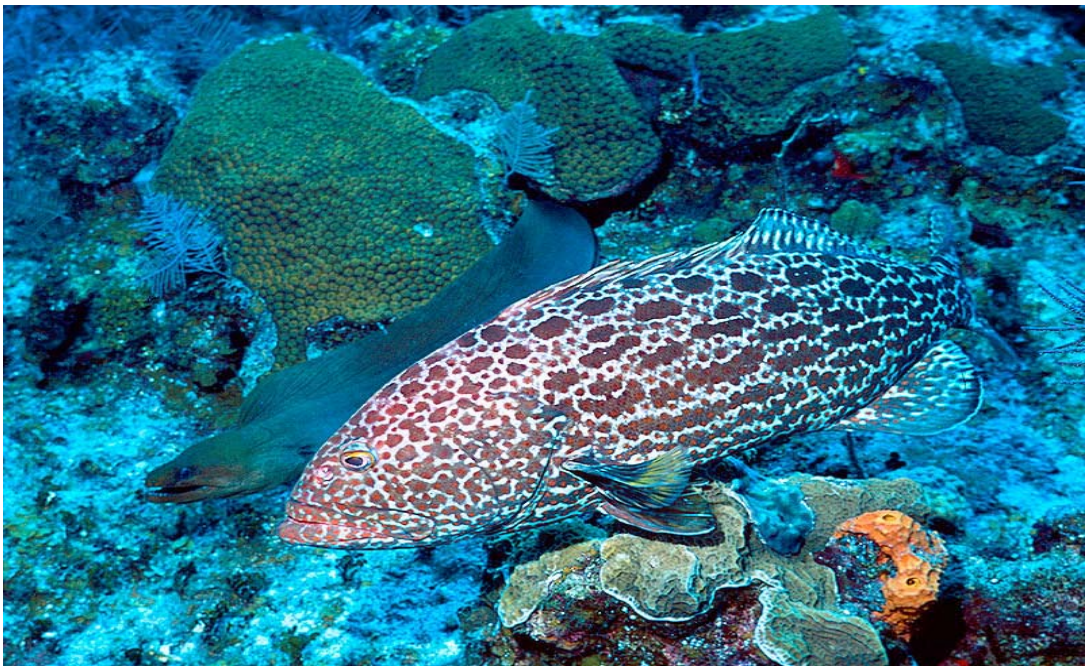

Figure 3. Yellowfin grouper displaying distinct red coloration, in the Caymans. [Photograph taken by Jonathan Powel: Jonathan Powell: http://www.reefnews.com/reefnews/news/v06/v06n08/moraygpr.html].

Figure 4. Computer Generated Native Distribution Map of *Mycteroperca venenosa* (un-reviewed) Distribution: Western Atlantic: Bermuda, Gulf of Mexico and the Caribbean south to Sao Paulo, Brazil. Central and south American coasts to Guianas (Ref. 26938). [Reprinted from Fishbase 2007].

FIG. 2. Colour variations on the lower jaw of male and female yellowfin grouper from Bajos del Norte and Cayo Arenas, Campeche Bank, Mexico: (a) 870 mm total length (L_T) male with bright yellow blotch (⇒) on lower jaw and (b) 740 mm L_T female with reddish lower jaw (⇒).

Figure 5. Photographs of yellowfin grouper sampled from Campeche Bank, Mexico illustrating sexual dichromatism. Reprinted from Tuz-Sulub et al.(2006).

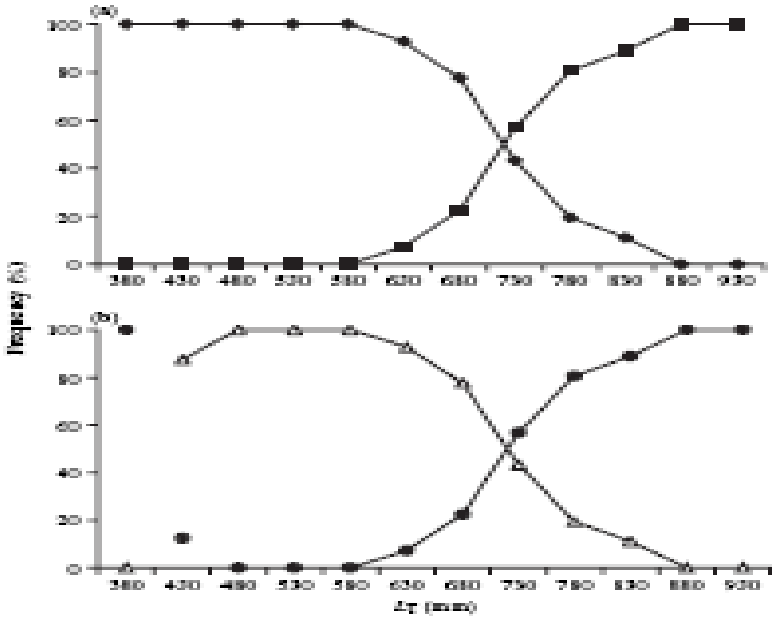

FIG. 3. Size-frequency distribution for yellowfin grouper from Bajos del Norte and Cayo Arenas, Campeche Bank, Mexico. (a) Individuals with (■) or without (●) bright yellow blotch on lower jaw and (b) male (■) and female (□) fish.

Figure 6. Size frequency information of yellowfin grouper by a) dichromatic type (with or without identifying yellow blotch on lower jaw) and by b) sex (male, female). Reprinted from Tuz-Sulub et al. (2006).

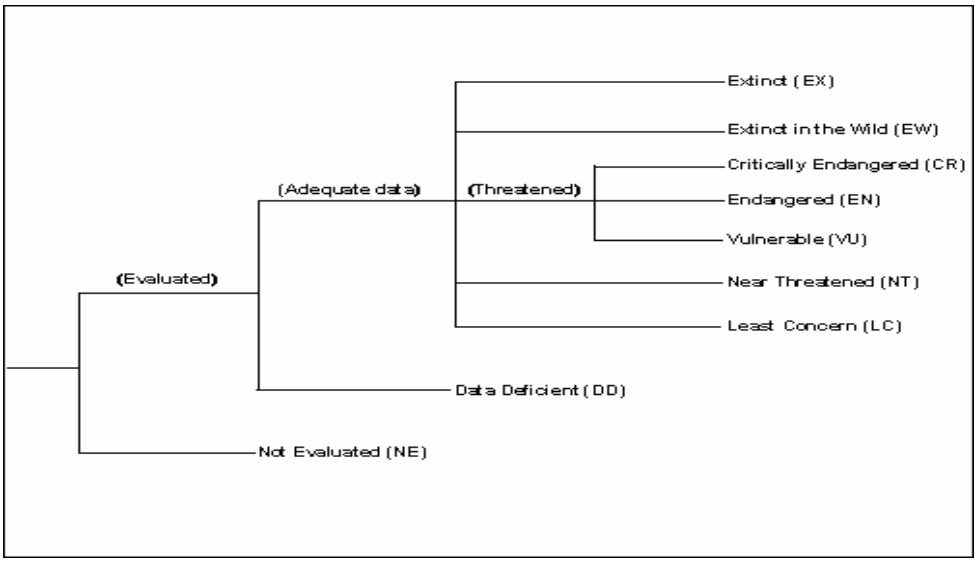

Figure 7. Structure of the IUCN Listing Categories [From: http://www.iucnredlist.org/info/categories_criteria2001].

Table 1. Yellowfin grouper weight – length equation parameters (Tabled data reprinted from Froese and Pauly (2007), equation form = log (W)=log(a) + b * log(L)).

a	b	Sex	Length (cm)	Len_Unit	n	Country	Locality
0.0198	2.976	unsexed	22.0 - 55.0	FL	19	Puerto Rico	
0.0269	2.980	unsexed	31.0 - 69.0	TL	36	Cuba	Southwest Zone
0.0122	3.000	unsexed	25.0 - 64.0	FL	11	US Virgin Is.	St. Croix
0.0132	3.040	unsexed	25.0 - 92.0	TL	54	Cuba	Southwest Zone
0.0069	3.140	unsexed	28.0 - 90.0	FL	103	US Virgin Is	St.T./St. J.

Table 2. Yellowfin grouper length conversion formulae (Tabled data reprinted from Froese and Pauly (2007), equation form = Unknown Length = a + b * Known Length).

Unknown Len Unit	a	b	Known Len Unit	Len Range(cm)			Sex
SL	0.310	0.880	TL	25	-	54	Unsexed
TL	0.000	1.031	FL		-		unsexed
TL	0.000	1.037	FL		-		unsexed
TL	0.000	1.051	FL		-		unsexed
TL	1.000	1.160	SL	26	-	77	Unsexed
TL	0.000	1.208	SL		-		unsexed
TL	0.000	1.304	SL		-		unsexed
TL	0.000	1.327	SL		-		unsexed

Table 3. Information on size and sexual dichromatism recorded for yellowfin grouper from Campeche Bank, Mexico. Tabled data reprinted from Tuz-Sulub et al. 2006).

TABLE I. Number of males and females with or without bright yellow blotch on lower jaw, by total length class, for yellowfin grouper caught between March and May 2002 and 2004 at Bajos del Norte and Cayo Arenas, Campeche Bank, Mexico

	Males			Females	
L_T class (mm)	n[a]	n with bright yellow blotch	n without bright yellow blotch	n[a]	n without bright yellow blotch
360–400	1	0	1	0	0
410–450	1	0	1	7	7
460–500	0	0	0	26	26
510–550	0	0	0	51	51
560–600	0	0	0	56	56
610–650	5	4	1	64	64
660–700	13	13	0	45	45
710–750	21	21	0	16	16
760–800	25	25	0	6	6
810–850	16	16	0	2	2
860–900	7	7	0	0	0
910–950	1	1	0	0	0
Total	90	87	3	273	273

[a]Sex determined from histological sections of gonads.