Status of Multi-Species Spawning Aggregations in Belize

Will Heyman and Nicanor Requena
The Nature Conservancy
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Executive Summary

The two goals of this study were to 1. Re-evaluate the status of Nassau grouper in Belize, and 2. Evaluate if known grouper spawning aggregation sites could be considered as "multi-species spawning aggregation sites" in order to guide the management of these areas as such. Six teams of divers surveyed 12 locations during the period 4 – 10 January 2002. The teams were comprised of local and international scientists, fishermen, guides, and local and international NGO's, representing the following organizations: Green Reef, Fisheries Department, The Nature Conservancy, Toledo Institute for Development and Environment, Friends of Nature, Belize Audubon Society, and Wildlife Conservation Society. All teams utilized the *Belize Reef Fish Spawning Aggregation Protocol* (Heyman et al, 2001) for the survey and all sent results to The Nature Conservancy for compilation into this report. The study found that the maximum number of groupers at any site was at northern Glover's Reef at 4,600, a number consistent with the highest number in the 2001 survey. Since recent historical Nassau grouper aggregations numbered in the several tens of thousands at many sites that are now virtually devoid of aggregating groupers, this study concluded that Nassau grouper aggregations and the population is in critical condition throughout Belize, and in need of immediate and drastic management measures. In addition, this study found that all sites were "multi-species" spawning aggregation sites with a mean of 6 ± 7 species recorded in these aggregations during the January 2002 observation period. The Nature Conservancy has been collecting data on multi-species spawning sites throughout Belize from March 1998 through July 2002. Using this combined data, and including some data gathered from published reports (Paz and Grimshaw, 2001; Sala, Starr and Ballesteros, 2001) that incorporates 159 dives, over 4 years and 16 sites, we calculated a mean of 8 ± 7 species, with from 2 – 20 species spawning at these sites. These data are considered support for the conclusion that those sites used by Nassau grouper for spawning should be considered, and managed, as multi-species spawning aggregation sites. Given the critical status of Nassau grouper, and the fact that all sites appear to be multi-species spawning areas, **this report recommends that all 16, known multi-species spawning aggregation sites within Belize be carefully monitored, and closed permanently to fishing.** This measure will provide an important contribution to sustainable fisheries management in Belize.

Forward

Spawning aggregations are crucially important in the life cycle of most commercially important reef fish, and often represent the total annual reproductive output from these species. As a result, the loss of these aggregations often results in diminished recruitment and subsequent severe population declines. Nassau grouper aggregations are under considerable threat from direct fishing pressure, and have been extirpated in many areas and throughout their natural range, including Belize. In areas where these aggregations have been destroyed, they have not returned in over 20 years of observation. For this reason, Belize, and other countries of the MesoAmerican Reef consider the management of spawning aggregations as a key management objective for nearshore reef fisheries.

The January 2001 National Grouper Assessment, lead by Green Reef, concluded that only two of the 9 sites that were traditionally known as grouper spawning sites, were still viable. These "viable" sites, Sandbore in Lighthouse Reef and Northern Glover's Reef, had only 3,000 – 5,000 fish, far fewer than previously recorded, and considerable danger of extirpation. In conclusion, Green Reef's report recommended drastic measures to conserve dwindling Nassau grouper stocks by protecting the remaining aggregation sites, and through seasonal harvest and gear bans. The study also noted several other species that aggregate to spawn at traditional Nassau grouper sites.

That many species utilize the same spawning areas, was the main point of a paper entitled, "Spawning Aggregations in Belize", that was released at the Green Reef sponsored, July, 2001 consultation, called, "Towards the Sustainable Management of Nassau grouper Belize" (Heyman, 2001). **The consultation ended with nearly unanimous support for national closure of Nassau grouper banks to ensure the survival of the species.** The point about managing multi-species aggregations, however, was more complex and resulted in the **formation of a National Spawning Aggregation Committee** which was given a mandate to develop recommendations to the Fisheries Department for the management of all spawning aggregations in Belize.

Lead by Dwight Neal of the Fisheries Department, the committee met four times over the course of several months and eventually made several recommendations that were presented to the Fisheries Department via public consultation, in November 2001. The group concluded that more research and monitoring was needed but it was the **opinion of the working group that all documented, multi-species spawning aggregations should be closed to fishing, year-round,** in order to protect the multi-species spawning aggregations at these sites. Along with these recommendations, the committee presented maps of the proposed closed areas. **The main goal of this study was to illustrate that traditional Nassau spawning areas serve as multi-species spawning aggregation sites.**

Acknowledgments

This project was completed with the support and collaboration of the various individuals and organizations. Thanks to Dwight Neal and James Azueta of the Fisheries Department who provided coordination for Fisheries Department survey teams. Thanks to Mrs. Janet Gibson and The Coastal Zone Management Authority and Institute for providing duty free fuel. The various aggregation sites were surveyed through the participation of the following Team Leaders: Mito Paz, Isias Majil, Kevin Rhodes, Eloy Cuevas, Albert Munnings, Alberto Patt, Dennis Garbutt, Enric Sala, and team participants Dan Castellanos, Jr., Mateus "Tamba" Nicholas, Jason Williams, Sonny Garbutt, Rachel Graham, Elmar Nunez, Emory Gonzalez, Norman Castillo, Neal Ariola, Nicholas Casimero, Anthony Sam Noralez, Wyatt Cabral, Ian Cuevas, Julie Berry, Alfonso J. "Fox" Nunez, Jack Cabral, Brett Wolfenberger, Brian Luckhurst, Leslie Waylen, Casurina McKinney, Leonard "KK" Nunez, Roger Arana, Sergio Hoare, Auriel Samos, Peirs Flemming, and others that we may have omitted by name. We also would like to acknowledge the logistical support from Dave Duncan. Tim Boucher provided satellite image analysis and site mapping. at The Nature Conservancy. Finally, we gratefully acknowledge our funding sources, The Mellon Foundation, Summit Foundation and Oak Foundations, The Nature Conservancy, and the counterpart funding of all participating organizations, and other private donors.

Dog snapper, *Lutjanus jocu*, spawning at Gladden Spit – one of 18 species documented to spawn there.

Introduction

Spawning aggregations represent most, if not all, of the reproductive output for reef fish species and are thus critical life history stages. Among reef species that aggregate to spawn, perhaps the best known examples are the epinepheline groupers, such as Nassau grouper, *Epinephelus striatus*, which was a significant commercial species in Belize and much of the Caribbean in the 1960-70s. Over the past two decades, however, there has been a very sharp decline in the annual landings in almost all areas in Belize. Paz and Grimsaw (2001) deemed the Nassau grouper population in critical state in Belize, while Sala, et al., (2001) suggested that Nassau grouper would be eliminated from Belize by 2013. In many areas of the Caribbean, including, Mexico, Honduras, Virgin Islands, Puerto Rico and Bermuda, Nassau grouper spawning aggregations have been fished to extinction, with no sign of recovery after 20 years of observation.

Spawning aggregations are convenient areas for fishermen, since large numbers of large fish are all aggregated in very specific times and places. This is especially true for "transient" spawning aggregations, where fish migrate to specific sites from great distances, aggregate and spawn, and then disperse (Domeier and Colin, 1997). As a result, traditional fishermen, including those from Belize have learned to capitalize on these aggregations to supplement their annual income. Hopkins fishermen for example, count on the December Nassau grouper aggregations as a source of Christmas money. Similarly, fishers, such as Carleton Young, Sr., and Lawrence and Elvis Leslie of Placencia have realized that at the Gladden Spit aggregation site, there is a seasonal pattern of arrival and departure of various species, which these fishers are accustomed to, and have capitalized on for years. As a result, **any management decisions involving these traditional fishing grounds should include the opinions and participation of local fishers.** These fishers have witnessed the declines in aggregations and are supportive of management measures, as long as provisions for their livelihood are taken into account.

Though spawning aggregations in Belize have been studied relatively extensively (Craig, 1969; Carter, Marrow, and Pryor, 1994; Paz and Grimshaw, 2001; Sala et al., 2001), studies have largely focused on the Nassau grouper. However, after speaking with local fishermen, The Nature Conservancy recognized that traditional Nassau grouper spawning sites may also function as multi-species spawning sites (Heyman, 2001). Therefore, protection and management of Nassau grouper aggregation sites, within year-round closures, could also protect other vulnerable species during spawning. This question has been the focus of The Nature Conservancy's Spawning Aggregation and Research Program, since 1998.

The two main goals of this study are therefore to 1. Re-examine the status of Nassau grouper in Belize, and 2. Evaluate the multi-species nature of traditional Nassau grouper spawning sites. Finally, this study aims to make recommendations for management, based on the findings.

Methods

During 4 – 10 January 2002, six teams of divers evaluated 15 spawning aggregation sites for the presence and sizes of Nassau grouper and other spawning species, using the Belize Reef Fish Spawning Aggregation Protocol (Heyman *et al*., 2001). The sites and the monitoring teams are indicated in Table 1. In addition to the organizations mentioned, 12 fishermen from Hopkins, who traditionally fish for Nassau grouper at this time, were present on monitoring teams spread across the country.

The teams used a standardized protocol to simultaneously evaluate the numbers and sizes of spawning fishes at these aggregation sites via underwater visual assessments. In addition and when possible, the teams collected catch per unit effort (CPUE) data, and conducted some limited tagging, to evaluate the migration and site fidelity of these fishes.

Table 1: Sites monitored during the January 2002 Survey, and monitoring organization.

	Site Name	General Location	Monitoring Organization During January 2002 Survey
1	Rocky Point	Ambergris Caye	Bacalar Chico Marine Reserve
2	Soldier Caye	Turneffe Atoll	Green Reef
3	Calabash Caye	Turneffe Atoll	Green Reef
4	Caye Bokel	Turneffe Atoll	Green Reef
5	Dog Flea Caye	Turneffe Atoll	Green Reef
6	Sandbore	Lighthouse Reef Atoll	The Nature Conservancy
7	Halfmoon Caye	Lighthouse Reef Atoll	The Nature Conservancy
8	"El Nic" South Point	Lighthouse Reef Atoll	The Nature Conservancy
9	Northern Glover's	Glover's Reef Atoll	Wildlife Conservation Society
10	Middle Caye	Glover's Reef Atoll	The Nature Conservancy
11	S.W. Caye Glover's	Glover's Reef Atoll	The Nature Conservancy
12	Gladden Spit	Belize Barrier Reef	Friends of Nature
13	Rise and Fall Bank	Sapodilla Cayes	TIDE
14	Nicholas Caye	Sapodilla Cayes	TIDE
15	Seal Caye	Sapodilla Cayes	TIDE

Underwater video cameras were used when possible to record underwater observations. Traditional knowledge of local fishers and GPS were used to identify and map the sites. Observations were made both at midday, to observe and count fishes within the aggregation, and around the time of sunset (5:30 to 6:10 PM local time) in order to observe fish spawning. The survey teams recorded underwater observations on each dive, using underwater slates. Description of fish behavior, color changes, spawning events, and fish size and number for each species were recorded at each site for each dive. After each dive, observers verified and discussed their observations with the survey team leader and the data was transferred on to prepared visual survey data sheets (Appendix I) that were included in the protocol.

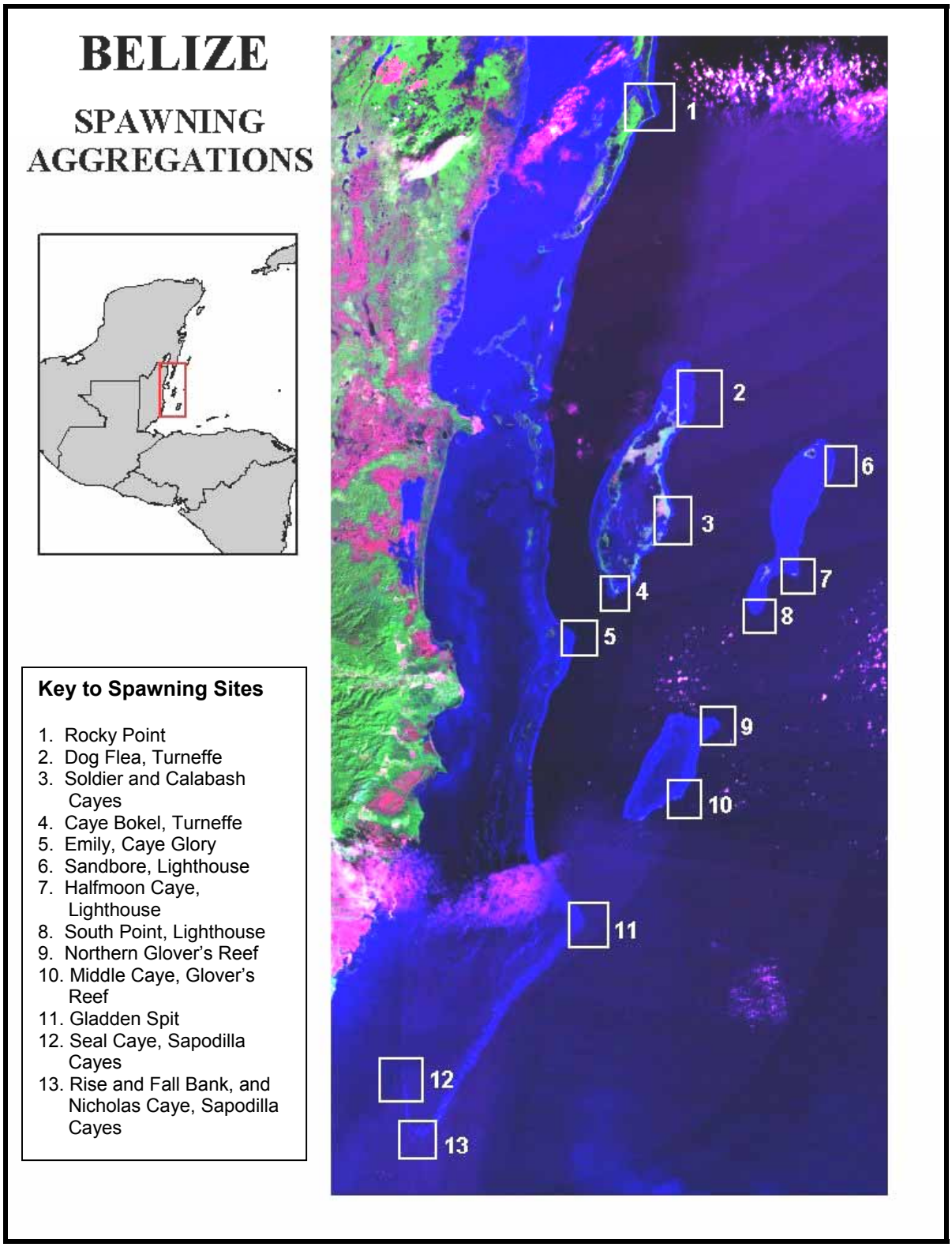


Figure 1: Locator map of multi-species spawning aggregation sites in Belize. Base map is a Landsat TM image.

Underwater video was also reviewed, using freeze frame and slow motion analysis, to verify species identification and counts of fishes, to confirm spawning times and duration, and to accurately describe spawning behavior. Fish ID cards were provided to each team to verify the fish species.

Due to differences in the sizes of the aggregations and their shapes, the observation team used a stratified sampling protocol such that the entire area was surveyed systematically, without double counting or missing fish. At aggregation site such as Sandbore, Lighthouse Reef, which is nestled in a spur and groove system, divers surveyed different spurs simultaneously. Hook-and-line fishing by the team leaders and/or local fishers collected specimens of several reef fish species from each spawning site; gonads were collected and macroscopically observed to determine if these fish were aggregated to spawn. All specimens collected were measured (fork length [FL] to the nearest cm), sex and gonad stage observed, and the data used as part of the CPUE measurements and to verify that those fish aggregated, where there for the purpose of reproduction.

Fish tagging has been part of The Nature Conservancy's ongoing spawning aggregation research and monitoring program since 1999. This technique is being used to evaluate the site fidelity and the distances fish travel to their aggregation sites. The technique is described in detail within the Belize Reef Fish Spawning Aggregation Protocol. Each aggregation monitoring team was equipped with tags, taggers, measuring boards, the monitoring protocol and data sheets. In January of 2002, 17 fish were tagged, 1 Vemco-brand acoustic tag and 16 with Floy-brand Teflon tipped "spaghetti-tags" with unique identification numbers.

Summary data from the January 2002 survey were plotted for all sites and are included in the results section (Figures 2 and 3). One of two the main goals of the January 2002 survey was to evaluate the hypothesis that the grouper spawning sites were also used for other species and served as multi-species spawning aggregation sites. The data, however, are only from a single month of the year. Therefore, The Nature Conservancy has also included summary data from 159 survey dives (including some data from Paz and Grimshaw, 2001, and Sala et al., 2001) conducted over a four-year period, from March 1998 – July 2002, at 16 spawning aggregation sites.

Results

The first goal of this study was to evaluate the Nassau grouper status at their spawning sites, which was deemed in critical condition, the previous year (Paz and Grimshaw, 2001). Figure 2 highlights site-specific daily abundance of Nassau grouper at each site. From previous studies, Nassau grouper are known to aggregate to spawn between two and ten days after the full moon, which occurred on the 30th of December 2001. Northern Glover's had 4,600 individuals at the peak of the aggregation period (Sala, Starr and Ballesteros, 2002; Figure 3). The single dive at Sandbore on 6 January (7 days after full moon) revealed 450 Nassau groupers. The previous year, peak spawning occurred 4 or 5 days after full moon, with peak numbers between 4,000 and 6,000 individuals, and less

then 40 remaining by 7 days after the moon. It is possible that the observation that occurred in January 2002 occurred after the peak aggregation period.

Personal communication with three local fishermen that fish at the Sandbore aggregation site revealed that they had captured about 300 Nassau groupers in 7 days in January. These fishermen agreed that over the past 10 years, there has been a drastic decline in the number of Nassau groupers they capture at the site even as they increase their fishing effort. The fishermen also claim that about 20,000 to 30,000 Nassau groupers were present at the site during the mid-1980s. During the January 2002 survey, 13 fish traps were observed at the aggregation site. Underwater observations revealed that most traps had two or three Nassau groupers and one had seven groupers, revealing the effectiveness of this fishing method at aggregations, and reinforcing the existing ban on the use of traps at spawning sites.

The next highest count of Nassau grouper was at Gladden Spit, where 350 were observed. Other sites had 20 – 200 Nassau groupers, showing signs of courtship and indicating their potential for spawning.

The second goal of this study was to evaluate the multi-species nature of the Nassau grouper spawning sites as hypothesized the previous year. Specifically, The Nature Conservancy hypothesized that windward facing reef promontories, that jut into deep water serve as multi-species spawning sites, providing critical spawning habitat for 20 or more reef species (Heyman, 2001). Figure 3 illustrates the numbers of all fish species found to aggregate at the surveyed sites, during the January 2002 spawning time. Underwater observations confirmed that the all sites had aggregations of several reef fish species confirming that all sites were "multi-species" spawning aggregation sites. Of the 12 sites surveyed, the mean number of aggregating species was six, with a minimum at Dog Flea Caye, Turneffe Atoll (n=2), and a maximum number at El Nic, southern Lighthouse Reef (n=12).

The January 2002 survey results (Figure 3) indicated the co-occurrence of several aggregating reef fish species at the traditional Nassau grouper spawning sites. However, since each reef fish species has a seasonal spawning pattern, often peaking at different times of the year than Nassau grouper, surveys for only the month of January, provide insufficient evidence of the multi-species nature of these spawning sites.

In order to further indicate the multi-species nature of the aggregation sites, we have included within this report, the results of comprehensive surveys of these sites through various times of the year. The data in Figure 4 include data gathered over a 4-year span, from March 1998 – July 2002, and 159 dives. The main differences between Figure 3 (January 2002 data) and Figure 4 (four year data set) are seen at Halfmoon Caye and El Nic in Lighthouse Reef, and at Gladden Spit, where more dives were taken throughout the year, and have thus dramatically increased the number of documented species spawning at these sites. Figure 4 indicates that the numbers of species aggregating at these sites are: Halfmoon (n= 20), El Nic (n=15), and Gladden Spit (n=18), and the mean number of species aggregating for all sites increased to (n=8). However, the data from

Figure 4 are still mostly drawn from January dives. Further survey dives in other seasons and at other sites, especially February - June are likely to dramatically increase the number of species at each site. Nonetheless, Figure 4 clearly indicates the pattern that these spawning sites serve as multi-species aggregation sites, and should be managed as such.

Figure 2. Nassau grouper abundance during January 2002 surveys. Full moon December 30, 2002.

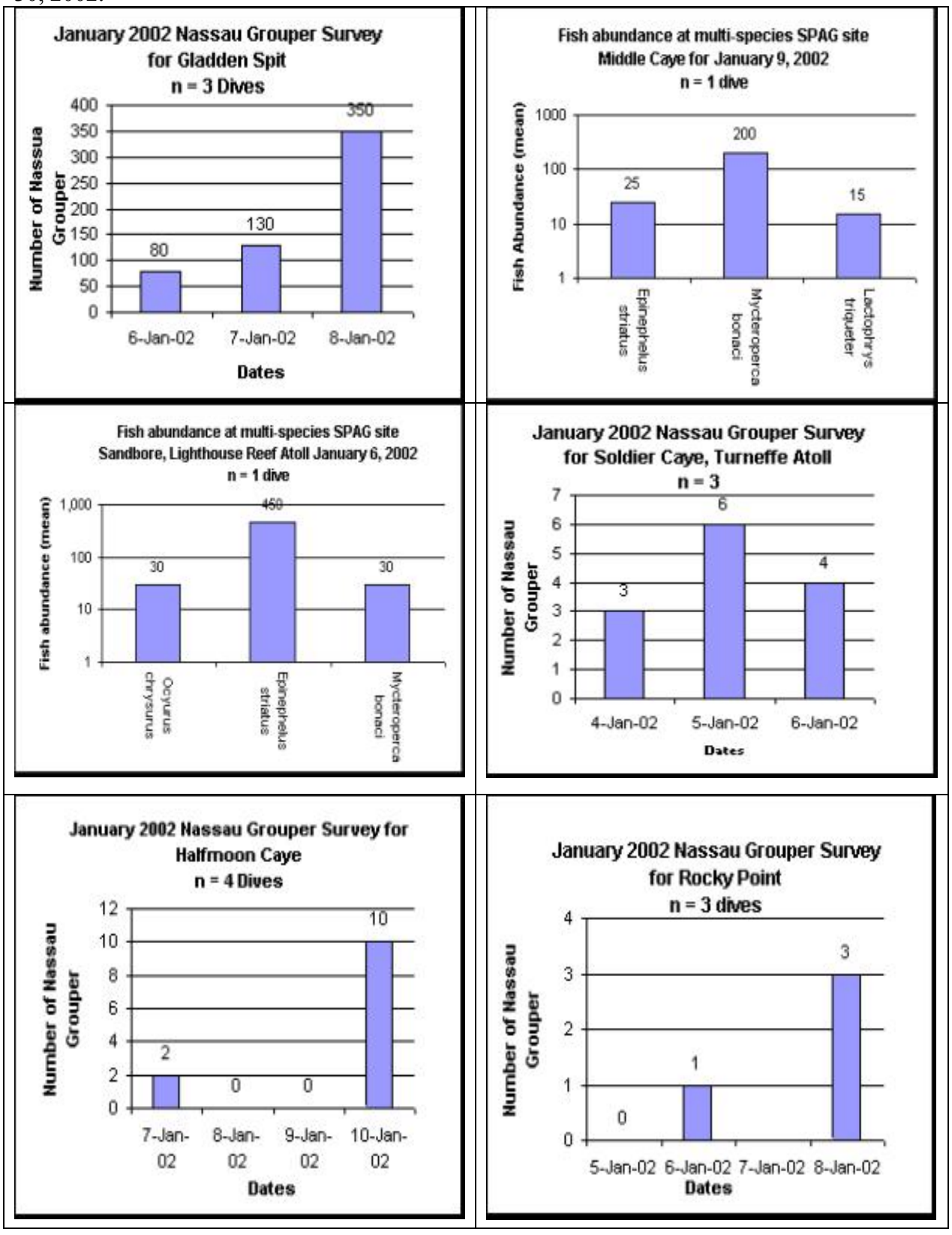
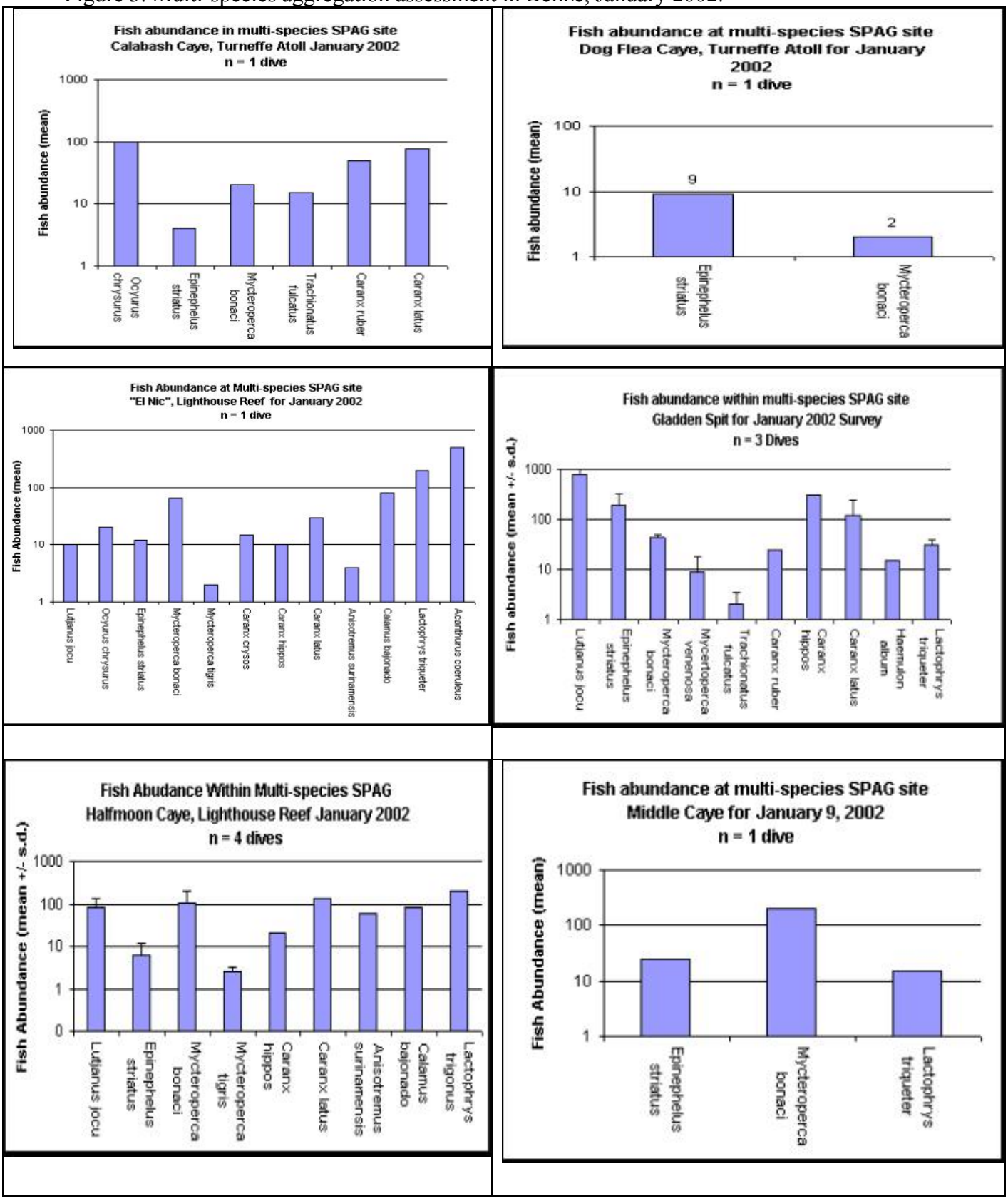
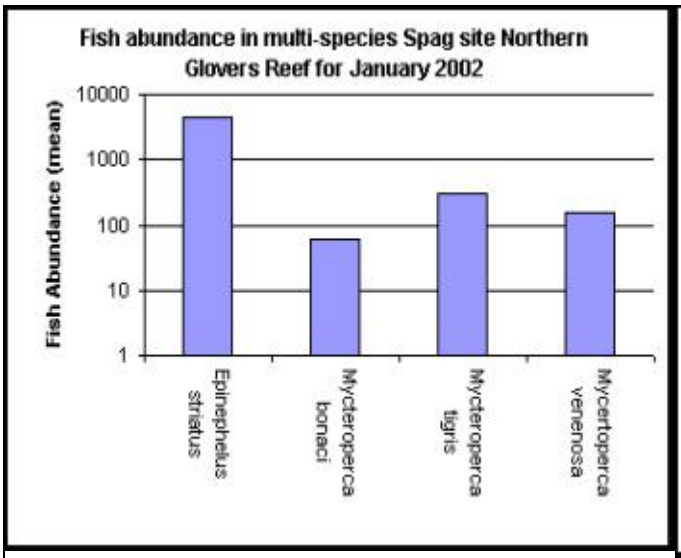
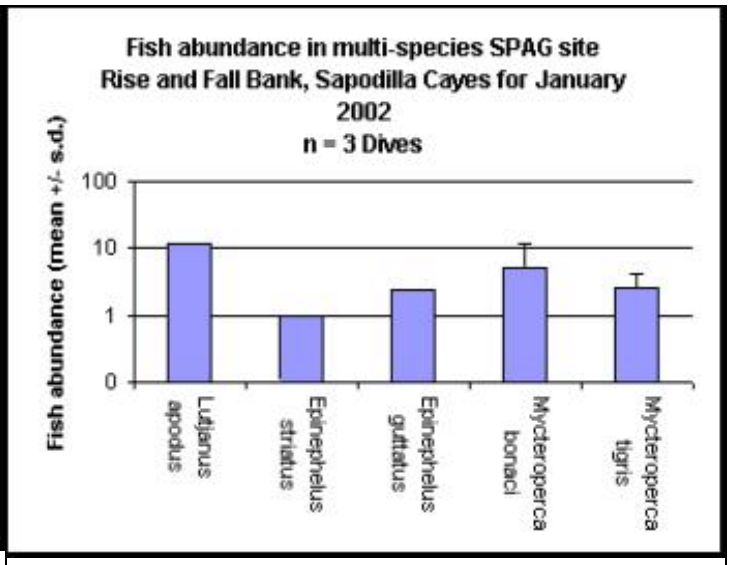
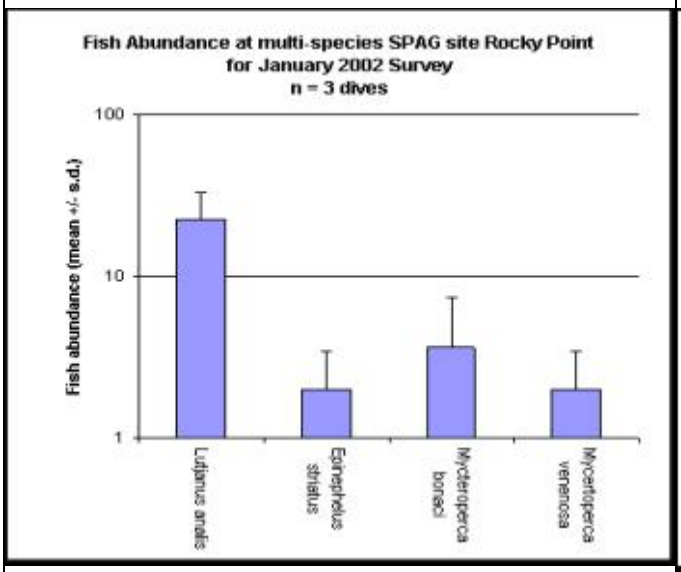


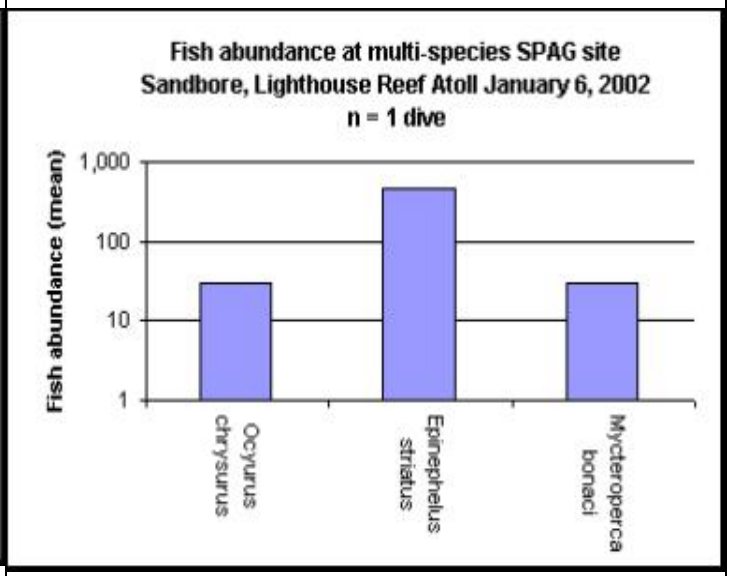
Figure 3. Multi-species aggregation assessment in Belize, January 2002.

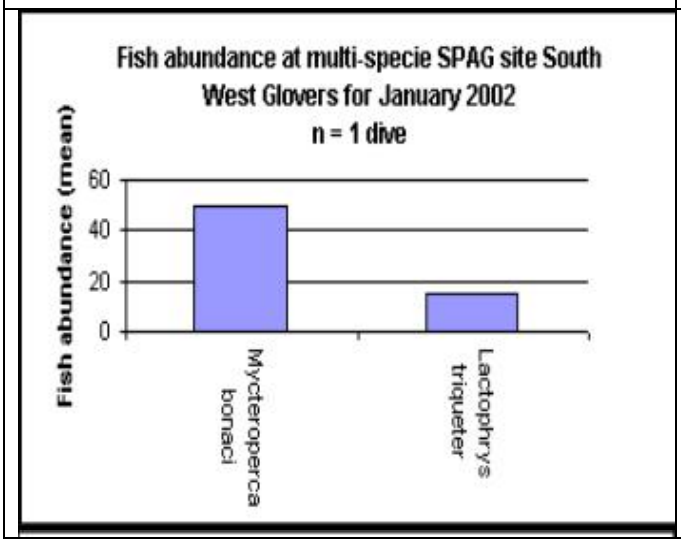


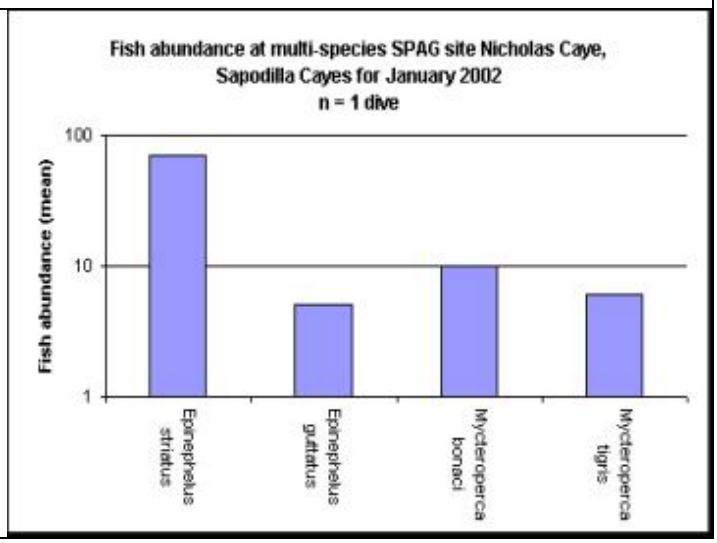

Fish abundance in multi-species Spag site Northern Glovers Reef for January 2002
Fish Abundance (mean)
10000
1000
100
10
1
Epinephelus striatus
Mycteroperca bonaci
Mycteroperca tigris
Mycertoperca venenosa

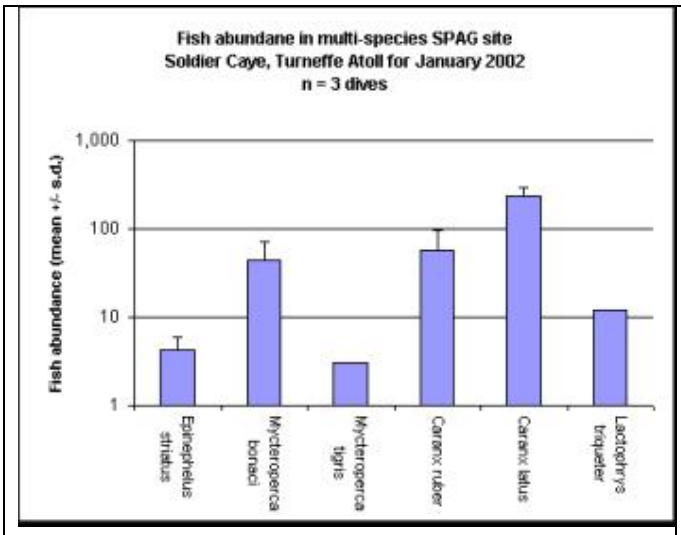

Fish abundance in multi-species SPAG site Rise and Fall Bank, Sapodilla Cayes for January 2002
n = 3 Dives
Fish abundance (mean +/- s.d.)
100
10
1
0
Lutjanus apodus
Epinephelus striatus
Epinephelus guttatus
Mycteroperca bonaci
Mycteroperca tigris


Fish Abundance at multi-species SPAG site Rocky Point for January 2002 Survey
n = 3 dives
Fish abundance (mean +/- s.d.)
100
10
1
Lutjanus analis
Epinephelus striatus
Mycteroperca bonaci
Mycertoperca venenosa


Fish abundance at multi-species SPAG site Sandbore, Lighthouse Reef Atoll January 6, 2002
n = 1 dive
Fish abundance (mean)
1,000
100
10
1
Ocyurus chrysurus
Epinephelus striatus
Mycteroperca bonaci


Fish abundance at multi-specie SPAG site South West Glovers for January 2002
n = 1 dive
Fish abundance (mean)
60
40
20
0
Mycteroperca bonaci
Lactophrys triqueter


Fish abundance at multi-species SPAG site Nicholas Caye, Sapodilla Cayes for January 2002
n = 1 dive
Fish abundance (mean)
100
10
1
Epinephelus striatus
Epinephelus guttatus
Mycteroperca bonaci
Mycteroperca tigris


Fish abundane in multi-species SPAG site
Soldier Caye, Turneffe Atoll for January 2002
n = 3 dives
Fish abundance (mean +/- s.d.)
1,000
100
10
1
Epinephelus striatus
Mycteroperca bonaci
Mycteroperca tigris
Carnax ruber
Carnax latus
Lactophrys triqueter

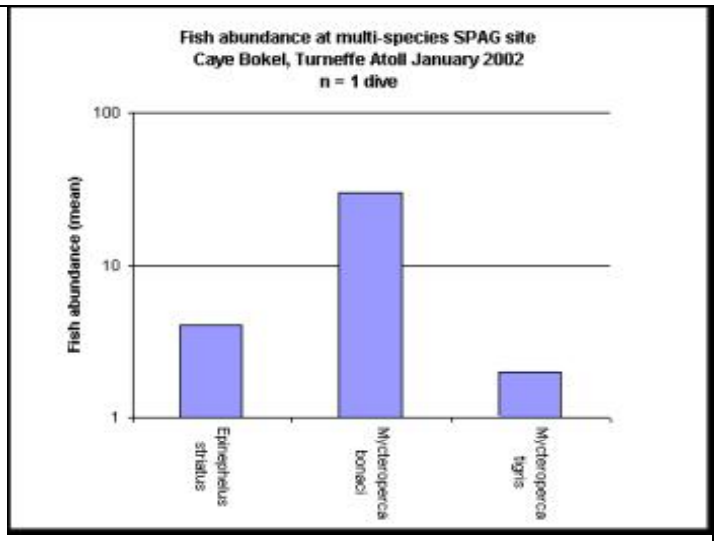
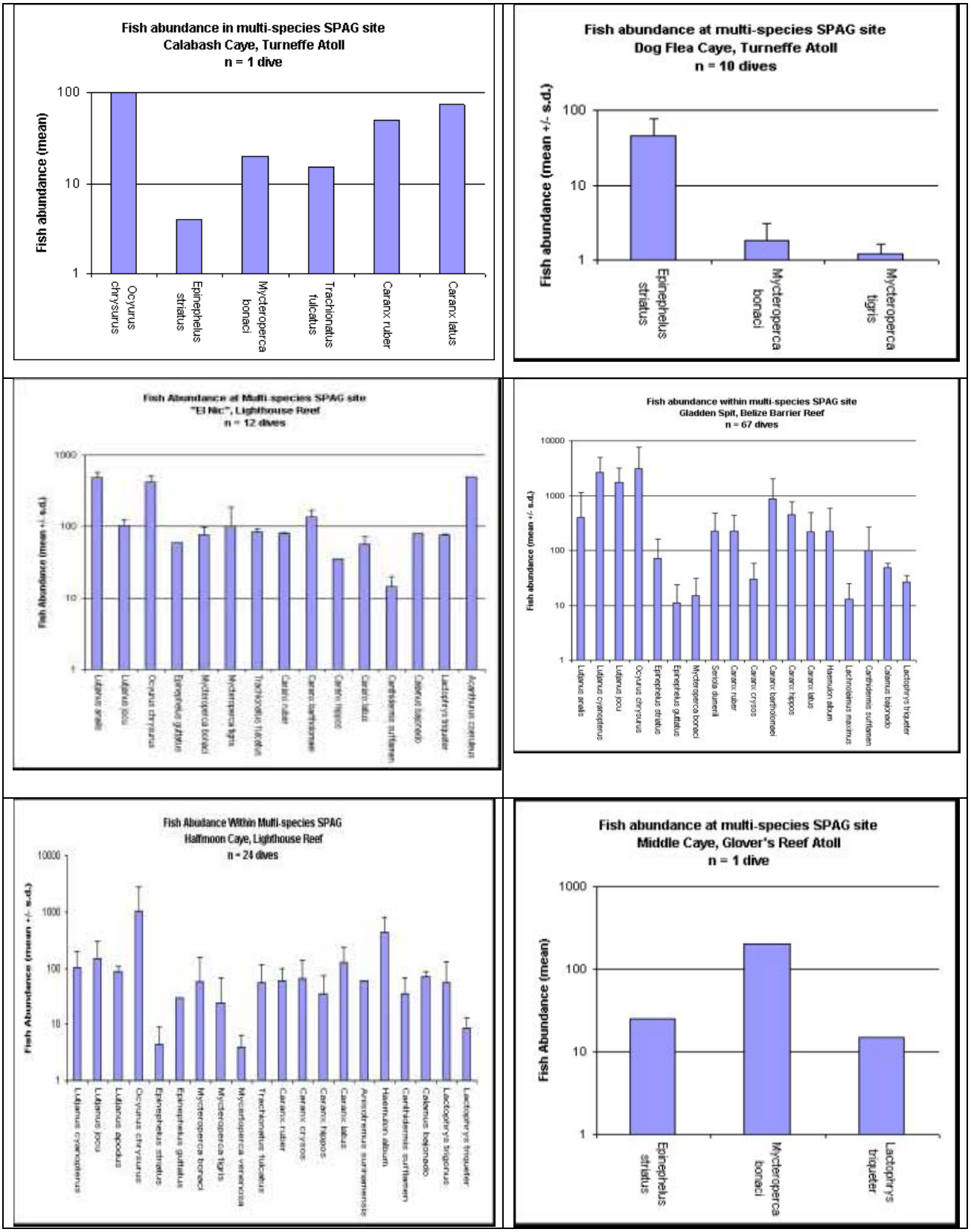
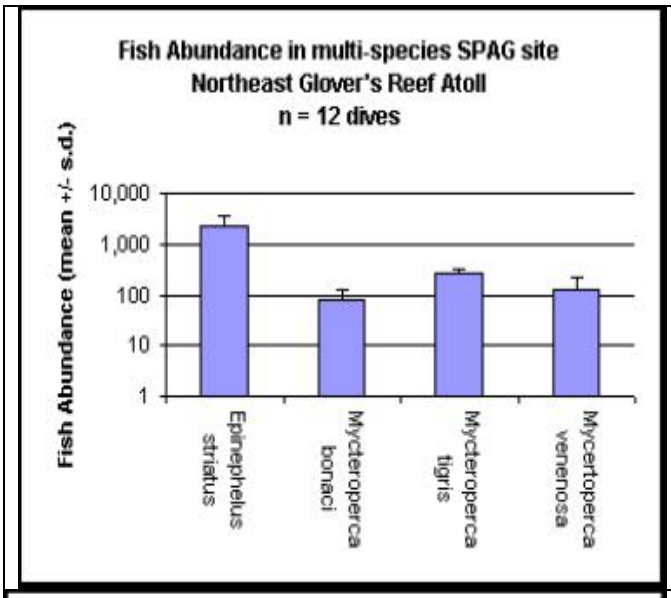
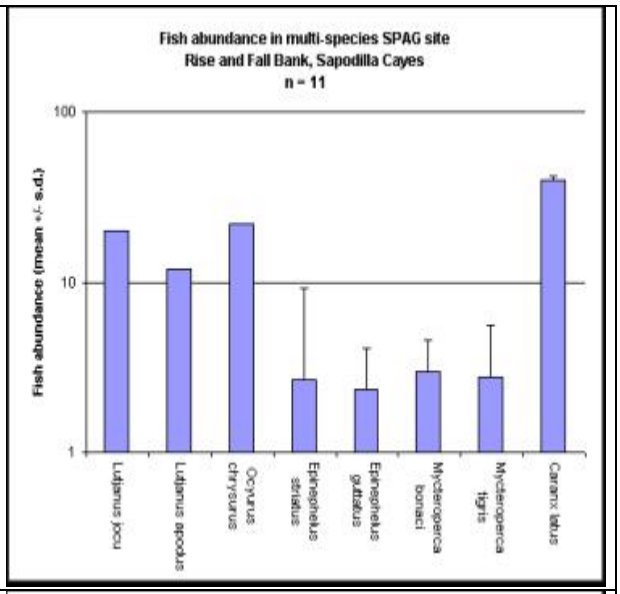
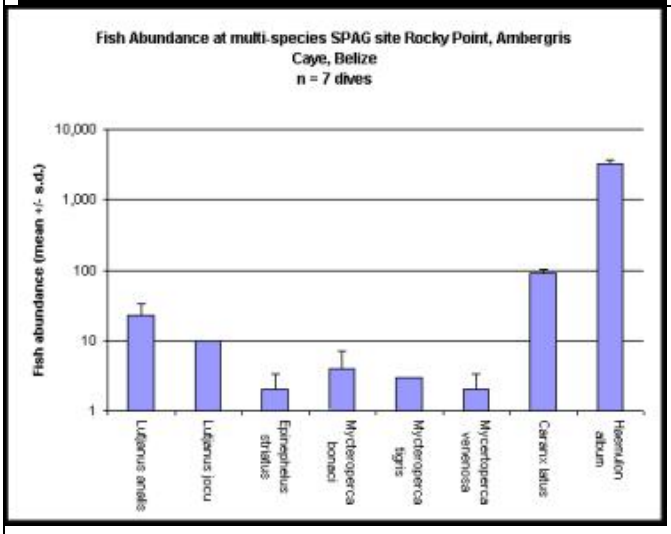

Fish abundance at multi-species SPAG site
Caye Bokel, Turneffe Atoll January 2002
n = 1 dive
Fish abundance (mean)
100
10
1
Epinephelus striatus
Mycteroperca bonaci
Mycteroperca tigris

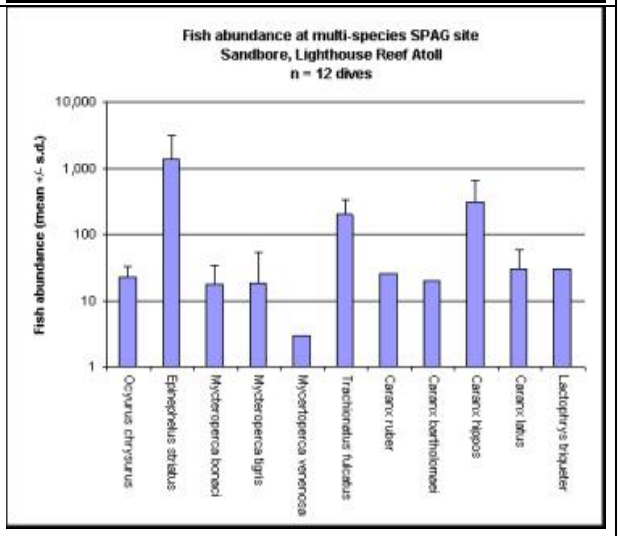
Figure 4. Multi-species assessment for March 1998 - July 2002.

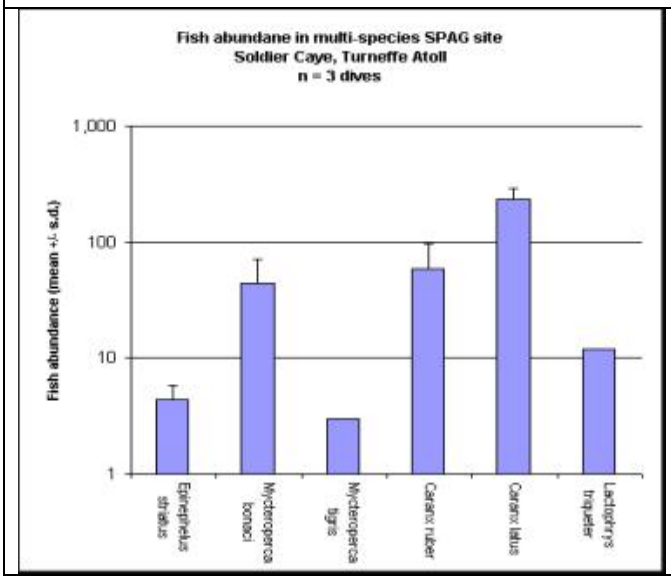


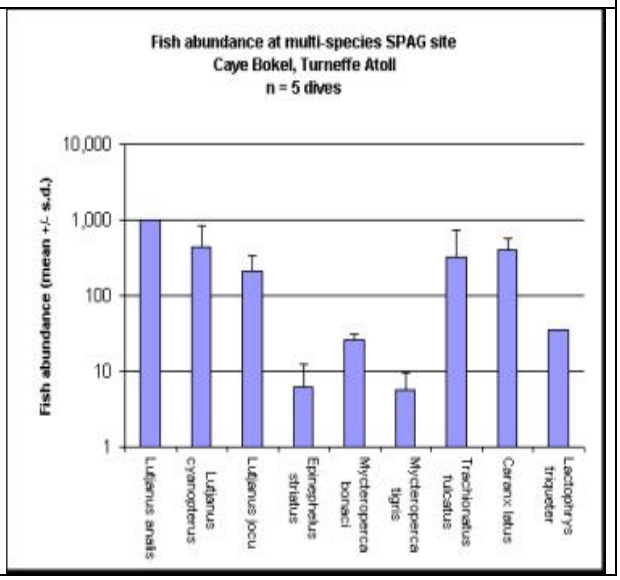

Fish Abundance in multi-species SPAG site
Northeast Glover's Reef Atoll
n = 12 dives
Fish Abundance (mean +/- s.d.)
10,000
1,000
100
10
1
Epinephelus striatus
Mycteroperca bonaci
Mycteroperca tigris
Mycertoperca venenosa

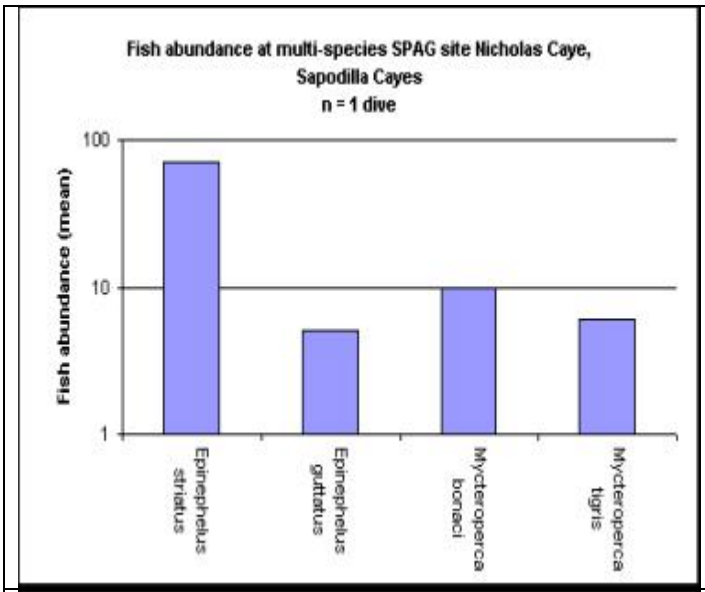

Fish abundance in multi-species SPAG site
Rise and Fall Bank, Sapodilla Cayes
n = 11
Fish abundance (mean +/- s.d.)
100
10
1
Lutjanus jocu
Lutjanus apodus
Ocyurus chrysurus
Epinephelus striatus
Epinephelus guttatus
Mycteroperca bonaci
Mycteroperca tigris
Carcharinus latus

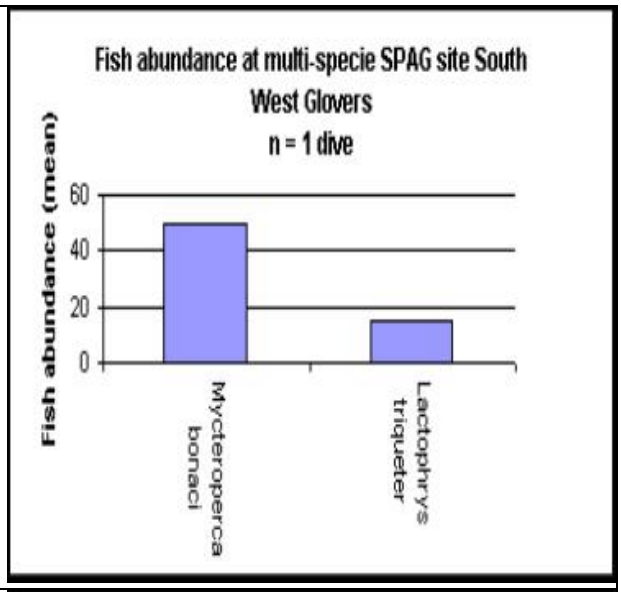

Fish Abundance at multi-species SPAG site Rocky Point, Ambergris Caye, Belize
n = 7 dives
Fish abundance (mean +/- s.d.)
10,000
1,000
100
10
1
Lutjanus analis
Lutjanus jocu
Epinephelus striatus
Mycteroperca bonaci
Mycteroperca tigris
Mycertoperca venenosa
Carcharinus latus
Haemulon album

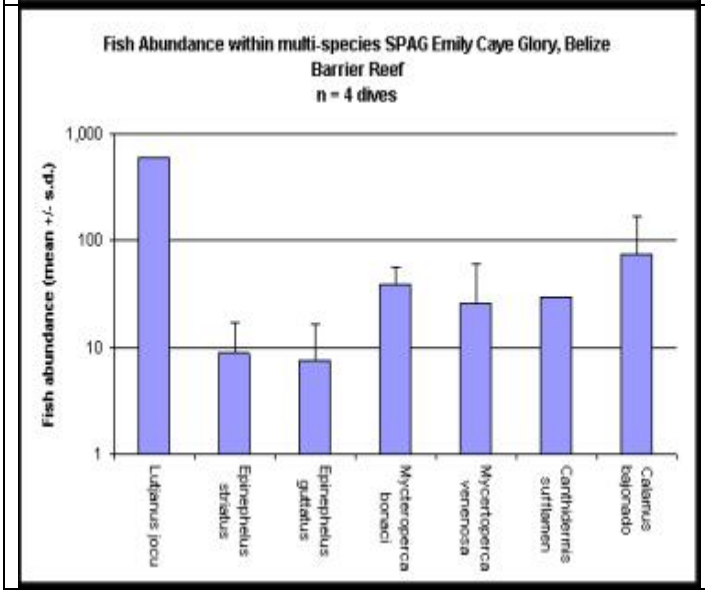

Fish abundance at multi-species SPAG site
Sandbore, Lighthouse Reef Atoll
n = 12 dives
Fish abundance (mean +/- s.d.)
10,000
1,000
100
10
1
Ocyurus chrysurus
Epinephelus striatus
Mycteroperca bonaci
Mycteroperca tigris
Mycertoperca venenosa
Trachinotus falcatus
Carcharinus ruber
Carcharinus barthlomaei
Carcharinus hippos
Carcharinus latus
Lactophrys triqueter

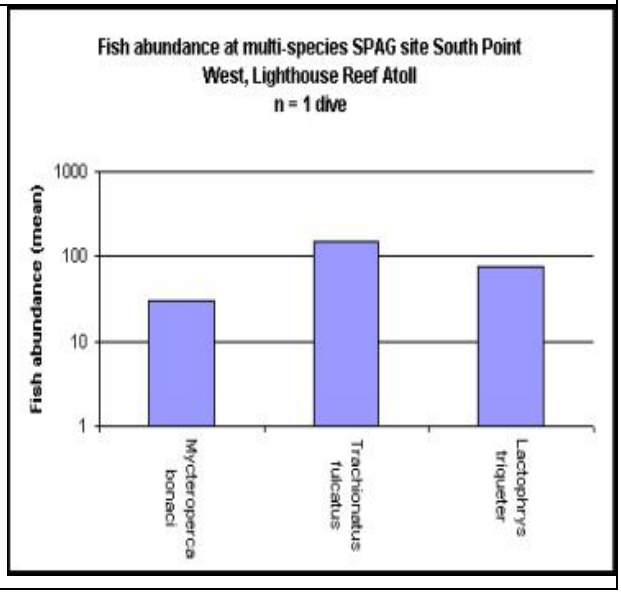

Fish abundane in multi-species SPAG site
Soldier Caye, Turneffe Atoll
n = 3 dives
Fish abundance (mean +/- s.d.)
1,000
100
10
1
Epinephelus striatus
Mycteroperca bonaci
Mycteroperca tigris
Carcharinus ruber
Carcharinus latus
Lactophrys triqueter


Fish abundance at multi-species SPAG site
Caye Bokel, Turneffe Atoll
n = 5 dives
Fish abundance (mean +/- s.d.)
10,000
1,000
100
10
1
Lutjanus analis
Lutjanus cyanopterus
Lutjanus jocu
Epinephelus striatus
Mycteroperca bonaci
Mycteroperca tigris
Trachinotus falcatus
Carcharinus latus
Lactophrys triqueter


Fish abundance at multi-species SPAG site Nicholas Caye, Sapodilla Cayes
n = 1 dive
Fish abundance (mean)
100
10
1
Epinephelus striatus
Epinephelus guttatus
Mycteroperca bonaci
Mycteroperca tigris


Fish abundance at multi-specie SPAG site South West Glovers
n = 1 dive
Fish abundance (mean)
60
40
20
0
Mycteroperca bonaci
Lactophrys triqueter


Fish Abundance within multi-species SPAG Emily Caye Glory, Belize Barrier Reef
n = 4 dives
Fish abundance (mean +/- s.d.)
1,000
100
10
1
Lutjanus jocu
Epinephelus striatus
Epinephelus guttatus
Mycteroperca bonaci
Mycteroperca venenosa
Carthidermis surfamen
Calamus bajonado


Fish abundance at multi-species SPAG site South Point West, Lighthouse Reef Atoll
n = 1 dive
Fish abundance (mean)
1000
100
10
1
Mycteroperca bonaci
Trachinotus ruficatus
Lactophrys triqueter

Discussion and Conclusion

The objectives of this study were to 1. Re-evaluate the status of Nassau groupers in Belize, and 2. To demonstrate that numerous reef fish species utilize the traditional Nassau grouper spawning sites for spawning. As indicated in Figure 2, and in comparison with previous abundance estimates, Nassau groupers are in critical state, and in need of immediate and drastic management measures.

Craig (1966) reports 2 tons per day of Nassau grouper being harvested at Emily, while Paz and Grimshaw (2001) report only 21 fish at the site. Rocky Point on Ambergris Caye was well known as a rich Nassau grouper fishery during the December and January moon. Fishermen report 45,000 pounds of filet landed the first year that it was discovered by Gil Gonzalez, in the early 1980s; Gil and his 2 brothers fished 10,000 pounds of filet during the first week of discovery. Many fish were still there the second year and it was again, fished heavily. In the third year, no fish were found to aggregate at the site (Mito Paz, pers. comm.). The present survey revealed a maximum of 3 Nassau grouper at the site during the January 2002 spawning time. Rise and Fall Bank in the Sapodilla Cayes is reputed to be one of the largest aggregations for Nassau grouper in southern waters, attracting fishermen from Punta Gorda, Punta Negra, and Monkey River, but also received heavy pressure from Guatemala. The present survey revealed a only a single Nassau at the site in 2002. Sala et al., (2001) have made estimates of the decline of the grouper fishery at Northern Glovers Reef, and suggest that groupers will be removed from Belize by 2013. The world conservation union (IUCN) has listed the Nassau grouper, *Epinephelus straitus,* as an endangered species and the state of Florida has a complete ban on this species as well as the critically endangered goliath grouper (Jewfish), *Epinephelus itajara*. By all counts, Nassau grouper are in critical condition and require immediate and drastic management measures if the species is to persist within Belize.

The second goal of the study was to evaluate if those sites used by Nassau groupers, are also used by other species for spawning. Most of the survey dives taken to answer this question were done during the January moon as part of the 2002 spawning aggregation survey and provided reasonable support for the hypothesis with an average of 6 species aggregating at all sites (Figure 3). Because many species arrive at spawning sites at various times of the year, the January data did not adequately address the issue. Therefore, to the extent possible given limited financial and human resources, our teams went back to several of the sites at various times of year, in order to evaluate the multi-species nature of the promontories and the data are more convincing (Figure 4). Most dramatically, sites most extensively surveyed at various times of year, all show a similar pattern of multi-species utilization – South Point Lighthouse Reef (n = 15 species), Halfmoon Caye (n = 20 species), and Gladden Spit (n = 18 species). Other sites were also verified as multi-species sites. For example, at Rocky Point, a site historically well-known for Nassau groupers, an aggregation of white margate, *Haemulon album,* was verified with several thousand individuals, along with smaller aggregations of other important grouper species including black, yellowfin, and tiger grouper, *Mycteroperca*

bonaci, M. venenosa, and *M. tigris*. Rise and Fall Bank, while depauperate of Nassau groupers, did harbor aggregations of other groupers, snappers, and jacks (Figure 4). We consider the data herein, strong support for the hypothesis that all reef promontory sites identified serve as multi-species aggregation sites. Further surveys at various times of year – particularly between February and September, are likely to reveal additional species at all sites. This very question will from the next phase of our research.

We conclude with the general policy recommendation that all known multi-species spawning aggregations in Belize be closed to fishing, and be carefully monitored. Specifically we include the following table of legislation changes needed.

Table 2: Legislative changes needed for identified multi-species spawning aggregation sites in Belize

	Site Name	General Location	Within Marine Reserve	New Legislation Needed	Most suited Organization to Monitor and Protect the site
1	Rocky Point	Ambergris Caye	Yes	No	Bacalar Chico Marine Reserve
2	Soldier Caye	Turneffe	No	New reserve or closure	University of Belize
3	Calabash Caye	Turneffe	No	New reserve or closure	University of Belize
4	Caye Bokel	Turneffe	No	New reserve or closure	University of Belize
5	Dog Flea Caye	Turneffe	No	New reserve or closure	University of Belize
6	Emily, Caye Glory	Barrier Reef	No	New reserve or closure	South Water Caye Marine Reserve
7	Sandbore	Lighthouse Reef	No	New reserve or closure	Belize Audubon Society
8	Halfmoon Caye	Lighthouse Reef	Yes	No	Belize Audubon Society
9	"El Nic" South Point	Lighthouse Reef	No	New reserve or closure	Belize Audubon Society
10	Northern Glover's	Glover's Reef	Yes	Update management plan	Glover's Reef Marine Reserve
11	Middle Caye	Glover's Reef	Yes	No	Glover's Reef Marine Reserve
12	S.W. Caye Glover's	Glover's Reef	No	Update Management plan	Glover's Reef Marine Reserve
13	Gladden Spit	Barrier Reef	Yes	Update Management plan	Friends of Nature
14	Rise and Fall Bank	South of Reef	Yes	Update Management plan	TIDE/ Sapodilla Cayes Mar. Res.
15	Nicholas Caye	Barrier Reef	Yes	Update Management plan	TIDE/ Sapodilla Cayes Mar. Res.
16	Seal Caye	Barrier Reef	Yes	Update Management plan	TIDE/ Sapodilla Cayes Mar. Res.

In sum, to affect the recommended policy, the following legislation changes would be needed.

- Three sites are already protected within marine reserves and will need not change in legislation.
- Six sites are within or adjacent to reserves requiring only a change in management plans.
- Seven sites are outside of any existing protected area, and would require new legislation for small closed areas.
- One national regulation that will halt spearing and hooking of groupers.

Recommendations

1. All 16 documented "multi-species" spawning aggregation sites should be closed to fishing throughout the year. The table of sites, legislative needs, and possible management authorities for each site is listed in Table 2 of the discussion.

2. A national monitoring program be should enacted, utilizing the existing standardized protocol and data collection system, to further evaluate all of the known sites, during all months of the year. The Nature Conservancy is willing to coordinate the development of the national monitoring program, as part of a regional spawning aggregation monitoring program that is being jointly developed with the MBRS project, by providing training, technical support, and data compilation and report generation, and a competitive small grants program to support monitoring teams at sites. It is envisioned that the once the system is fully operational, the coordination role would be transferred to appropriate, and mutually agreed upon agencies in each country.

3. Special provisions should be made for those fishermen who have traditionally, and recently used these sites for fishing. Specifically, they should be included, when possible, as paid members of the monitoring teams. Special provisions for traditional fishermen at these sites may have to be made, including preferential access to economic alternatives training courses, jobs as reserve rangers, and possibly some limited access to sites, outside of grouper season, negotiated with local co-management bodies.

4. A harvest and possession ban on all Nassau grouper, *Epinephelus striatus*, should be enacted; in order to protect this endangered species from local extirpation.

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Domeier, M. and P. Colin, 1997. Tropical reef fish spawning aggregations: defined and reviewed. Bull. Mar. Sci. **60**, 69.

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Sala E., R. Starr, and E. Ballesteros, 2001. Rapid decline of Nassau grouper Spawning Aggregations in Belize. Fishery Management and Conservation Needs. Fisheries. 26(10): 23 – 30.

Sala E., R. Starr, and E. Ballesteros, 2002. Grouper Spawning Aggregation in Glover's Reef: Interim report to the Fisheries Department, Wildlife Conservation Society and Scripps Institute of Oceanography.

Appendix 1. Visual survey data: spawning aggregations

Date:	**Time:**				
Team Leader:	**Team Members:**				
Location:[1]	**GPS coordinates**[2]				
Surface Conditions					
Air Temperature					
Water Temperature					
Surface Current Speed and Direction[3]					
Sea State					
Wind Speed and Direction[4]					
Number of Fishing Boats Nearby					
Underwater Conditions					
Depth					
Temperature					
Visibility					
Estimate of Current at Spawning Depth					
Species	**Count**	**Mean Length (cm)**[5]	**Minimum Length (cm)**	**Maximum Length (cm)**	**Spawning Behaviors (note all)**[6]

[1] Write a detailed site description including sketches of the spawning bank, on the back of this sheet or additional sheets. In addition, please write any anecdotal information gathered on the spot, and note any further or abnormal observations.

[2] For Belize, GPS coordinates should be taken in UTM with datum, NAD 27 Central America – (other areas, WGS 84).

[3] Sea current direction is the direction in which the current is moving, e.g. current is moving to the south at .5 knots so write, "south current, 0.5 knots". Please also note if current speed is estimated or calculated with a current drogue.

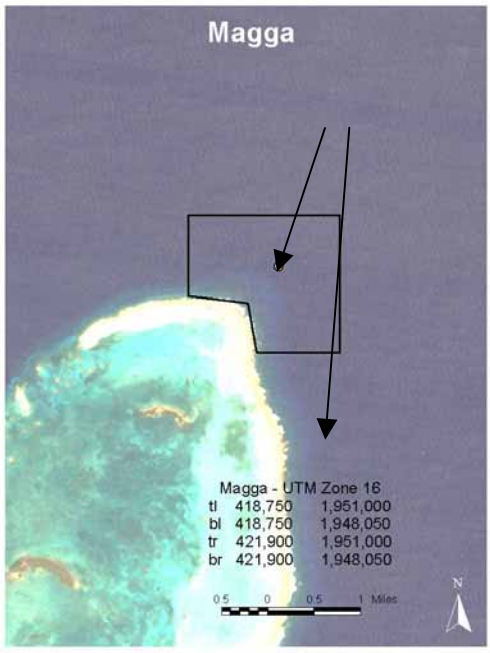
[4] Wind direction is the direction from which the wind is coming, e.g. wind is from the northeast at 5 – 10 knots then write, "Northeast wind, 5 – 10 knots".

[5] Length is measured to the fork of the tail (fork length).

[6] Please note any of the observed spawning behaviors using the following letters: a) grouping, b) fighting, c) color changes, d) bite wounds, e) Gravid, f) courtship, g) spawning.

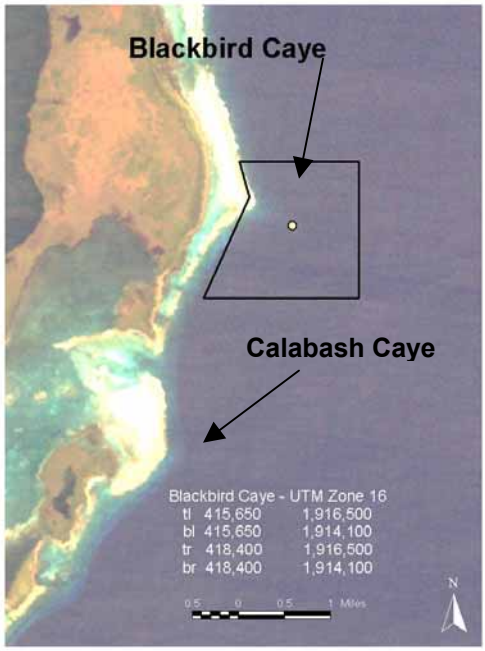
Appendix 2: Detailed spawning site locator maps of multi-species spawning aggregation sites, indicating proposed protected areas as agreed upon by the National Spawning Aggregations Working Committee in November 2001.

Mauger Caye, Turneffe Atoll

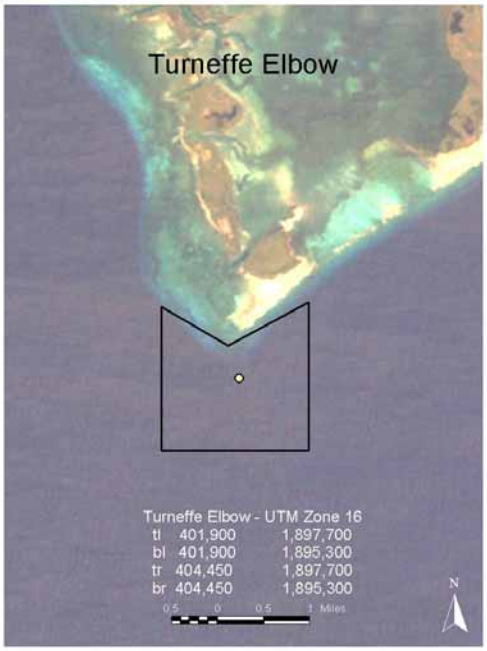


Dog Flea Caye, Turneffe Atoll

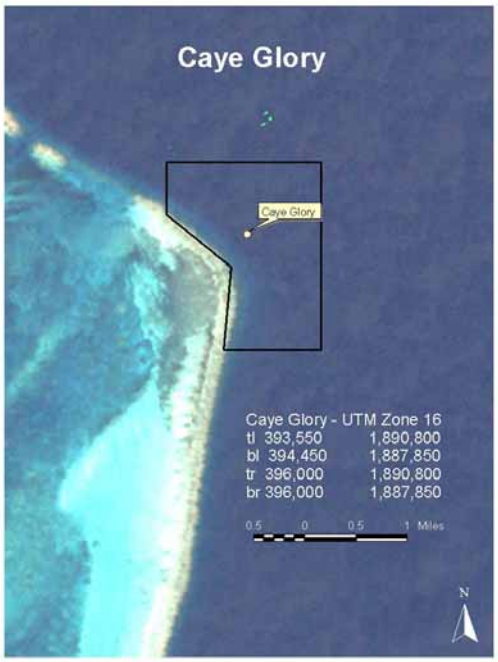
Soldier (Blackbird) and Calabash Caye



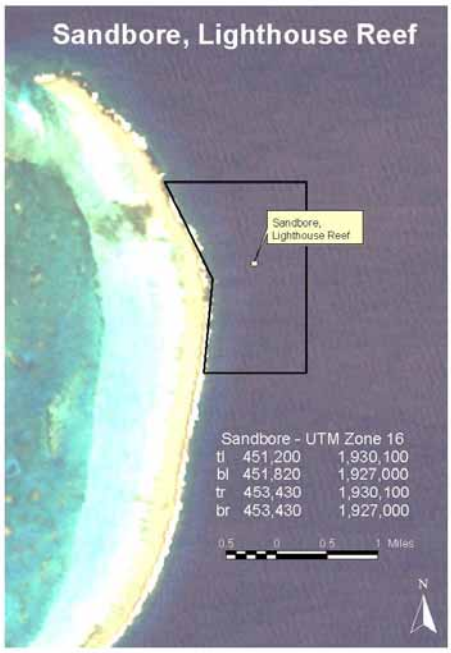
Caye Bokel, Turneffe Atoll



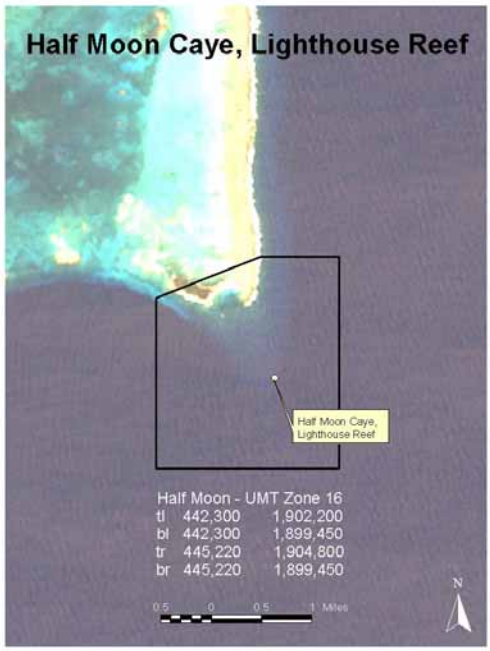
Emily, Caye Glory, Belize Barrier Reef



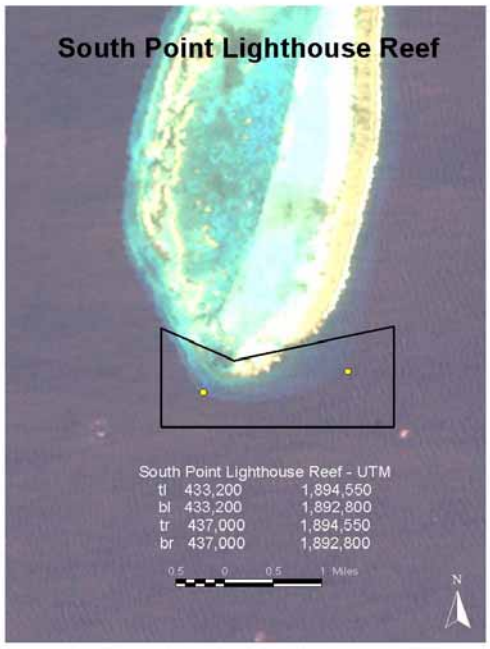
Sandbore, Lighthouse Reef



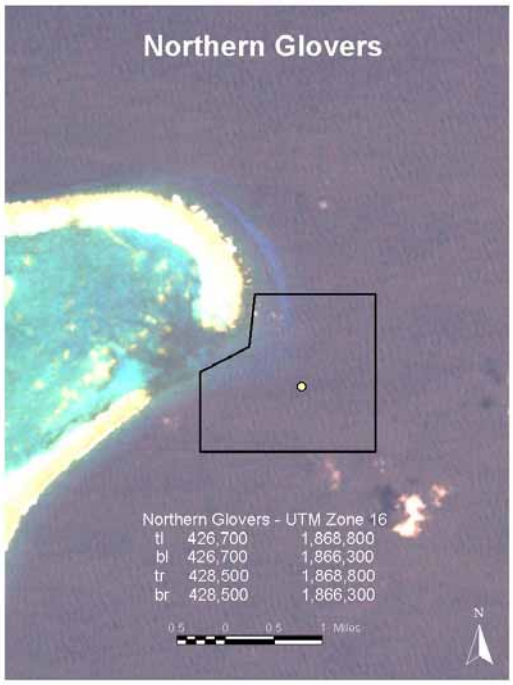
Halfmoon Caye, Lighthouse Reef



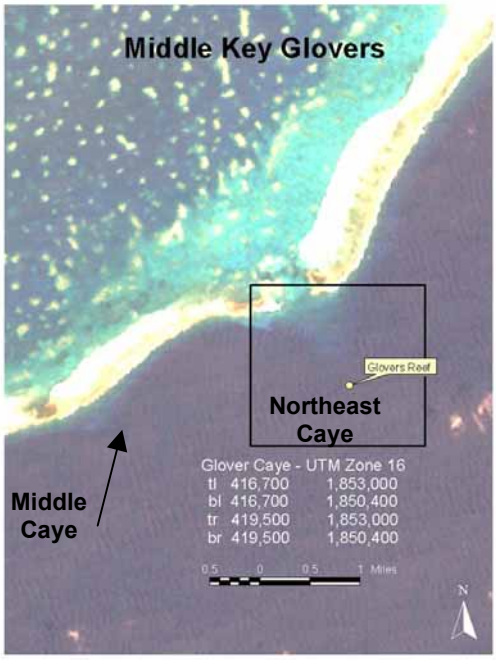
South Point, “El Nic”, Lighthouse Reef



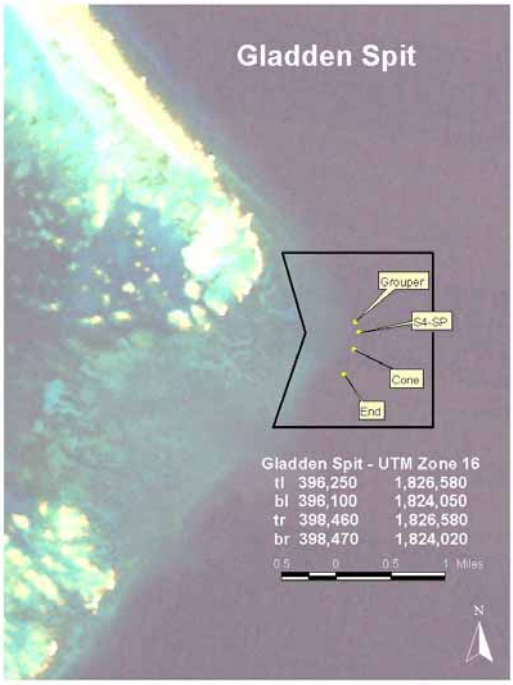
Northern Glover's Reef



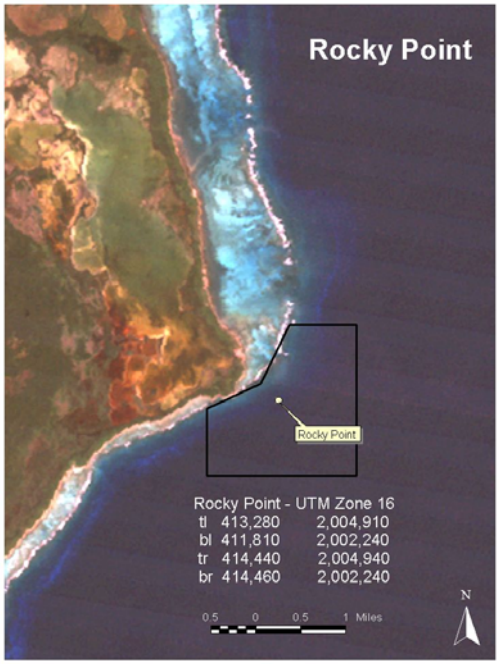
Middle and Northeast Caye, Glovers



Gladden Spit, Belize Barrier Reef



Rocky Point, Ambergris Caye



Seal Caye, Sapodilla Cayes	Rise and Fall Bank, Sapodilla Cayes