

Probable Nursery Areas for Juvenile Groupers Along the Northern Coast of the Yucatan Peninsula, Mexico

XIMENA RENÁN¹, KENNETH CERVERA-CERVERA²,
and THIERRY BRULÉ¹

¹*Centro de Investigación y Estudios Avanzados del IPN, Unidad Mérida,
Mérida, México*

²*Centro Regional de Investigación Pesquera.
CRIP- Yucalpetén, SAGARPA.
Yucatán, México*

ABSTRACT

Groupers contribute with the maximum number of individuals and catch biomass of the entire Yucatan's fishfish production. Despite the importance of this resource, little information is available on the biology of grouper juveniles.

Through a five month survey in nine different sites along the coast, we captured 192 individuals, belonging to five species of juvenile's groupers. *E. morio* (5.5* cm), *M. bonaci* (38* cm), *M. microlepis* (7.1* cm), *E. striatus* (34* cm) and *E. adscensionis* (15.7* cm) (*minimum value for standard length). *E. morio* was the most abundant specie captured (N = 89), following *M. microlepis* (n = 84) and *M. bonaci* (n = 17), being July the month in which more individuals were captured (n = 89).

The potential nursery areas defined by this study match the four natural protected areas along the coast of Yucatan, even though when these areas were decreed, the marine environment was not taken into account, and there are no marine management plans for any of them. Therefore, this study is focused on the distribution of juveniles, potential nursery and recruitment areas, and habitat dependency along the Yucatan coastline.

KEY WORDS: Groupers, juveniles, nursery areas

INTRODUCTION

In Yucatan State, the catching of groupers was by 1995, the 91.5% of the entire national fishing production in Mexico and in 2000, 8.755 tons were captured in this State (INEGI, 2000). Based on the studies carry out by Colás- Marrufo, *et al.*, (1998) and Tuz- Sulub (1999), 17 different species of groupers could be identified at the Campeche Bank. From these species, the most important registered were the red grouper (*Epinephelus morio* 84% individuals), the black grouper (*Mycteroperca bonaci*, 12% individuals) and the gag (*Mycteroperca microlepis*, 2% individuals).

The shoreline of the state of Yucatan is approximate 342.47 km long, and represents different ecosystems such as coastal lagoons, estuaries, mangroves and an extensive continental platform (part of the Campeche Bank) limited 25 km inwards the Gulf of Mexico, where different bottom habitats can be found. This

biotic richness offers multiple possibilities for sustainable uses, such as fishing, which is the main economic activity of the state (Figure 1).

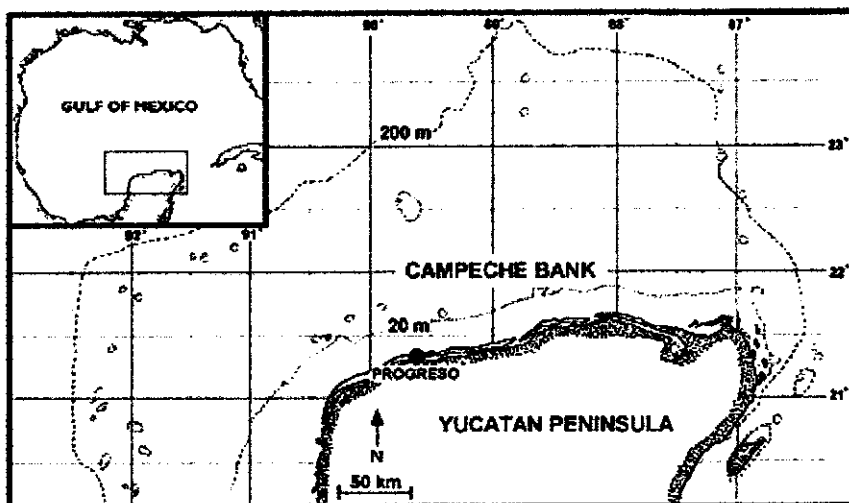


Figure 1. Map of the Yucatan Peninsula and the northern coast of Yucatan where the surveys were performed

In the state of Yucatan, and due to the bathymetric distribution known for groupers, juveniles live in shallow waters closer to the coast whereas adults select deeper habitats (Thompson and Munro 1978, Sluka and Sullivan 1996). The fishing activities for these populations are divided into technified and artisanal fishing fleets. The first fleet harvests mainly adults while the second one captures juveniles and sexually immature individuals (Sánchez-Salazar et al. 1999). Groupers are known to be hermaphrodite protogynous species (Moe 1969, Shapiro 1987, Sadovy and Shapiro 1987, Bullock and Smith 1991), but there are still some doubts whether some are monandric or diandric (Collins et al. 1987, Brulé et al. 1999, Renán et al., 2001).

The coastline of Yucatan has a dynamic and complex interrelationship between different natural, demographic and economical factors. These processes involve the exploitation and transformation of the whole natural system, which becomes the most important impacts to the topography's shoreline, its natural processes, and its biological resources (UNCED, *in*: INE 2000).

The Yucatan State has four Natural Protected Areas (272, 050 ha approximately) adjoined to the sea. Two of them are Natural Biosphere Reserves, Ría Lagartos, and Ría Celestún, and the other two are Natural State Reserves, Bocas

de Dzilam and El Palmar (INE 2000). Of the nine sites probed, six are found in these Protected Areas.

The main objective of this study is to determine the existence of potential nursery areas for groupers in order to established adequate management policies for this important fishery resource in four different Yucatan Natural Protected Areas. An additional objective is to determine, through histological samples of juvenile grouper gonads, whether these populations are diandric or monandric, at least for the captured species.

METHODS

Grouper juveniles were caught from June to November 2000 in shallow waters near shore (ranging from 1 to 10 m depth). These grouper juveniles were captured with standard hook, traps, a small trawl net, and spear gun fishing, depending on the type of bottom habitat existing in each site. Nine sites were chosen according their importance as fishing ports along the coast of Yucatan: El Cuyo, Ría Lagartos, San Felipe, Dzilam de Bravo, Progreso, Uaymitún-Telchac, Sisal, El Palmar and Celestún. These nine different sites (100 x 100 m) were surveyed for nine days each, in an extent up to 10 km from the shoreline using a small vessel belonging to the artisanal fleet (Figure 2). Data registered for each individual included grouper specie (Bullock and Smith 1991, Heemstra and Randall 1993, Humman 1994), collection date, location (using a GPS), fork (FL) and standard length (SL) (cm), total (TW) and gutted body weight (GW) (g), and gonads were removed for an histological study., The preserved gonads were embedded in paraffin, thin sectioned at 6 μ m, and stained as suggested in Gabe (1968). Gonads were examined to determine sex and gonad development, according to the microscopic cellular characteristics established by Moe (1969) and Brulé and Déniel (1996). Gonads exhibiting male-like tissue were classified as male according to Sadovy and Colin (1995). When no distinguishable tissue was observed, individuals were classified as "unidentified".

Data recorded for each site was number of species found per site, number of individuals captured per site, number of individual for each grouper species. Frequency histograms were done for the number of individuals for each species found per month and for the standard length of number of individuals. To establish the relationship between the standard length and the presence of males or "unidentified" individuals, a linear regression was performed ($\alpha = 0.05\%$)(Scherrer 1984).

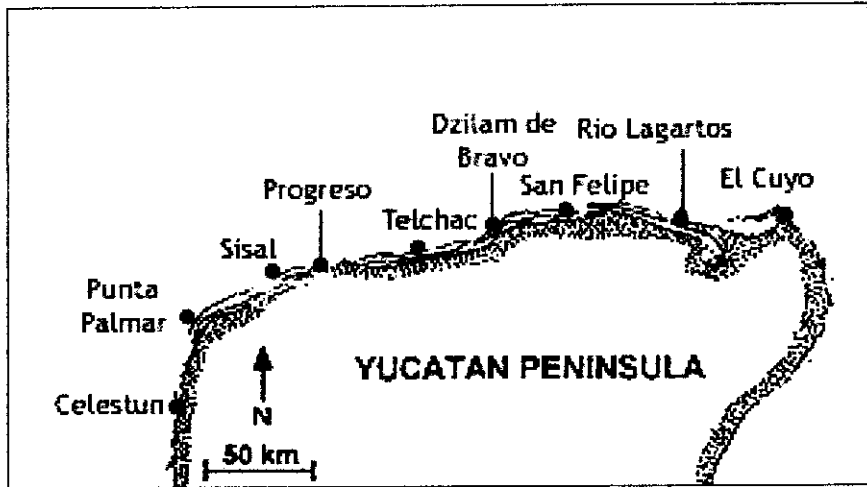


Figure 2. Nine sampling sites surveyed to identify probable nursery areas for grouper juveniles

RESULTS

A total of 192 grouper juveniles were caught and examined during this study. Five different species were captured: 89 individuals of *Epinephelus morio* (6.0–38 cm SL), 17 individuals of *Mycteroperca bonaci* (7.6–43 cm SL), 84 individuals of *Mycteroperca microlepis* (10.9–38.5 cm SL) and one individual of *Epinephelus striatus* (46.2 cm) and one of *Epinephelus adscensionis* (20.3 cm SL) (Figures 3 and 4).

Individuals were capture nearshore in the eastern part of the coast of Yucatan in El Cuyo, Ría Lagartos and San Felipe, in the central part in ports of Dzilam de Bravo, Uaymitún-Telchac, Progreso and Sisal, and in the western part in El Palmar and Celestún. From the nine explored sites the highest number of individuals were captured in El Cuyo (56 individuals), Dzilam de Bravo (52 individuals) and Ría Lagartos (21 individuals) (67% of the total number). Progreso (19 individuals), Uaymitún-Telchac (11 individuals), San Felipe (7 individuals), Celestún (2 individuals), El Palmar (12 individuals) and Sisal (12 individuals) (33% of the total) had more or less the same number of individuals caught (Figure 5).

In the six months survey, 26 individuals were captured in June, 74 were captured in July, 43 individuals were capture in August, 30 were capture in September, 7 were capture in October and 12 individuals were capture in November (Figure 6).

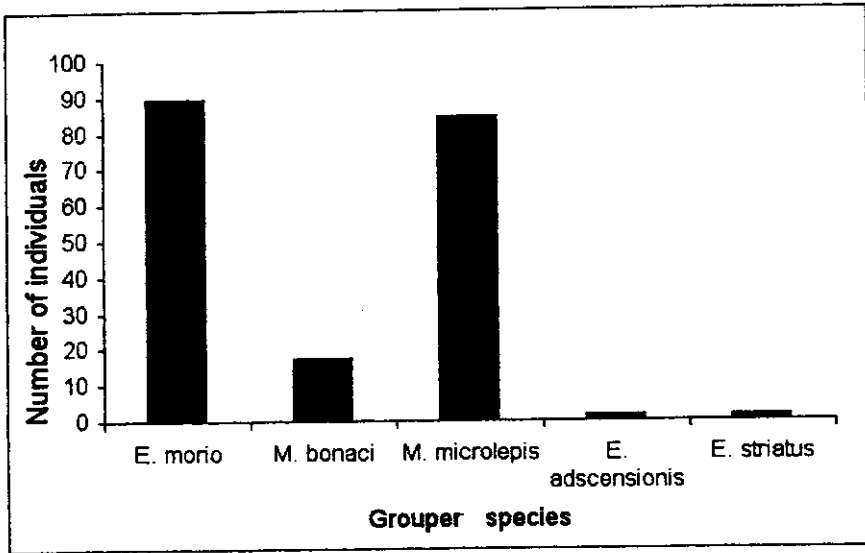


Figure 3. Grouper species caught in the northern coast of Yucatan through June to November 2000

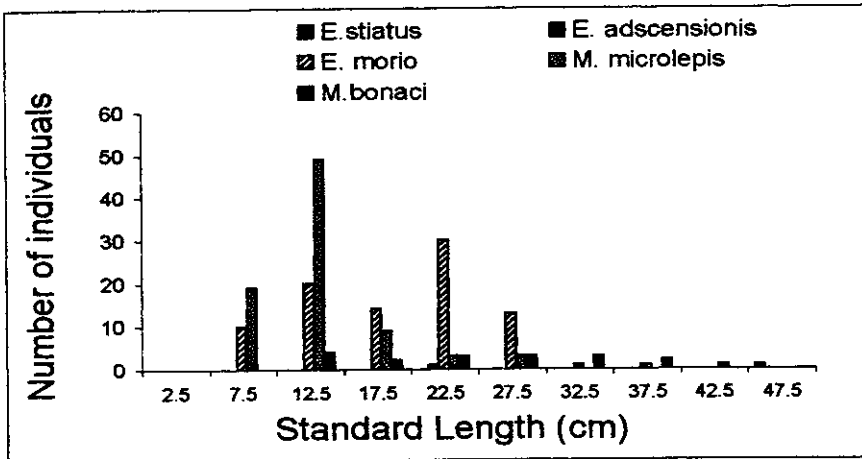


Figure 4. Size frequency distribution of five grouper species caught along the northern coast of Yucatan. The X-axis is the class distinction (cm).

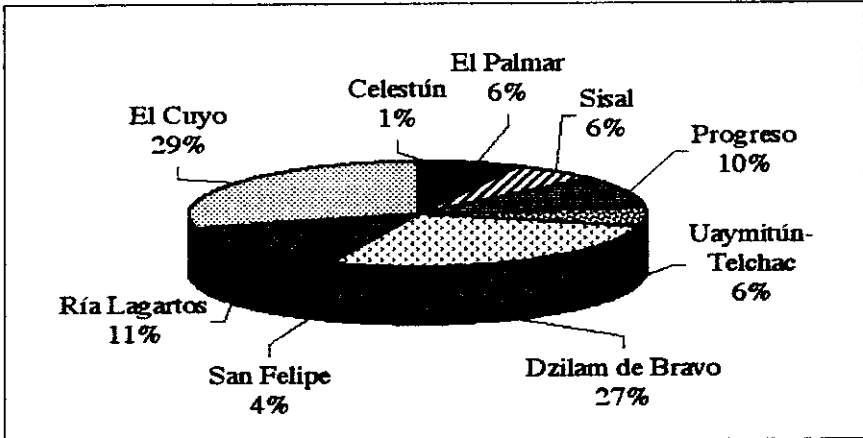


Figure 5. Percentage of captured grouper individuals per site along the northern coast of Yucatan

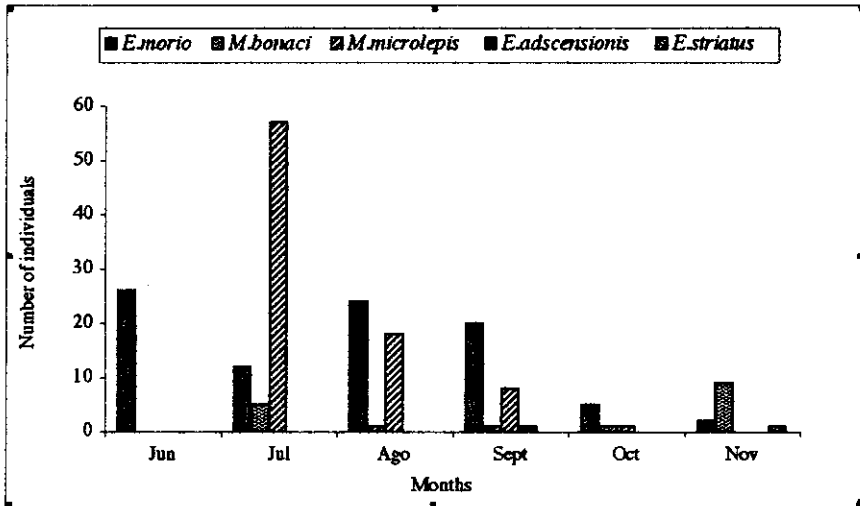


Figure 6. Number of individuals per species captured in each month from June to November 2000 along the northern coast of Yucatan

Different kinds of bottom habitats were recorded. El Cuyo, San Felipe and Dzilam de Bravo presented conspicuous seagrass beds, whereas Ría Lagartos, Progreso, Uaymitún-Telchac, Celestún, El Palmar and Sisal hard bottom habitats dominate. Some clear habitat specific associations were observed; *M. microlepis* upon sea grass beds (*Thalassia* spp. and *Gracillaria* spp.), and *E. morio*, *E. striatus*, *E. adscensionis* and *M. bonaci* with sandy-rocky bottoms with some ridges and crevices.

Species associated with hard bottom were caught using traps (4 individuals), hook line (43 individuals) and spear (71 individuals), this fishing technique the most effective one. In the case of *M. microlepis*, most of the specimens (74 individuals) were captured with a trawl net as they were found in seagrasses beds.

Through a histological analysis 68% of the captured individuals were females (n = 131), 8% were males (n = 15) and 24% (n = 46) were "unidentified" individuals (Table 1).

Table 1. Sex determination for each species caught along the Yucatan Peninsula from June to November 2000.

Species	Females	Males	"Unidentified"	Total Individuals
<i>E. morio</i>	69	1	19	89
<i>E. striatus</i>	1			1
<i>E. adscensionis</i>	1			1
<i>M. bonaci</i>	10	3	4	17
<i>M. microlepis</i>	50	11	23	84

All females were immature individuals as they display gonias and/ or primary oocytes. All male specimens exhibited seminiferous tubules and spermatogenic cysts, in a "compact" gonad tissue without the presence of a lumen or lamellar wall were classified as immature males. "Unidentified" individuals showed no characteristic cellular development so it was decided to left them unclassified.

E. morio females sizes ranged from 7.5 cm to 38.0 cm (SL), the only male registered has a standard length of 26.7 cm, and "unidentified" individuals ranged from 6.0 - 24.3 cm (SL). *M. microlepis* sizes recorded for females, males, and "unidentified" individuals ranged from 7.6 - 43.0 cm, 9.5 - 20.2 cm and 9.5 - 20.5 cm (SL), respectively. For *M. bonaci* sizes ranged from 13.0 - 38.5 cm for females, 12.5 - 22.5 cm for males and 9.5 - 20.5 cm for "unidentified" individuals (SL). The sizes for individuals of *E. striatus* and *E. adscensionis* were 46.2 and 20.3, respectively.

The relationship between the standard length of each individual and the sex differentiation was statistically significant ($p = 0.048$; $\alpha = 0.05$) but its correlation between the variables was moderately weak ($\text{sex} = 0.06063 + 0.01077 \times \text{sizes}$; correlation coefficient = 0.145).

DISCUSSION

Grouper juveniles live in shallow waters near the coastline where they established to feed and protect themselves from predators (Jory and Iversen 1989). The individuals captured during this study were all juveniles as defined as an individual who has completed its metamorphosis, lives in a benthic habitat, but is sexually immature (King 1996, Kováč and Copp 1999).

The five species caught *E. morio*, *E. striatus*, *E. adscensionis*, *M. bonaci* and *M. microlepis* are considered "giant" groupers since they grow larger, reproduce at an older age when compared with other "dwarf" groupers (Sluka and Sullivan 1996), and settle in nearshore waters. Like most of the groupers in the present study, these five species display a bathymetric distribution where larger individuals live in open, wide and deeper waters, whereas juveniles tend to live in defined small areas in shallow waters living inside caves, ridges, and crevices (Johnson and Collins 1994).

In the nurseries areas groupers are dependant on their habitat for food, shelter and cleaning, but this dependency is probably more closely related to the need for shelter than for food (Sluka et al. 1994). The dependency for rocky bottoms by *E. morio*, *E. striatus*, *E. adscensionis* and *M. bonaci* and for seagrass beds by *M. microlepis* was observed, in accordance with Moe (1969), Thompson and Munro (1978), Ross and Moser (1995), García-Cagide and García (1996), and Shirripa and Legault (1997).

The most effective gear for rocky-bottom species such as *E. morio*, *E. striatus*, *E. adscensionis* and *M. bonaci* was the spear, while for *M. microlepis* the most effective one was the trawl net, since most of the individuals were captured in seagrasses beds.

Six of the surveyed sites match with four Yucatan's Natural Protected Areas (NPA's) adjoined to the coastline. El Cuyo, Ría Lagartos and San Felipe belong to the Biosphere Natural Reserve "Ría Lagartos", Dzilam de Bravo is part of the Natural State Reserve "Bocas de Dzilam", "El Palmar" is a Natural State Reserve and "Celestún" is another Natural Biosphere Reserve. All of these Protected Areas include the part of sea habitat (1 mile from the coastline), although when these Areas were decreed, the marine environment was not taken into account, and there are no management plans for them. If NPA's are to be used to protect a resource, the nursery areas for grouper populations, in this case, must be known in order to protect them from the effects of exploitation (Sadovy 1998).

All of the individuals captured during this study were determined to be sexually immature individuals. *E. morio*, *M. bonaci*, *M. microlepis*, and *E. adscensionis* are considered protogynous hermaphrodites displaying monandric populations (Mc Erlean and Smith 1964, Collins et al. 1987, Brulé et al. 1999, and Renán et al. 2001), because they only exhibit secondary males in the commercial captures. Nevertheless, the individuals analyzed in these studies are bigger than 15 cm (FL). For *E. striatus* Sadovy and Colin (1995) established as essentially gongochoristic with potential for sex change. The males determined trough the

histological study, display characteristics of primary males, and so we may considered this populations as probable diandric. However, an extensive study should be made, using more individuals, in order to conclude this. The "unidentified" individuals were found at different sizes, but there was no relationship between the length and the presence of these individuals.

Threats to juvenile grouper populations include nearshore habitat degradation and recruitment overfishing (Sluka et al. 1994). Therefore, it may be prudent to evaluate a habitat-based management strategy as a viable alternative to traditional fisheries measures, such as minimum size limits. In order to establish adequate management policies for the juvenile grouper populations in the northern coast of Yucatan, scientific research needs to continue. We propose a comprehensive investigation of these nursery areas found for groupers in at least an annual cycle, to determine their biology, habitat dependency, and populations sexuality.

ACKNOWLEDGMENTS

We would like to express our gratitude to the Federación de Cooperativas de Pescadores de Oriente: Sociedad Cooperativa de Producción Pesquera (SCPP) El Cuyo, SCPP Ría Lagartos, SCPP San Felipe. Also to the Federación de Cooperativas de Pescadores de Centro- Poniente: SCPP Dzilam de Bravo, SCPP Sisal, SCPP La Pobre de Dios y SCPP Real de Celestún.

LITERATURE CITED

- Bullock, L.H. and G.B. Smith. 1991. *Seabasses (Pisces: Serranidae)*. Memoirs of the Hourglass Cruises. Volume 8(2). Miami, Florida USA.
- Brulé, T., and C. Déniel. 1996. Biological research on the Red Grouper (*Epinephelus morio*) from the southern Gulf of Mexico. Pages 28-42. in: F. Arreguín-Sánchez, J.L. Munro., Balagos, and D. Pauly (eds.) *Biology, Fisheries and Culture of Tropical Groupers and Snappers*. ICLARM Conference. Proceedings. Manila, Philippines.
- Brulé, T., C. Déniel, T. Colás-Marrufo, y M. Sánchez. 1999. Red Grouper Reproduction in the Southern Gulf of Mexico. *Transactions of the American Fisheries Society* 128:385- 402.
- Colás-Marrufo, T., T. Brulé, y C. Déniel. 1998. Análisis preliminar de las capturas de meros realizadas a través de unidades de flota mayor en el sureste del Golfo de México. *Proceedings of the Gulf and Caribbean Fisheries Institute*. 50: 780-803.
- Collins, M.R., C.W. Walte., W.A. Roumillat, and P.L. Stubbs. 1987. Contribution to the life history and reproductive biology of gag (*Mycteroperca microlepis*) (Serranidae), in South Atlantic Bight. *Fisheries Bulletin* 85: 648-653.
- Gabe. 1968. *Techniques Histologiques*. Masson, Paris, France. 113 pp.

- García-Cagide, A. y T. García. 1996. Reproducción de *Mycteroperca bonaci* y *Mycteroperca venosa* (Pisces: Serranidae) en la plataforma cubana. *Reviews in Tropical Biology* 44 (2):771- 780.
- Heemstra, P.C. and J.E. Randall. 1993. *FAO Species Catalogue. 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 Fisheries Synopsis. FAO, Rome, Italy. (125) 16.
- Humman, P. 1994. *Reeffish identification: Florida, Caribbean, and the Bahamas*. New World Publications, Inc. Jacksonville, Florida USA. 396 pp.
- INE, 2000. <http://www.ine.gob.mx/dgoeia/zcooster.html>
- INEGI. *Anuario estadístico de Yucatán*. Edición 2001. Aguascalientes, Ags. 575 p.
- Johnson, A.G. y L.A. Collins. 1994. Age-size structure of red grouper (*Epinephelus morio*) from the eastern Gulf of Mexico. *Northeast Gulf Science* 13:101-106.
- Jory, D. and E. Iversen. 1989. Species Profiles: *Life histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Florida)*. U.S. Fish Wild. Ser. Biological Report . 82 (11-110).
- King, M. 1996. Population dynamics. Pages 151-153 in: *Fisheries, Biology, Assessment and Management*. Fishing New Books. Oxford, London.
- Kováč, V. Y. and H.G. Copp. 1999. Prelude: looking at early development of fishes. *Environmental Biology of Fish* 56:7-14.
- Mc Erlean, A.J. y L. Smith. 1964. The age of sexual succession in the protogynous hermaphrodite *Mycteroperca microlepis*. *Transactions of the American Fisheries Society* 53: 301-302.
- Moe, M.A. 1969. Biology of the Red Grouper *Epinephelus morio* (Valenciennes) from the Eastern Gulf of Mexico. *Prof. Pap. Ser. Fla. Dep. Nat. Resour. Mar. Res. Lab.* 10- 95p.
- Renán, X., Brulé, T., Colás-Marrufo, T., Hauryón, Y. and C. Déniel. 2001. Preliminary Results on the Reproductive Cycle of the Black Grouper, *Mycteroperca bonaci*, from the Southern Gulf of México. *Proc. 52th Gulf and Caribb. Fish. Inst. Key West, Florida*, November, 1999. Pp. 1- 14.
- Ross, S.W. y M.L. Moser. 1995. Life history of juvenile gag *Mycteroperca microlepis*, in North Carolina estuaries. *Bulletin of Marine Science*, 56 (1): 222- 237.
- Sánchez-Salazar, M.T., J. Fraga-Berdugo, y S. Maas- Rodríguez. 1999. Capítulo 11.2 Pesca. Páginas 91- 106 en: *Atlas de Procesos Territoriales de Yucatán*. Universidad Autónoma de Yucatán. Facultad de Arquitectura. Mérida, México.
- Sadovy, Y. 1998. MPA's as a generic tool, with emphasis on the protection of long-lived fishes, such as groupers. *Proceedings of the EXPO '98 Conference on Ocean Food Webs and Economic Productivity*. Lisbon, Portugal. ACP- EU Fisheries Research Report (5):43.