



## **Integration Framework: ESA Section 4 & 7**

Provided to the USACE for the  
Nassau Grouper (*Epinephelus striatus*)

|                                                                                                                                                          |   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| I. PURPOSE AND SCOPE                                                                                                                                     | 1 |
| II. SECTION 7 CONSIDERATIONS (Specific Section 7 Consultation Assistance)                                                                                | 1 |
| A. Range for consultation purposes (how common is the species and where is the species found based on data from our FWC, university, and NOAA partners?) | 2 |
| B. Considerations for Projects Located in Florida Keys                                                                                                   | 2 |
| C. Consideration for Projects within the U.S. Caribbean                                                                                                  | 4 |
| D. Conservation and Recovery Considerations                                                                                                              | 5 |
| III. BACKGROUND INFORMATION                                                                                                                              | 6 |

### **I. PURPOSE AND SCOPE**

In order to inform consultation activities regarding the recently listed Nassau grouper, this document consolidates and interprets information obtained through the recent listing process and collected through collaboration with state, federal (Southeast Fisheries Science Center [SEFSC]), and university partners. This collection of information provides section 7 assistance, and identifies early conservation/recovery concepts to be considered during consultation. The contents are intended to summarize best available information as well as facilitate integration of conservation/recovery considerations into routine consultation practices. A large quantity of data was synthesized in the production of this document and as such it should be considered a job aid and used as general guidance only.

### **II. SECTION 7 CONSIDERATIONS (Specific Section 7 Consultation Assistance)**

**This section provides information to help you with section 7 consultations.**

Following the June 2016 Nassau grouper listing under the Endangered Species Act (ESA), we began considering what types of federal actions could have the potential to affect the species. This analysis considered Nassau grouper distribution and habitat use within its range based on the various life stages of the species. We relied on the 2013 Biological Report used to inform our listing determination ([http://sero.nmfs.noaa.gov/protected\\_resources/listing\\_petitions/documents/biological\\_report.pdf](http://sero.nmfs.noaa.gov/protected_resources/listing_petitions/documents/biological_report.pdf)) and collected additional information from various state, university, and federal agencies, as presented below, to ensure the most recent data available was incorporated.

## A. Range for consultation purposes (how common is the species and where is the species found based on data from our FWC, university, and NOAA partners?)

All data to date suggest that Nassau grouper are absent from the waters surrounding most of the continental United States. The exception is Florida where a small number of larger juveniles and adults (293 individuals) have been recorded in surveys since 1994 (see supporting data for details). No larval Nassau grouper or juveniles smaller than 19 cm fork length (FL) have been collected or observed in Florida waters. However, it should be noted that sampling along shoreline habitats of the Florida Keys where smaller juveniles might be expected to occur has been limited to date.

Based on the information detailed later in this document, we evaluated the functional range of Nassau grouper to ensure that our section 7 consultation practices consistently and accurately consider where the species may be present.

- General construction projects occurring in the southeastern United States, with the exception of those in the Florida Keys (including the Dry Tortugas), will have no effect on the species due to the absence of Nassau grouper in these locations. The general absence of Nassau grouper outside of the Florida Keys is well documented by the lack of records in Florida Fish and Wildlife Conservation Commission's, Fisheries Independent Monitoring data as well as various surveys conducted by the National Marine Fisheries Service's SEFSC. Specifically, **we do not believe Nassau grouper will be present in waters of Florida Bay (inside of the Everglades National Park (ENP) Boundary), the Gulf of Mexico, and all locations along the Atlantic coast north of Government Cut.**
- Adult and large juvenile Nassau grouper **may be present in waters surrounding the Florida Keys and the Dry Tortugas.** In this area, consultations should carefully evaluate the habitat preferences for these life stages in determining whether Nassau grouper may be present in affected areas.
- **All life stages of Nassau grouper may be present throughout Puerto Rico and the U.S. Virgin Islands (i.e., the U.S. Caribbean).** Again, habitat associations for the various life stages should be considered in determining whether the species may be present in the area affected by proposed actions.

## B. Considerations for Projects Located in Florida Keys

Projects (e.g., general construction) occurring in waters of the Florida Keys (up to the ENP boundary along the Florida Bay side of the Keys and all waters on the ocean side of the Keys) may have the potential to affect the species, with the following clarification and limitations:

- NMFS does not expect small (e.g., newly settled or recently recruited, <19cm total length; TL) Nassau grouper to occur anywhere in the Keys.
- While larger juveniles (19cmTL and larger) do occur off of the Keys, NMFS **does not** expect any Nassau grouper of this size to be present **on soft habitat (mud/sand areas with no coral or rock)**. "No effect" determinations by the action agency are appropriate for projects occurring over soft bottom habitat.
- Nassau grouper (19cm TL and larger) **could occur over corals, reefs, and other hardbottom habitat, including channels and canals cut through the limestone hardbottom found throughout the Keys.**

In this instance a “no effect” determination CANNOT be supported as the species may be present and a “may affect” determination will be made; subsequent analysis to analyze the potential effects of the project based on its stressor(s) is necessary. Additional information to assist with that analysis is provided below.

- Nassau grouper, like other grouper species, are closely associated with structure and utilize these areas for cover. Therefore they may be found in areas with docks and seawalls even if hardbottom is absent. Again, additional information to assist with the analysis is provided below.

#### Common Routes of Effect to Consider for Projects Occurring in waters surrounding the Florida Keys

If a project will occur near corals, reefs, hard bottom, or shoreline structures, the biologist should consider the following list of potential stressors and their effects. The biologist should also include the accompanying rationale to justify a determination that effects are discountable or insignificant, as applicable and appropriate.

*Exceptions beyond routine small scale projects for which this rationale may not be appropriate could include: large scale projects such as marinas that have a longer construction duration, fishing piers that could result in the incidental capture of Nassau grouper, port expansion projects that may require significant impacts to hard-bottom habitat, consultation on fishery management plans that could result in the incidental bycatch of Nassau grouper in otherwise legal federal fisheries, and activities that could result in significant impacts to hard bottom habitats used by Nassau grouper.*

- PHYSICAL INJURY FROM EQUIPMENT - Nassau grouper have the potential to be physically injured or killed by interactions with construction equipment and pile installation. However, we believe this effect is discountable because this species is mobile and expected to move away from active construction equipment.
- TEMPORARY LOSS OF FORAGE OR REFUGE HABITAT - Nassau grouper may temporarily be unable to use the project area as forage or refuge habitat due to avoidance related to construction noise and/or physical exclusion from the area via turbidity curtains or disturbance. We believe these types of effects would be insignificant, based on the typical small footprint and short duration associated with most projects. Additionally, Nassau grouper (at the sizes that would be found in the action areas) are highly mobile organisms and provided similar habitat was nearby, we expect these adjacent sites could provide similar short-term refuge or forage habitat.
- LONG TERM HABITAT ALTERATIONS - Larger juvenile and adult Nassau grouper (>19cm TL) use a variety of hardbottom habitats. While the listing rule characterized habitat loss as a low risk to species survival and distribution, habitat loss may affect species recovery. Projects resulting in the removal or modification of reef or hardbottom habitat may affect Nassau grouper by displacing them from these specific habitats. However, we believe any effects from most small scale removals or modifications of reef or hardbottom habitat will be insignificant provided there is other habitat in close proximity to the project site that can serve a similar habitat function for Nassau grouper. Projects removing or altering larger areas of habitat will require further considerations and analyses. Activities that have significant or large scale direct or indirect impacts to reef or hard bottom habitat may result in adverse effects to the species through the modification or loss of habitat. Long term/permanent impacts to reef or hardbottom habitat should be considered in assessing potential for adverse effects to the species.
- NOISE - Effects to ESA-listed animals as a result of noise created by construction activities can physically injure animals in the affected areas or change animal behavior in the affected areas. Injurious

effects can occur in 2 ways. First, immediate adverse effects can occur to listed species if a single noise event exceeds the threshold for direct physical injury. Second, effects can result from prolonged exposure to noise levels that exceed the daily cumulative exposure threshold for the animals, and these can constitute adverse effects if animals are exposed to the noise levels for sufficient periods. Behavioral effects can be adverse if such effects interfere with the animal movement, feeding, resting, or reproduction, for example. Our evaluation of effects to listed species as a result of noise created by construction activities is based on the analysis prepared in support of the Opinion for SAJ-82.<sup>1</sup> The biologist should conduct a noise analysis to evaluate effects to ESA-listed fish identified by NMFS and whether the effects are NLAA or LAA.

- TURBIDITY - Project construction could increase turbidity that may adversely affect Nassau grouper. To control and reduce turbidity, the applicant will generally be required to use turbidity curtains, which will be installed prior to and remain in place throughout all in-water construction. Turbidity curtains will remain in place post-construction until turbidity and siltation subsides. Given the short duration and this best management practice associated with typical projects it is likely there will be no effect from turbidity.

### C. Consideration for Projects within the U.S. Caribbean

Based on the assumption stated above that all life stages of Nassau grouper are likely present in the U.S. Caribbean, action agencies, and subsequently NMFS, must consider possible impacts to multiple life stages of Nassau grouper from a variety of in-water projects that are likely to occur in the Caribbean. UNLIKE THE FLORIDA KEYS, all size classes may occur in project areas of the U.S. Caribbean. This becomes especially important in considering noise analyses for which there are different thresholds for smaller fish (those <2g) versus larger fish (>2g). NMFS is uncertain about how individual projects may affect the species and therefore effects will need to be considered on a project-by-project basis. Considerations should include time of year (to determine life stages that may be present), the lower mobility of small juveniles if present, habitat types in the vicinity of the project, scale of the project, and then potential routes of effects. These routes of effects may include but are not limited to:

- Physical injury from equipment.
- Loss of forage or refuge habitat – Based on the 2013 Biological Report, habitats used by small Nassau grouper include a variety of microhabitats (*Laurencia spp.* mats, queen conch shells, tilefish mounds) and more traditional habitats (coral, mangroves, seagrass beds, hard bottom). However large-scale projects that have direct or indirect impacts to reef or harbottom habitat can have potential effects to adults. In locations where small juveniles may occur, loss of seagrass and mangroves may also have potential effects to the species' nursery areas. In the U.S. Caribbean, activities with permanent impacts to the nearshore seagrass and mangrove habitat should be assessed for potential adverse effects to newly settled and juvenile life stages.
- Behavioral or physical injury from noise.
- Accidental bycatch.

#### Potential Work Window To Avoid Effects of Noise to Small (<2g) Recent Recruits

---

<sup>1</sup> NMFS. Biological Opinion on Regional General Permit SAJ-82 (SAJ-2007-01590), Florida Keys, Monroe County, Florida. June 10, 2014.

- Construction windows to avoid impacts to newly recruited juveniles - proposed actions should occur **between July 7 – December 11** to avoid noise impacts to small (<2g) Nassau grouper. While applicants are not required to conduct work within this window; but projects conducted during this period would consider potential impacts of noise to these small (<2g) juvenile Nassau grouper.
  - This work window is based on the following;
    - Assuming (1) aggregations form at the same sites every year from November – February, (2) eggs hatch as larvae 23-40 hours post fertilization, and (3) larvae are planktonic for up to 70 days but typically recruit to demersal habitat around 40 days at an average size of 2.5cm (25mm), then the latest that a young 2.5cm (25mm) new recruit would show up in the action area would be February 28th + 2 days (to hatch) + 70 days planktonic then recruit (conservative, worst case scenario) = **May 11**.
    - Estimated growth rate is 0.57mm/d (this assumes the growth rate for slightly larger fish applies to this size class),
    - A 2g fish is approximately 57mm, therefore the recruit at 25mm needs to grow 32mm in order to reach a TL of 57mm (size at recruitment to 57mm to reach a weight of 2g; or a total of 32mm (57mm – 25mm = 32mm).
    - With a growth rate of 0.57mm/day it would take 56.2 days for the recruit to grow 32mm (32mm/0.57mm/d = 56.2).
    - Therefore with a spawn date of February 28 + 2 days (to hatch) + 70 days planktonic then recruit + 56.2 days for the recruit to grow to 2g = **July 7**.
    - Next, the date a new recruit from the next year class could enter the action area would be December 11 (earliest recruit would be November 1 + 1 day to hatch + 40 days to recruit on conservative side = **December 11**).
    - **So between July 7 - December 11** (roughly 5 months) Nassau grouper less than 2g should not be present in the nearshore habitat.
  - Noise Abatement Methods may be available and can be assessed for effectiveness.

## D. Conservation and Recovery Considerations

One of the goals of PRD is to promote conservation and recovery of ESA listed species. Section 7 consultations and the related engagement with action agencies (and applicants) provide an opportunity to help achieve these goals. While the most serious threats to Nassau grouper is removal by fishing at spawning aggregations and inadequate law enforcement (which are beyond the scope of the routine consultations addressed by this document, except perhaps FMP consultations), other threats contribute to the status of this species. Possible issues to consider during consultation include, but are not limited to:

- Loss of any of the habitats utilized by groupers during various life stages may influence their distribution, abundance, and survival, including alterations or destruction of nearshore nursery areas, including mangroves and seagrasses, and degradation of hardbottom habitat. Therefore, consulting biologists should not only work to avoid and minimize potential project impacts to Nassau grouper habitat during consultation with action agencies, but encourage proactive conservation actions that could help improve or protect habitat through conservation recommendations whenever possible.
- Additionally, where applicable and practicable, staff should seek the cooperation and assistance of action agencies and applicants in helping with public outreach concerning the plight of the species. This may include, but is not limited to, helping communicate (e.g., signage) the importance of minimizing human impacts to habitats used by the Nassau grouper (and other protected species!), compliance with existing regulations including no take and seasonal/areal closures, and promoting responsible fishing

practices (use of circle hooks when fishing in areas where this species may be captured, safely returning this species to the water if captured).

### III. BACKGROUND INFORMATION

This section presents information to help familiarize you with the species to understand its basic biology, life history, ecology, and habitat use. This information was used in combination with the listing rule, and the 2013 Biological Report, to guide development of the Section 7 framework.

#### Listing Information

- Listed as threatened on June 29, 2016 (81 FR 42268), effective July 29, 2016.  
<https://www.federalregister.gov/documents/2016/06/29/2016-15101/endangered-and-threatened-wildlife-and-plants-final-listing-determination-on-the-proposal-to-list>.
- Critical Habitat has not been designated.

#### Species Description

- Adult appearance: Dark band on top of head from upper jaw through each eye and then curving to meet its corresponding band above eye (i.e., tuning fork pattern); 5 dark vertical bars; black saddle on the caudal peduncle; and, numerous black spots below/behind each eye.
- Juveniles exhibit a color pattern similar to adults.
- Maximum weight: 55lbs (25kg).
- Maximum length: 4 feet (122cm).



#### Range (based on literature and historical accounts)

- Bermuda and Florida (USA), throughout the Bahamas and Caribbean Sea (Figure 1).
  - *Florida Range: Cape Canaveral south through the Florida Keys and Florida Bay westward to the Tortugas and Pulley's Ridge. It is fairly uncommon in Florida, with mixed accounts historical abundance.*
  - *Considered rare in the Gulf of Mexico (outside of south Florida as described above).*
- Primary determinants of distribution in Nassau grouper are not known although water clarity, habitat, and benthos appear to be important. The mean depth range of the Nassau grouper (0-130m) may be influenced more by the availability of suitable habitat than by food resources, since diet is highly varied and more a function of body size than of water depth.
- Occurs in tropical/subtropical waters (~24°C - 30°C, but can vary); generally shallow water, but may be found in depths to 130m; can tolerate practical salinity of 15 for a few days, but prefer 30 or greater.
- Patchy abundance throughout the range of a species is common due to variability of habitat quality/quantity and/or exploitation level.

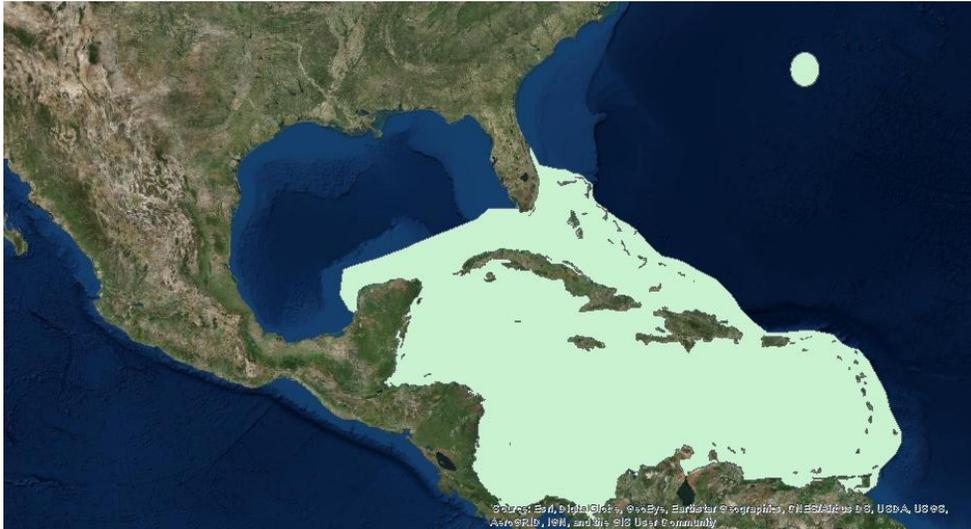


Figure 1. Confirmed distribution of Nassau grouper (in light blue) currently includes Bermuda, Florida (USA), the Bahamas, and Caribbean Sea (Smith 1971, Acero and Garzon-Ferreira 1991, Heemstra and Randall 1993, Cervigon 1994). Image courtesy Phil Caldwell, NMFS (2016). Note: as discussed above, the functional range of the Nassau grouper does not include the waters of Florida Bay north of the Florida Keys, waters of the Gulf of Mexico (exclusive of the Florida Keys), and coastal Atlantic north of Government Cut.

## Summary of Survey Results by Area

### *Continental U.S.*

- Florida Keys (South of Landmass) and Dry Tortugas
  - 14 animals have been tagged in waters off the Florida Keys and Dry Tortugas from 2008 to 2016. The animals ranged in size from 27 to 78.7cm TL.
  - 291 animals have been recorded during FWC/NOAA/National Park Service/UM-RSMAS in-water surveys from Biscayne Bay, through the Florida Keys and Dry Tortugas. Survey period is 1999 – 2014; however no sampling occurred in 2013 or 2015, and 2016 data are being processed. Nassau grouper observed ranged in size from 19.5 to 91cm FL in average depths ranging from 1.3 to 85.25m.
    - Habitat types where Nassau grouper were observed included: continuous reef high relief, continuous reef low relief, isolated patch low relief, isolated patch medium relief, isolated patch high relief, spur and groove low relief, and spur and groove high relief habitats.
    - All surveys were conducted on the south side of the Florida Keys, and only in reef habitat.
  - The smallest Nassau grouper that FWC has recorded in the Keys was at a site called Coral Gardens; FWC has observed many “juvenile” Nassau grouper here all at a length in the upper 20cm range or larger. Coral Gardens is described by FWC as a nearshore site with many patch reefs.
  - FWC has a seining program with monthly survey at ten sites in the middle Keys with no reports of Nassau grouper. This gear type (seine) is not likely to capture Nassau grouper.
  - The FWC collaborator queried several divers in the group if they recall observing Nassau smaller than 19.5cm in the Keys and none of them can recall such an event. Several of these people have thousands of dives each in the Keys.
  - There are limited data for nearshore non-reef areas where action areas may occur.

- Florida Bay - area on the north side of the upper Florida Keys that is encompassed within the Everglades National Park (ENP) boundary.
  - Surveys by FWC's Fisheries Independent Monitoring program reports only a single Nassau grouper record. The gear utilized for this survey otter trawls, 21.3 meter haul seines and purse seines are not likely to capture Nassau grouper.
  - The FWC Unified Florida Coral Reef Tract Map (available at <https://www.arcgis.com/home/item.html?id=e5ace3845f884e229ee6bad2b83ad11c>) identifies many areas around the Florida Keys and the Marquesas as hardbottom habitat including large areas immediately north of the Middle Keys.
  - Numerous studies have documented abundant red algae (*Laurencia* spp.) and sponges, corals, and other crevice-structures in these hard bottom areas, which are also near patch reefs and deeper contiguous reef tracts.
  - Available information indicates the species is not common; however, habitat to support each of its ontogenetic stages is prevalent, suggesting the potential of the area for supporting a recovering population.
- Miami-Dade to Martin County
  - No animals have been recorded during in-water surveys off the coast of Florida from Government Cut in Miami to St. Lucie Inlet in Martin County. These data are limited, surveying has only occurred from 2012-2015 (2016 data not yet available).
- Port St. Lucie, Florida to Cape Hatteras, NC
  - NOAA SEFSC conducts annual surveys in the Atlantic from Florida to North Carolina. Since the inception of this program in 1990, only 1 Nassau grouper has been observed. This individual was recorded by video on 8/16/13 in 52 meters of water off the coast of Jacksonville, FL and estimated weight was 4-5 pounds. Given this single record, it is our opinion that this was a seasonal wanderer that ventured outside of the known geographic range and it does not represent a true range expansion.
  - The SEFSC generally surveys hard bottom areas at depths starting around 50ft and out to about 350ft depth. The closest to shore the SEFSC surveys is approximately 3.5 miles at depths of 45 feet (at the shallowest point). Some survey sites have offshore varieties of seagrass, but no nearshore seagrass varieties present. While very young juvenile Nassau grouper could occupy habitat at this depth, the SEFSC has not surveyed near shore sea grass or algae habitats within 3.5 miles of shore.
- Spawning Locations
  - There are currently no known spawning aggregations in Florida, it is possible they occur. While a few larger juvenile-sized Nassau grouper have been observed in Florida waters, no information is available to determine their origin. Pair spawning of Nassau grouper has not been recorded. It is possible the few juvenile Nassau grouper recruited from a local event (either a small aggregation or pair spawning) or perhaps they were carried in from another location via currents.

*U.S. Caribbean (Puerto Rico and the U.S. Virgin Islands)*

- At least two Nassau grouper aggregation sites have disappeared.
- A newly identified small aggregation near Puerto Rico at Bajo de Sico may be a reconstitution of a former aggregation.
- Grammanik Bank, located south of St. Thomas, USVI, has shown a number of Nassau grouper aggregating during the reproductive season.
- Multiple life stages are assumed to be present based on the presence of these two spawning

aggregations.

*Caribbean – not within jurisdiction of ESA, but provided for informational purposes*

- Bahamas - all life stages present and common, numerous spawning sites are known.
- Cayman Islands – all life stages present and common, numerous spawning sites are known.
- Belize – all life stages present and common, numerous spawning sites are known.
- Mexico – fishing pressure in the 1990’s caused many aggregations to collapse and three aggregations are known to remain.
- Bermuda – previously abundant with numerous spawning sites, commercial fishing greatly reduced abundance where aggregation sites no longer form; presence of small individuals has recently increased.
- Cuba – data are few and difficult to validate, numerous spawning sites are reported to occur.

## Life History/Ecology/Habitat Use

### *Habitat Use by Size Class*

| Life stage              | Size          | Habitat                                                                                                                                                                                                                                                                                                                                                                                                             | Notes                                                                                                                                                                                                                        |
|-------------------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Egg                     | N/A           | Eggs are planktonic within the oceanic environment                                                                                                                                                                                                                                                                                                                                                                  | Eggs hatch as larvae 23-40 hours post fertilization                                                                                                                                                                          |
| Larvae                  | <2.5cm TL     | larvae are planktonic within the oceanic environment                                                                                                                                                                                                                                                                                                                                                                | Larvae are planktonic for up to 70 days but typically recruit to demersal habitat around 40 days at an average size of 2.5cm.                                                                                                |
| Newly-settled juveniles | 2.5 – 15cm TL | Recruit to macroalgal clumps (primarily <i>Laurencia</i> ), seagrass beds, and corals (particularly <i>Porites</i> spp.). May be found in mangrove lined lagoons or creeks and have been found in several microhabitats including empty queen conch shells, debris adjacent to seagrass, and rubble mounds. Begin shifting to reef habitats including solution holes, ledges, and artificial reefs around 12-15 cm. | Several studies indicate macroalgal clumps as being the most important settlement habitat. Become more solitary as they switch from settlement habitat to reef habitat. Also a shift towards deeper water as size increases. |
| Juveniles               | 15 – 50cm TL  | Inshore patch reefs at smaller sizes then transitioning to forereef habitat around 30-35 cm. Transition to progressively deeper water banks and offshore reefs with increased size.                                                                                                                                                                                                                                 | Generally solitary in specific habitats for extended periods.                                                                                                                                                                |
| Adults                  | >50cm TL      | High relief corals and rocky substrates in clear water from the shore to depths of 130 m. Occupy crevices, caves, solution holes, and ledges in these habitats.                                                                                                                                                                                                                                                     | <ul style="list-style-type: none"> <li>• Relatively sedentary,</li> <li>• correlation between size and depth,</li> <li>• movements generally diurnal</li> </ul>                                                              |

### *Biological Characteristics*

- Slow-growing.
- Long lived (~29 years).
- Naturally occur at low density across large spatial scale.
- Generation time (the interval between the birth of an individual and the subsequent birth of its first offspring) is estimated at 9-10 years.

- Data from scales and otoliths indicate that fish reach sexual maturity in approximately 4-7 years. Both male and female Nassau grouper typically mature at 4–5 years of age and at lengths between 40 and 45cm SL (44 and 50cm TL).
- Reproductive period is brief (days) as fish aggregate to spawn at transient, site-specific locations during consecutive full moons in the winter; there are no records of pair spawning.

### *Diet*

- Larval and pelagic juvenile Nassau grouper feed on a variety of plankton, including pteropods, amphipods, and copepods.
- Demersal juveniles occur in nearshore benthic habitats (i.e. mangroves, seagrasses, and macroalgal clumps) and feed mainly on crustaceans.
- Late juveniles/subadults occur on hard bottom and reefs and feed mainly on benthic invertebrates and fish.
- Adult Nassau grouper are unspecialized, bottom-dwelling, ambush-suction predators. Numerous studies describe adult Nassau grouper as piscivorous.
- Piscivores are generally diurnal to coincide with activity period of their prey. There are limited data regarding Nassau grouper foraging period. Nassau grouper may take advantage of the reduced light levels at dawn and dusk combined with the increased number of prey during changeover between diurnal and nocturnal fishes to forage as a means to reduce high energy costs associated with large fish abusing prey.

### *Reproduction*

- Spawning aggregation sites are transient and site-specific forming between November and February around the full moon when water temperatures around 25°C – 26°C. All known reproductive activity occurs within these spawning aggregations.
- Adults move from resident reefs as spawning time approaches to established spawning areas. Distances traveled are highly variable depending on distance to aggregation site. Some fish move only a few kilometers, but some individuals are known to travel up to several hundred kilometers to the aggregation site. Limited observations indicate: 1) fish move in groups numbering between 25 and 500; 2) movement is parallel to the coast or along the shelf edge; 3) movements are synchronous, and 4) individuals return to their home reef after spawning.
- Spawning aggregation sites have been found to occur near the edge of insular platforms, as little as 50 m from the shore, nearby a drop-off into deeper water across a wide (6-60m) depth range and diversity of substrate types. Sites are characteristically small, highly circumscribed areas, measuring several hundred meters in diameter, with soft corals, sponges, stony coral outcrops, and sandy depressions.
- The general spawning behavior consists of courtship among four distinct color phases concluding with a rapid vertical rush lead by a female followed by numerous males releasing eggs and sperm into the water column well above the substrate near sunset.
- Both the size and number of spawning aggregations have decreased over time (Figure 2). Based on the size and number of current spawning aggregations the Nassau grouper population appears to be just a fraction of its historical size. Recent evidence suggests that spawning is occurring at what may be reconstituted or novel spawning sites in both Puerto Rico and the U.S.V.I.
- The following figure denotes the location of historic and current spawning aggregations in the U.S. Caribbean.

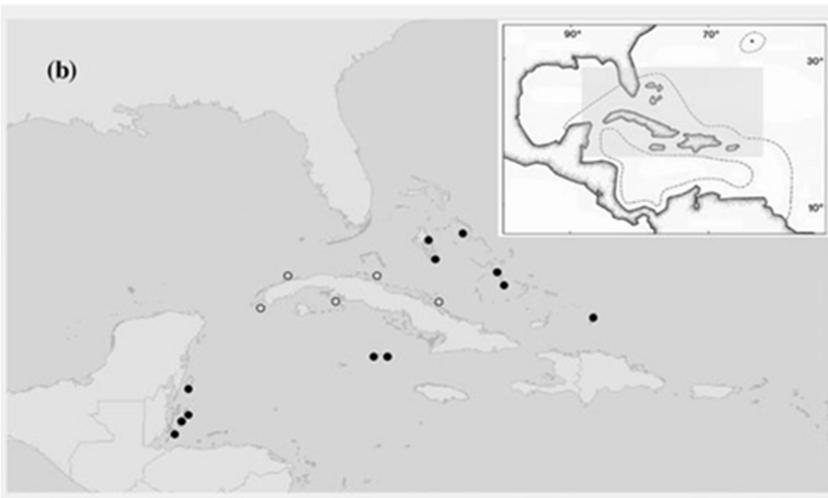
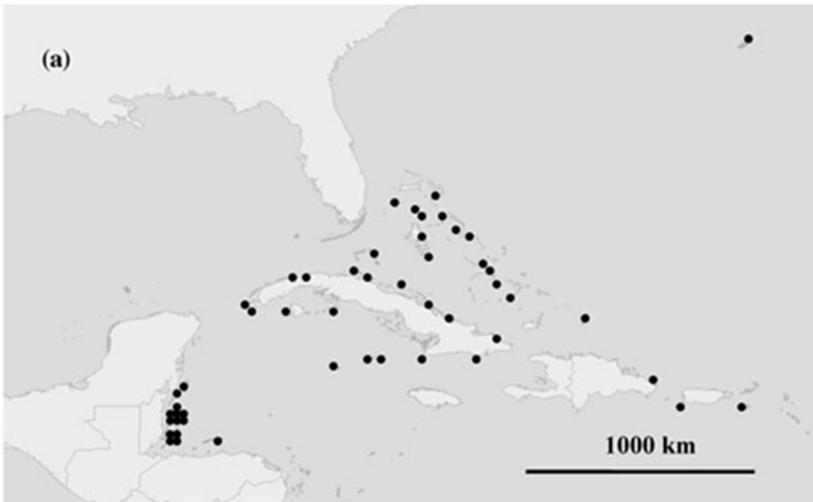


Figure 2. Maps showing locations of known Nassau grouper spawning aggregations both historically (a) and as of about 2007 (b) according to available information; not all sites have been validated. Inset shows full geographic range, main concentrations (shaded) and extended areas (dashed lines). Each closed circle represents 1, or occasionally 2, reported site(s). Open circles are “probable” sites. (Sources: Smith 1972; Sadovy and Eklund 1999; Sala et al. 2001; Whaylen et al. 2004; Belize Spawning Aggregation Working Group, unpublished data; R. Claro, unpublished data; E. Sala, unpublished data, as presented in Sadovy de Mitcheson et al. 2008)

### Summary of Threats

**The most serious threats to Nassau grouper are fishing at spawning aggregations and inadequate law enforcement.** In addition a variety of other threats have been identified as also impacting the status of this

species including: 1) negative pressures on growth rate/productivity and spatial structure/connectivity, as well as effectiveness of foreign regulations; and 2) potential impacts from artificial selection, insufficient abundance levels and diversity, commercial harvest, and effectiveness of state and territory regulations. Additional detail is provided in the listing rule.

**Major loss of any of the habitats utilized by groupers during various life stages is likely to influence their abundance and survival.** While habitat loss was categorized as a low risk threat during the listing process, it influences survival and recovery and deserves consideration when analyzing proposed project impacts.

- Perhaps the greatest habitat losses influencing grouper populations arise from alterations or destruction of nearshore nursery areas, including mangroves and seagrasses, and by the declining state of coral reef systems.
- Changes in water temperature experienced by early life stages of Nassau grouper may have profound effects on their food consumption, development and growth rate, and these factors may play a significant role in the annual fluctuations in the survival of this species. This may be compounded by the fact that these early life stages already experience high mortality rates due primarily to predation and disease susceptibility.
- Sea temperature may also affect adult grouper directly by affecting metabolism, reproduction, growth and behavior.
- Other environmental stressors that are likely to affect grouper survival directly include predicted climate related changes in ocean chemistry (e.g. ocean acidification).
- To date, very little research has been done examining the impacts of environmental stressors on the different life stages of Nassau grouper.