A working paper
Goliath SEDAR Data Workshop
April 27-29, 2010

Goliath surveys and samples: A summary of recent work by the Fish and Wildlife Research Institute (2006 -2010)

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The Fish and Wildlife Research Institute (FWC/FWRI) is uniquely suited to collect data regarding goliath grouper biology throughout Florida due to the statewide distribution of field labs and research groups. Since the goliath grouper fishery closure in 1990, most FWRI-based research efforts for this species have been indirect and opportunistic (i.e., collection of biological samples after a mortality event). A small amount of information is also collected by the Fish Biology and Fisheries-Independent Monitoring groups, who occasionally catch goliath grouper during routine sampling in estuaries throughout the state (Fig. 1) or observe them during underwater visual census (point count surveys) along the east coast and in the Florida Keys. These routine sampling methods do not specifically target goliath grouper but can contribute information regarding the geographic range and distribution of the species.

Because harvest is prohibited and typical sampling methods are not available (i.e., landings data, dock interviews), scientists and policy makers must rely on personal communications, anecdotal information or directed research efforts to gather accurate data regarding the current geographic range, size distribution and abundance of this species. The majority of commercially harvested goliath grouper were landed along the west coast of Florida before the harvest moratorium (Bullock et al., 1992). This area is believed to be the center of abundance for this species, making it an obvious location to explore the recovery of the population. Extensive research on goliath grouper has been conducted in southwest Florida, especially pertaining to juvenile abundance and habitat (e.g. Eklund and Schull, 2001; Coleman and Koenig, 2003; Frias-Torres, 2006; Koenig et al., 2007; Cass-Calay and Schmidt, 2009). However, less quantitative information is available regarding the status and behavior of adult goliath grouper along the central west coast (but see Koenig and Coleman, 2009).

The Goliath Grouper Cooperative Research Project (CRP NMFS award #NA07NMF4540085) was initiated as a cooperative research effort between recreational divers and scientists in order to explore goliath grouper distribution and abundance at offshore habitat along the central west coast of Florida. The objectives of this ongoing project are to quantify goliath grouper presence at designated sites over time. Specifically, the research aims to determine how presence, abundance and size distributions are related to habitat, depth and time of year.

Underwater visual surveys were conducted on both artificial and natural hard bottom habitat throughout the study area (Fig. 2). Artificial habitats included any man-made structure or debris (typically shipwrecks), while natural habitat was represented by rocky outcrops and limestone ledges. Site depths ranged 7-48 m, and 82 separate sites (39 artificial, 43 natural) were surveyed within the study area (Fig. 2). Surveys were performed during all months of the year (Fig. 3), with a total of 367 surveys completed between October 2008 and April 2010. During each survey, the number of goliath grouper present was assessed by a single observer (ABC) by performing a thorough survey of the entire site. Goliath grouper were filmed using a modified underwater video camera (fitted with lasers) to gather length data for fish present at each site. When possible, goliath grouper were tagged at the end of the survey with an external ID tag. Survey data are excluded from analyses when visibility < 3 m or survey time < 20 minutes.

To date, total survey effort (survey time on the bottom) is 218 hours, with an average survey time of 35 minutes per site. Goliath grouper were present during 272/367 surveys (74%). Goliath grouper were present at 95% of all artificial habitats visited (37/39 artificial sites), with at least one fish observed during 239/267 (90%) surveys of this habitat type. Conversely, goliath were recorded at only 39% of the natural habitats visited (17/43 natural sites), with fish observed during 33/100 (33%) surveys over natural bottom.

The number of goliath observed during a single survey ranged from 0 – 24 individuals (Fig. 4), and abundance was consistently higher over artificial habitat throughout the year (Fig. 5). The number of surveys per site ranged 1 – 29 over the course of the study period. Highest numbers of goliath grouper were observed over artificial habitat in deep (>20 m) water (fig 6). Twenty-one sites (16 artificial, 5 natural) were visited multiple times per quarter, with largest aggregations recorded over artificial habitat during the late summer months. Specific sites tended to hold similar numbers of goliath grouper throughout the year (Fig 7). Data analysis is ongoing but it is suspected that site features (volume and relief) are positively associated with goliath grouper abundance (Collins, 2009).

Preliminary analysis of size distribution data demonstrates a range of sizes present throughout the survey area. An interesting fact emerging from this research is that smaller than expected individuals (<100 cm TL) are appearing within all depth ranges surveyed (Collins, 2009). Size at maturity (and expected ontogenetic emigration from inshore nursery habitat) is ~ 1 m TL (Bullock et al. 1992), so the observation of small individuals, especially at deeper sites farther offshore, is intriguing.

To date, 171 goliath grouper have been fitted with external identification tags. Resightings or recaptures have been reported for 26/171 (16%) individuals. Time at large ranged 1 – 322 days, and seven individuals have been resighted multiple times. Recaptures were reported as far as 203 km away from the initial tagging site, but most resightings occurred in the same location as the initial tagging event (Table 2).

It is the goal of this project to provide abundance estimates for goliath grouper from specific sites over time. These data can potentially indicate changes in population size, distribution and recovery within the surveyed area. At the very least, these types of data can provide a baseline for comparison during future stock assessment (Porch and Eklund 2004). It is hopeful that these data can be integrated with existing information from other regions to help provide a more complete picture of the status of goliath grouper in U.S. waters.

In addition to the current CRP research, FWRI staff have made a dedicated effort to opportunistically collect biological samples from any incidental goliath grouper mortalities that are reported to FWC (i.e., through bridge demolitions, cold weather events or natural mortality). At a minimum, measurements (TL, SL, and weight), DNA and location (lat/long) are collected from each fish. All attempts are made to obtain otoliths, fin rays and fin spines for ageing. Gonads, stomach contents, and tissue samples for parasite, toxin and mercury analyses are collected when possible, depending upon the decomposition level of the specimen.

Since 2006, 105 fish have been measured or sampled for DNA (Table 1). Most of these samples were collected on the west coast of Florida, although a few fish were sampled on the east coast (Indian River Lagoon) and in the Dry Tortugas (Fig. 8). Otoliths were collected from 60 of these samples (the remaining samples were too decomposed or were sampled for DNA during a catch and release event). Goliath sizes ranged 112 – 1900 mm TL and 1-16 years (Fig. 9). Sex was confirmed through gonad histology for 23 fish (Fig. 10). Confirmed females (n=14) ranged 644-1650 mm TL and 2-11 years. Males (n=9) ranged 790 – 1750 mm TL and 4 – 10 years. Three of the males exhibited primary growth oocytes scattered throughout the gonad (Fig. 11). This character is not a reliable feature for discounting gonochorism (Shapiro, 1987; Bullock et al., 1992); however, together with the presence of a central lumen and the lamellar structure of the testicular tissue, it does provide further support for protogyny (Shapiro, 1987; H. Grier, pers. comm.).

FWC/FWRI will continue all efforts to ensure a timely and efficient response to investigate any reports of goliath grouper mortality. This opportunistic collection of biological samples provides an effective method for further investigation into life history aspects of this species.

Literature cited

Bullock, L.H., Murphy, M.D., Godcharles, M.F., and Mitchell, M.E. 1992. Age, growth and reproduction of jewfish *Epinephelus itajara* in the eastern Gulf of Mexico. Fishery Bulletin 90: 243-249.

Cass-Calay, S.L. and Schmidt, T.W. 2009. Monitoring changes in the catch rates and abundance of juvenile goliath grouper using the ENP creel survey 1973-2006. Endangered Species Research 7: 183-193.

Collins, A.B. 2009. A preliminary assessment of the abundance and size distribution of goliath grouper *Epinephelus itajara* within a defined region of the central eastern Gulf of Mexico. Proceedings of the 61st Gulf and Caribbean Fisheries Institute: 184-190.

Eklund, A. and Schull, J. 2001. A stepwise approach to investigating the movement patterns and habitat utilization of jewfish, *Epinephelus itajara*, using conventional tagging, acoustic telemetry, and satellite tracking. *In:* Sibert, J. and Nielsen, J.L. (eds.) Electronic tagging and tracking in marine fisheries research: methods and technologies in fish biology and fisheries. Vol. 1. Kluwer Academic, Netherlands.

Frias-Torres, S. 2006. Habitat use of juvenile goliath grouper *Epinephelus itajara* in the Florida Keys, USA. Endangered Species Research 1: 1-6.

Koenig, C.C., Coleman, F.C., Eklund, A.M., Schull, J. and Ueland, J. 2007. Mangroves as essential nursery habitat for goliath grouper (*Epinephelus itajara*). Bulletin of Marine Science, 80: 567-586.

Koenig, C.C. and Coleman, F.C. 2009. Population density, demographics and predation effects of adult goliath grouper. MARFIN Project (NA05NMF4540045) NOAA/NMFS Final Report. 79 pp.

Porch, C. E. and A. M. Eklund. 2004. Standardized visual counts of goliath grouper off south Florida and their possible use as indices of abundance. Gulf of Mexico Science 2: 155–163.

Shapiro, D.Y. 1987. Differentiation and evolution of sex change in fishes. Bioscience 37: 490-497.

Table 1. Number of specimens sampled by FWRI staff for DNA, otoliths, and/or gonads (2006-2010).

year	sample (n)	aged (n)	gonad histology (n)
2006	7	7	0
2007	4	4	1
2008	17	17	2
2009	7	0	0
2010	70	32	20
Total	**105**	**60**	**23**

Table 2. Tag/recapture data for goliath grouper that have been re-sighted since their initial tagging date. Days at large indicates number of days between sightings (resights during underwater surveys or recapture;* = caught by angler via hook and line). Distance moved corresponds to straight line distance between site of initial tagging and location of re-sighting event.

Individual	Tag date	Resight date	Days at large	Distance moved (km)
1	12/1/07	6/22/08	204*	230
2	12/29/07	7/20/08	204	29
3	1/12/08	6/19/08	159*	--
4	2/4/08	5/30/08	116	0
5	6/3/08	7/10/08	37	0
6	6/3/08	6/11/08	8*	16
		7/10/08	29	0
7	6/4/08	7/4/08	30	0
8	7/10/08	7/23/08	13	0
9	7/18/08	7/27/08	9	0
10	8/4/08	9/1/08	28	0
11	7/20/08	7/23/08	3	0
12	7/20/08	7/23/08	3	0
13	8/4/08	9/1/08	28	0
14	8/8/08	9/4/08	27	0
		9/28/08	51	0
15	5/8/09	5/9/09	1	0
		6/1/09	24	0
16	5/11/09	8/11/09	92	0
17	6/8/09	6/20/09	12	0
		7/10/09	20	0
		7/21/09	11	0
		8/28/09	38	0
		10/7/09	40	0
18	6/9/09	8/4/09	56	0
		9/1/09	28	0
		10/13/09	42	0
19	7/3/09	7/10/09	7	0
		8/15/09	36	15
20	7/17/09	7/19/09	2	0
21	7/17/09	8/11/09	25	0
		10/1/09	51	0
22	10/2/09	10/10/09	8	0
23	10/2/09	10/10/09	8	0
24	10/10/08	8/28/09	322	28
25	6/17/09	6/25/09	8	0
26	6/17/09	6/25/09	8	0

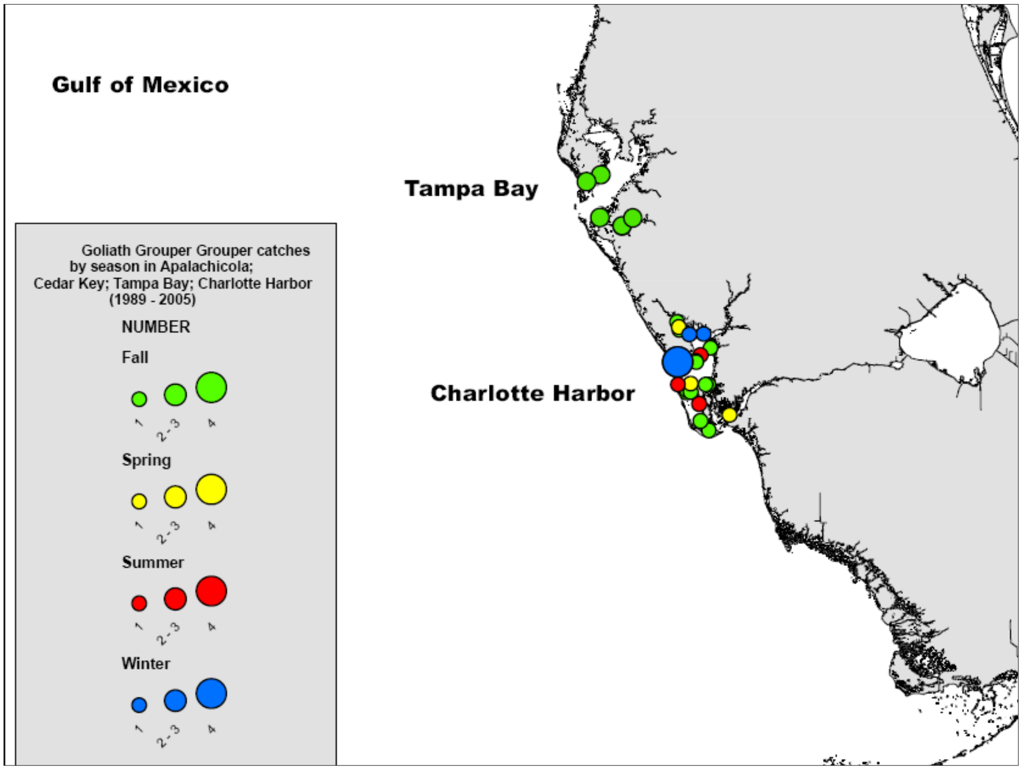

Fig. 1. Total number of goliath grouper caught per season by FWRI's Fisheries-Independent Monitoring Program (FIM) between 1989 and 2005. A total of 6 and 29 goliath grouper were caught in Tampa Bay and Charlotte Harbor, respectively, between 1989 and 2006 during FIM routine sampling. No goliath grouper were caught in Apalachicola or Cedar Key. Data courtesy of Bob McMichael, FWC, FWRI.

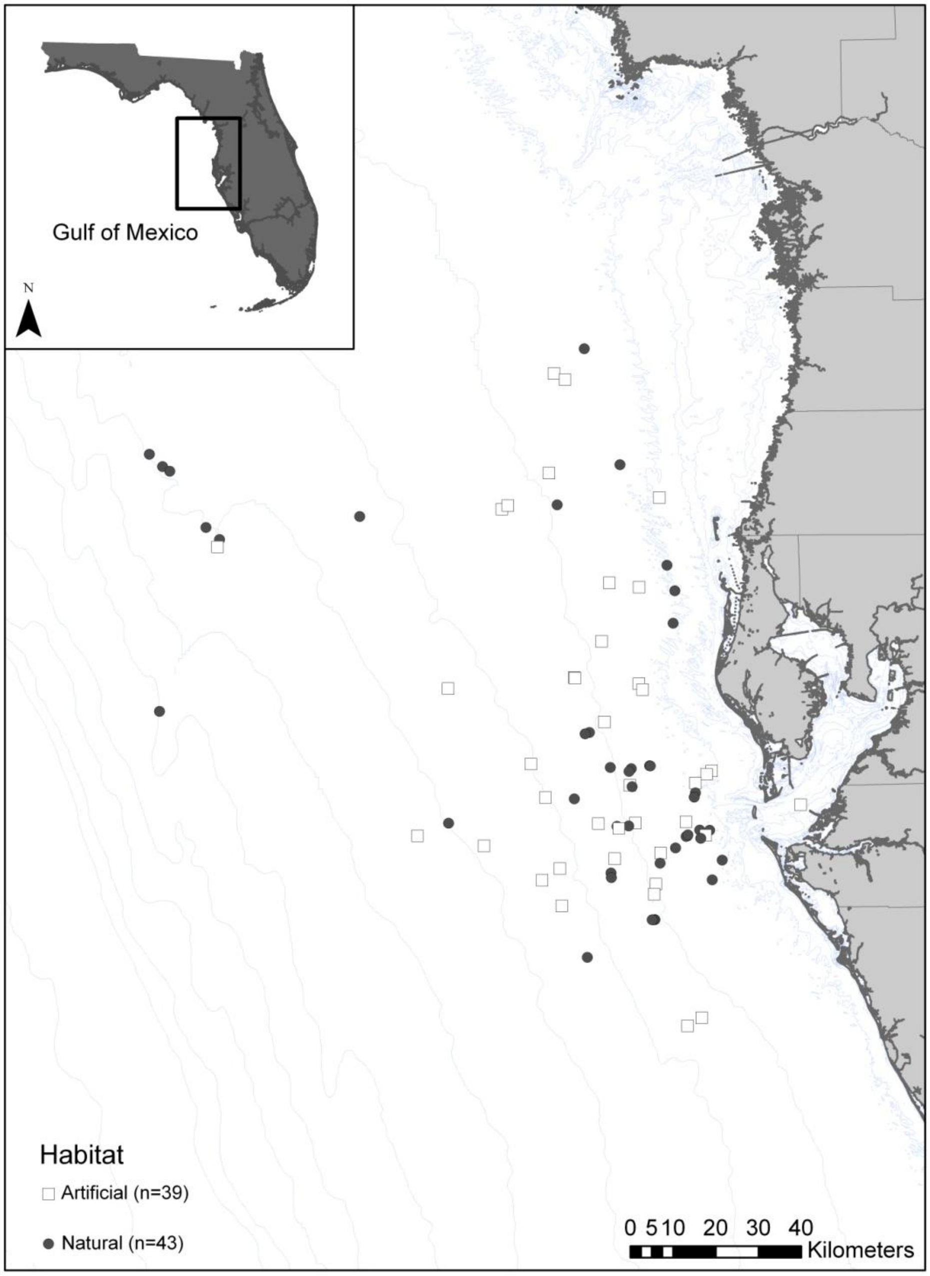

Fig. 2. Study area and designated survey sites for the goliath grouper CRP. Artificial habitat (squares) consisted of any man-made material (usually shipwrecks); natural habitat (circles) consisted of moderate to high relief (0.5-3 m) hard bottom (ledges and rock piles). Sites ranged in depth from 7-48 m, with 1-29 surveys performed per site between October 2008 and April 2010.

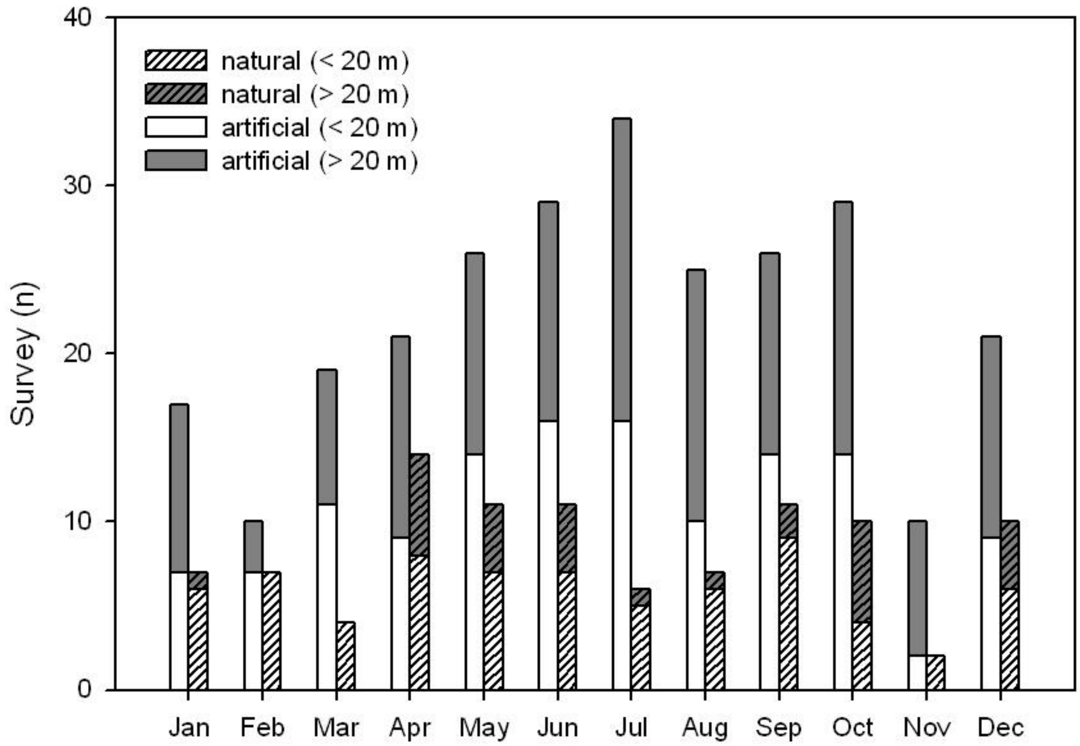

Fig. 3. Number of surveys performed per month over artificial and natural habitat. Hatched bars represent surveys at sites with depths > 20 m.

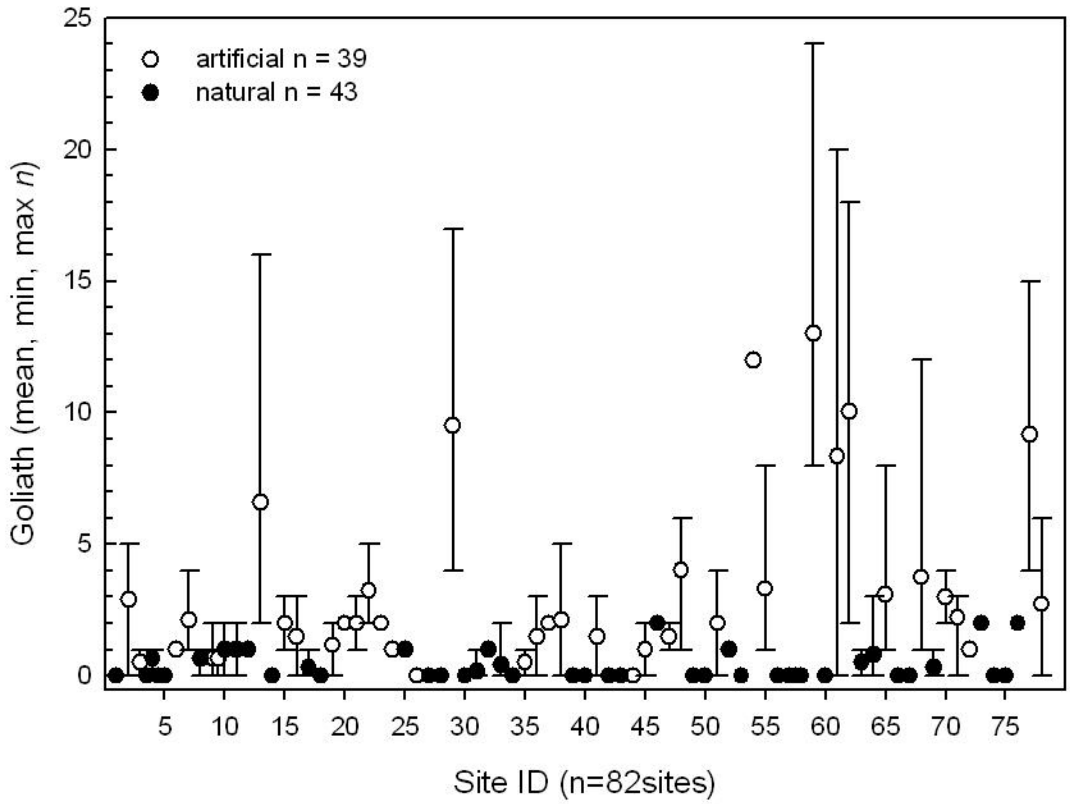

Fig. 4. Number of goliath grouper observed at each site. Symbols represent mean abundance. Error bars represent the maximum and minimum number observed at each site during the study period (October 2008 – April 2010). Sites are arranged by latitude (e.g., site 1 is the northernmost site). Total number of surveys = 367.

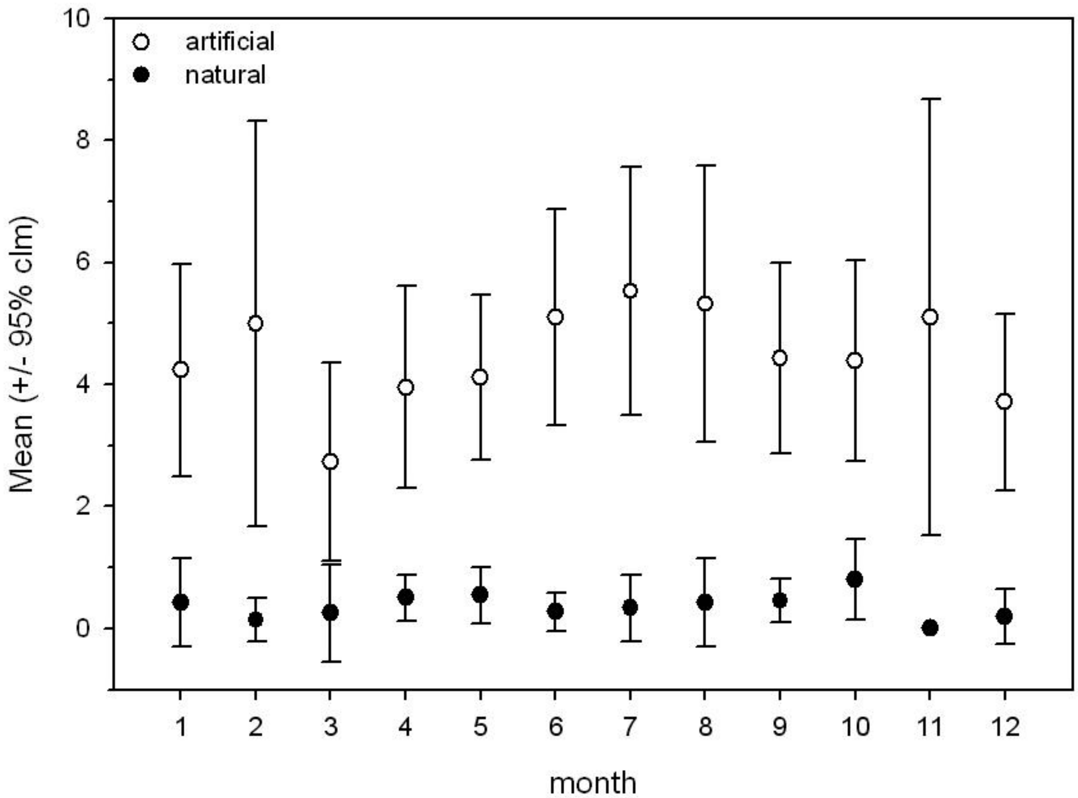

Fig. 5. Mean number of goliath grouper observed at artificial and natural habitat over all months. Error bars represent 95% confidence limits.

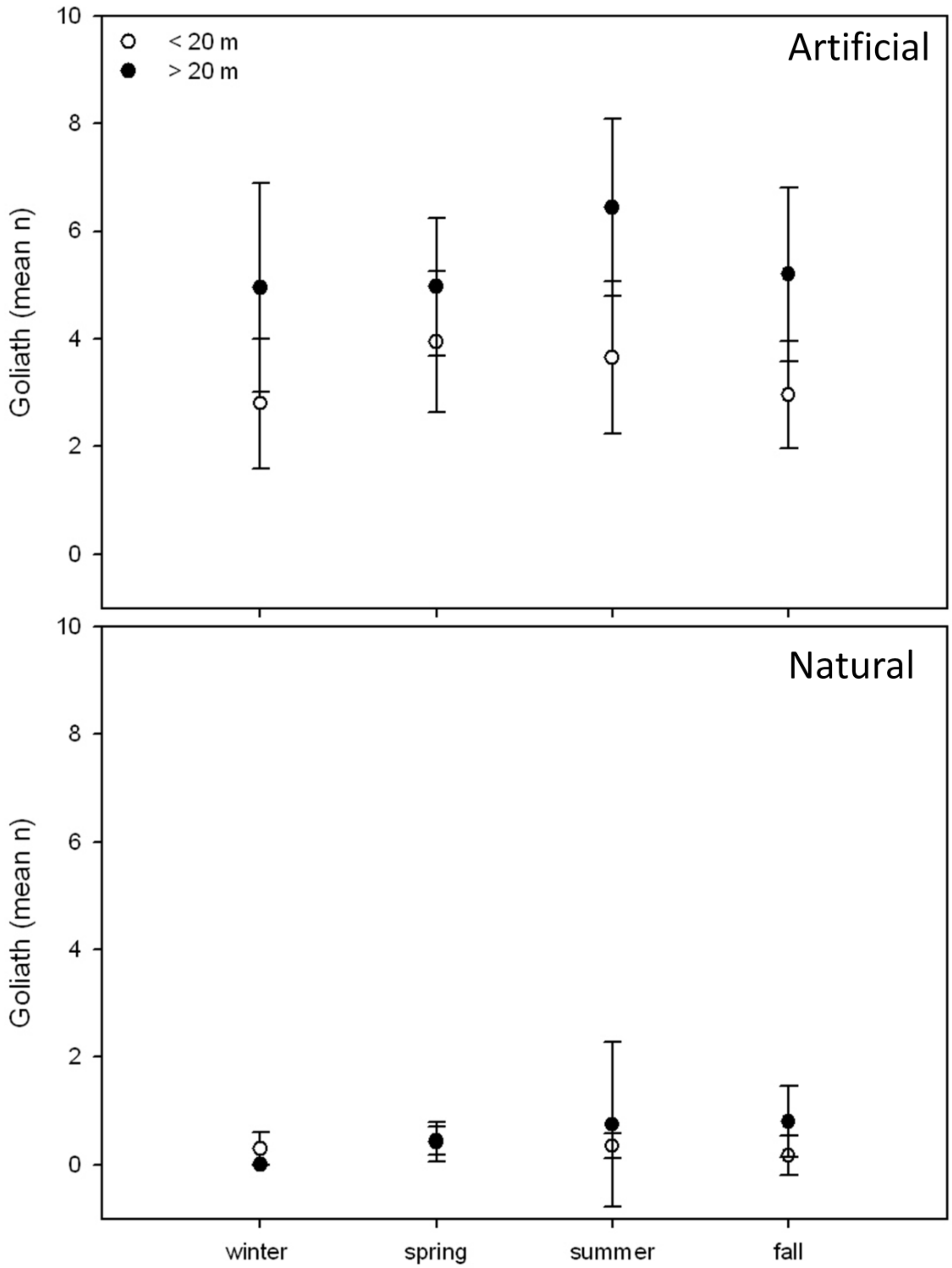

Fig. 6. Mean number of goliath grouper observed per season over artificial (top) and natural (bottom) sites. Open circles designate sites ≤ 20 m deep; closed circles designate site depths > 20 m. Error bars indicate 95% confidence limits. Seasons are designated as winter (Jan-Mar), spring (Apr-Jun), summer (Jul-Sep) and fall (Oct-Dec).

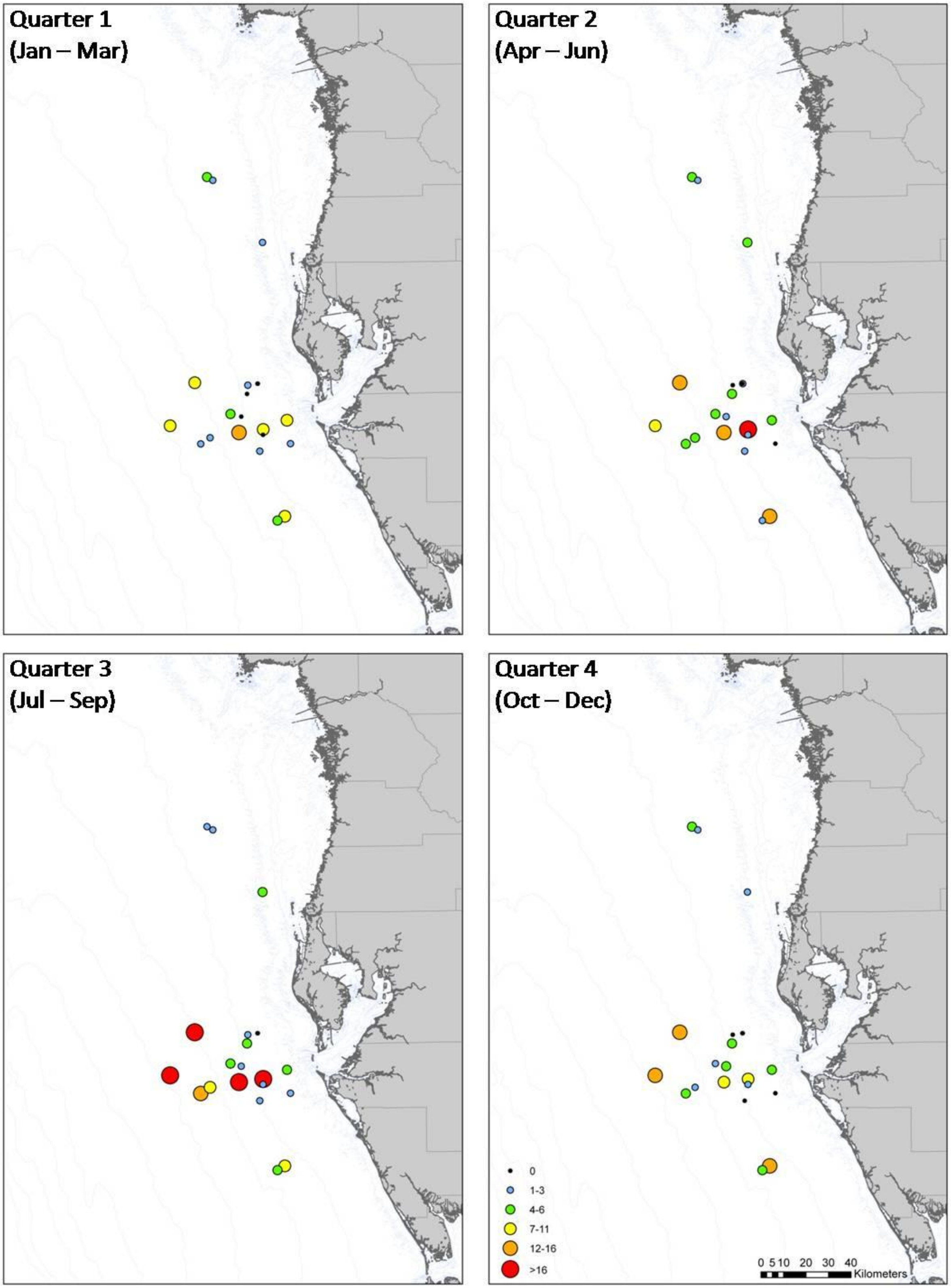

Fig. 7. Sites visited at least 4 times per year. Number of surveys per site ranged 5 – 29. Maximum number of goliath observed per quarter is displayed.

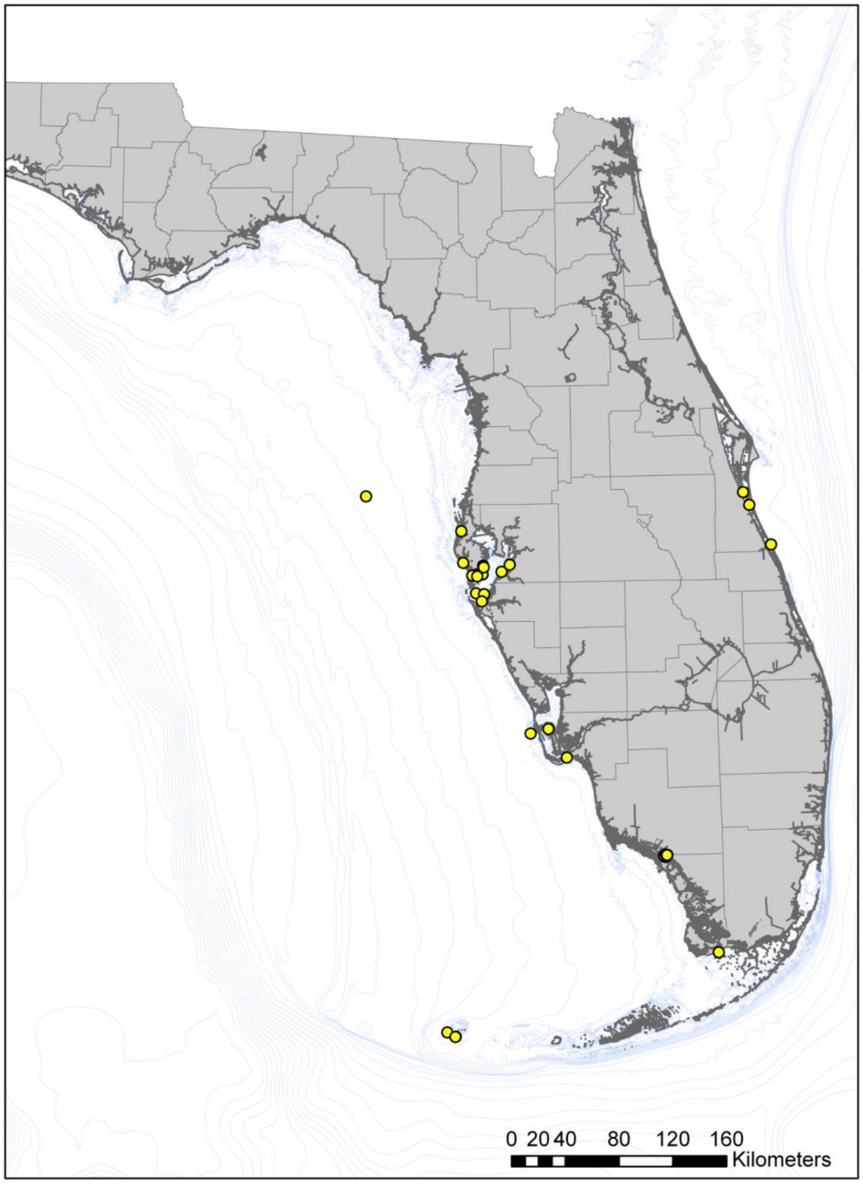

Fig. 8. Locations of opportunistic life history data collections between 2006 and 2010 by FWRI.

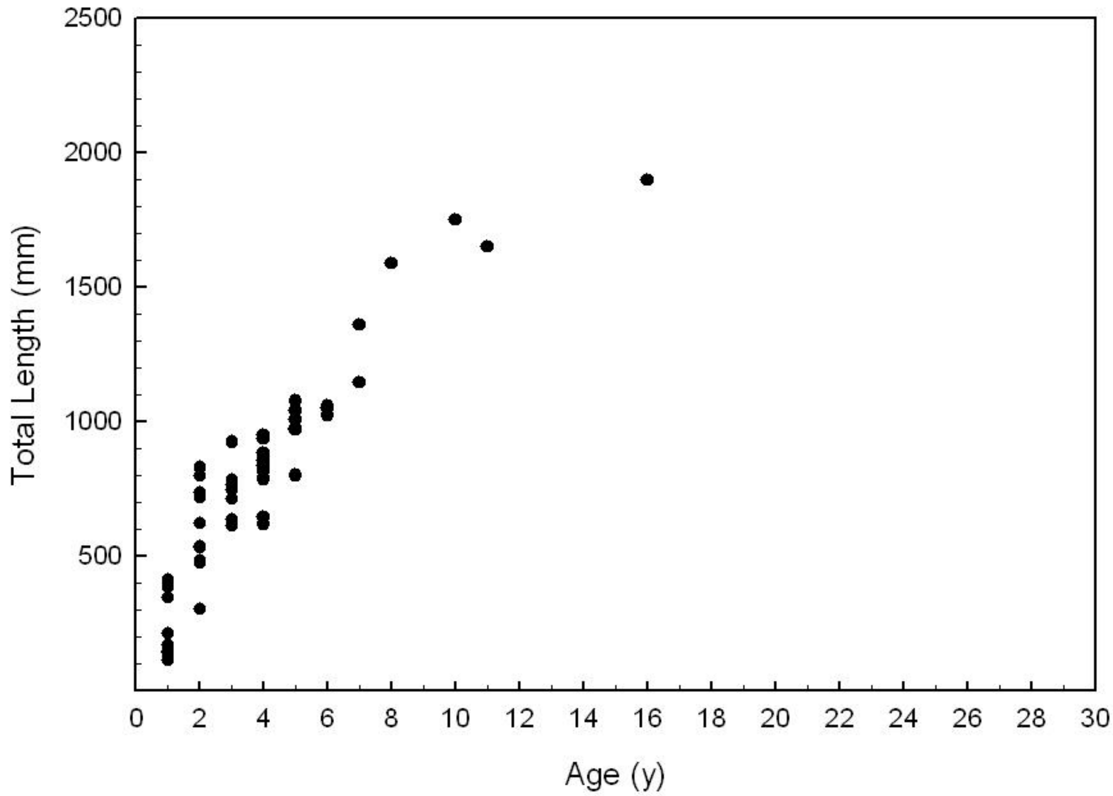

Fig. 9. Age – length data for goliath grouper opportunistically sampled for otoliths between 2006 – 2010.

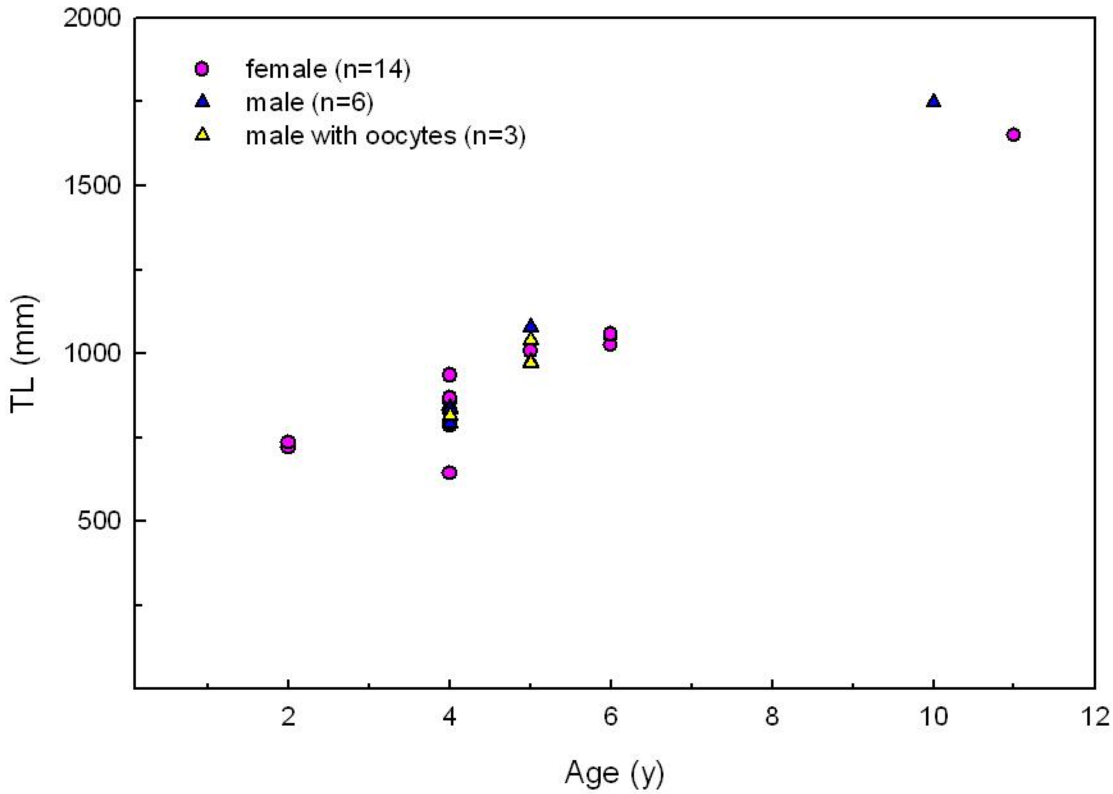

Fig. 10. Size – age data for goliath grouper whose sex was confirmed through histology (n=23).

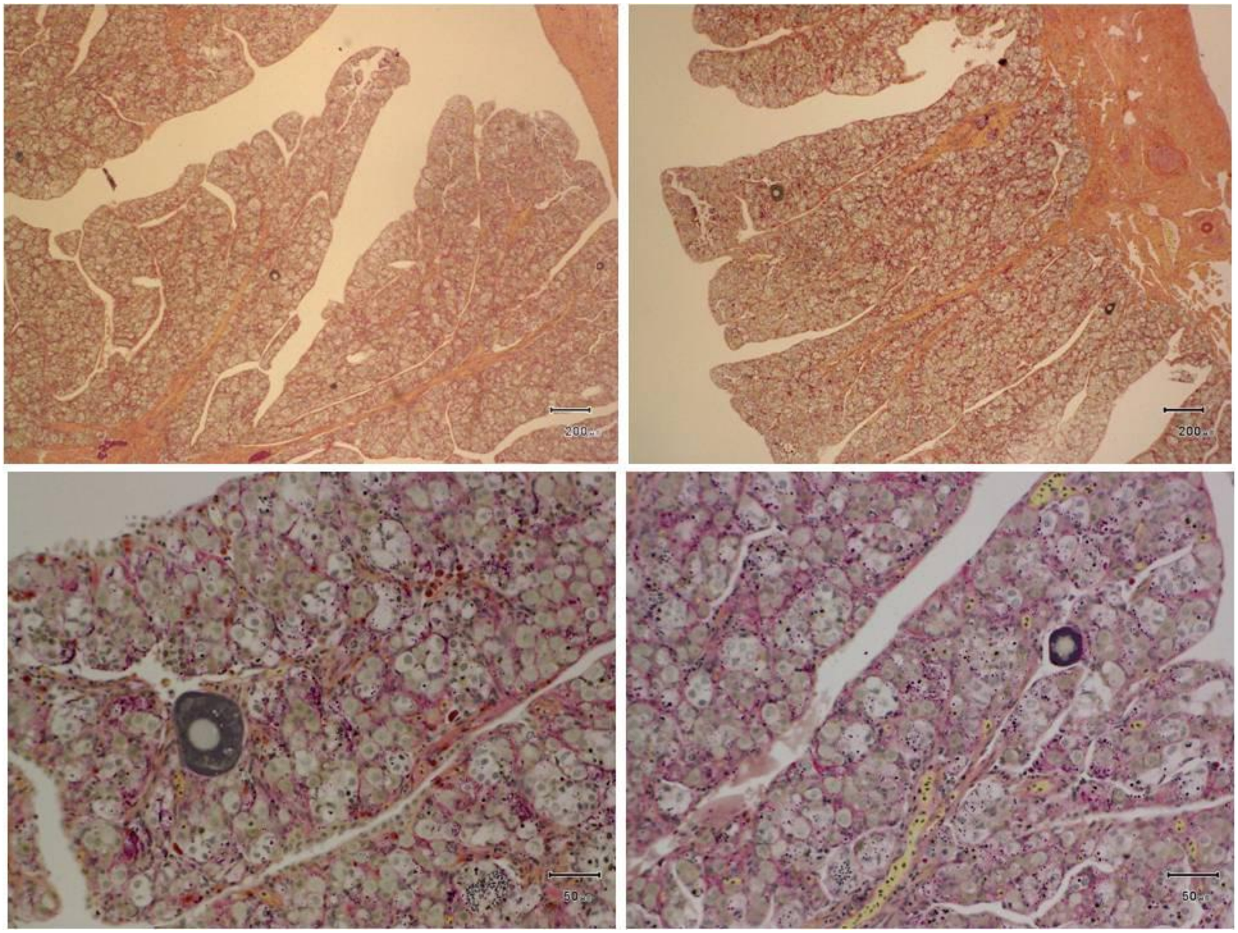

Fig. 11. Histology images for male goliath grouper with primary growth oocytes present within the gonad.