Long-distance movement of a Nassau grouper (*Epinephelus striatus*) to a spawning aggregation in the central Bahamas

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Smith (1972) first reported *Epinephelus striatus* (Nassau grouper) spawning aggregations. Since then, spawning aggregations from a few dozen individuals to perhaps 100,000 individuals have been reported from the Bahamas, Jamaica, Cayman Islands, Belize, the Virgin Islands, and Mexico (Olson and LaPlace, 1979; Colin et al., 1987; Carter, 1988; Colin, 1992; Aguilar-Perera and Aguilar-Davila, 1996). Colin (1992) investigated and documented actual spawning of *E. striatus* off Long Island, Bahamas. Colin et al. (1987) and Sadovy et al. (1994) have provided the only other observations of spawning aggregations of western Atlantic serranid species (*E. guttatus* and *Mycteroperca tigris*).

Epinephelus. striatus spawning aggregation sites are transient, site specific, and are usually known by local fishermen who fish them intensely during the spawning period. *Epinephelus striatus* spawn in the southern Caribbean during the full moon of December and January (Smith, 1972; Olsen and LaPlace, 1979; Colin et al., 1987; Colin, 1992), and at more northern locales (i.e. Bermuda) from May to July (Bardach et al., 1958). Johannes (1978) suggested that the period and location of reef fish spawning is selected to favor larval survival; more recently Colin (1996) has suggested that aggregation sites may be "learned." Differing densities of *E. striatus* at spawning sites prior to, during, and following full moon periods indicate that individuals move to an aggregation site for a limited period of time (Colin, 1992). Timing, size, and sex composition of moving prespawning individuals are unknown.

Knowledge of the distance and direction of *E. striatus* movement to historic spawning sites is based on Colin (1992) where a single tagged specimen was recaptured by a fisherman at a known spawning site east of Long Island, Bahamas, after travelling approximately 110 km in two months. This contribution documents long-distance movement (220 km) of a tagged *E. striatus* to a spawning aggregation.

Materials and methods

The Exuma Cay Land and Sea Park (ECLSP, Fig. 1) was the study site for an investigation of the home range of *E. striatus*. The 456-km^2 ECLSP was established in the central Bahamas in 1958 and fishing was banned in 1986. A total of eleven individuals were captured by traditional Bahamian fish traps, tagged, and released for the home range study during summer 1997. An *E. striatus* (58.1 cm TL) captured on 24 June 1997, tagged on 25 June, held in a fish trap and released at 24°18.8′N and 76°33.6′W on 2 July 1997 was later recaptured by a fisherman.

Each fish had a unique Floy dart tag (Floy Tag & Manufacturing, Inc., Seattle, Washington) inserted below the anterior dorsal-fin rays, between the second and third scale rows.

Each fish also had an acoustic transmitter (VEMCO Limited, Nova Scotia, Canada) surgically implanted into its body cavity.

Daily water temperature data were obtained from Caribbean Marine Research Center (CMRC) at Lee Stocking Island (approximately 120 km NW of Long Island, Fig. 1) to correlate with spawning season. Mean monthly water temperature was calculated for the months of February 1998 (this investigation) and February 1989 (Colin, 1992). February 1988 data (Colin, 1992) were not available.

Fish were continuously tracked by their individual acoustic frequency 24 hours a day for a 3-week period. Subsequent daily diver observations identified individual fish by their external tags.

Results

The recaptured Nassau grouper was tracked by ultrasound at its presumed "home reef" from 2 to 31 July 1997. Daily visual observations (by divers) from 9 to 15 August confirmed the presence of the Nassau grouper at its home reef. The last observation was recorded at the tagging locale on 16 August 1997 at the end of the field season.

Three other individuals tagged during the summer 1997 investigation were observed at the exact patch reef where they were tagged in summer 1998. Two of these tagged individuals were considered to be mature adults when tagged (47.1 cm TL and 44.1 cm TL), and the third was deemed a juvenile (25.2 cm TL). Measurement of two individuals indicated an annual growth rate of 3–4 cm: from 47.1 to 50.1 cm TL, and from 25.2 to 29.0 cm TL. Seven other *E. striatus* tagged during summer 1997 were not observed during summer 1998.

A fisherman caught the tagged individual on 16 February 1998 in a fish trap at the Long Island, Bahamas, spawning location described by Colin (1992) as the "south point aggregation site" at 22°51.0′N and 74°51.5′W, approximately 220 km (in a straight ESE route) from the release point (Fig. 1). Physical features of the aggregation site are described by Colin (1992). The fish was at large for 185 days and was caught in 18–21 m of water. Because fishing was limited during the period "due to high seas and strong wind,"[1] the exact date the fish entered the trap or the soak time is unknown.

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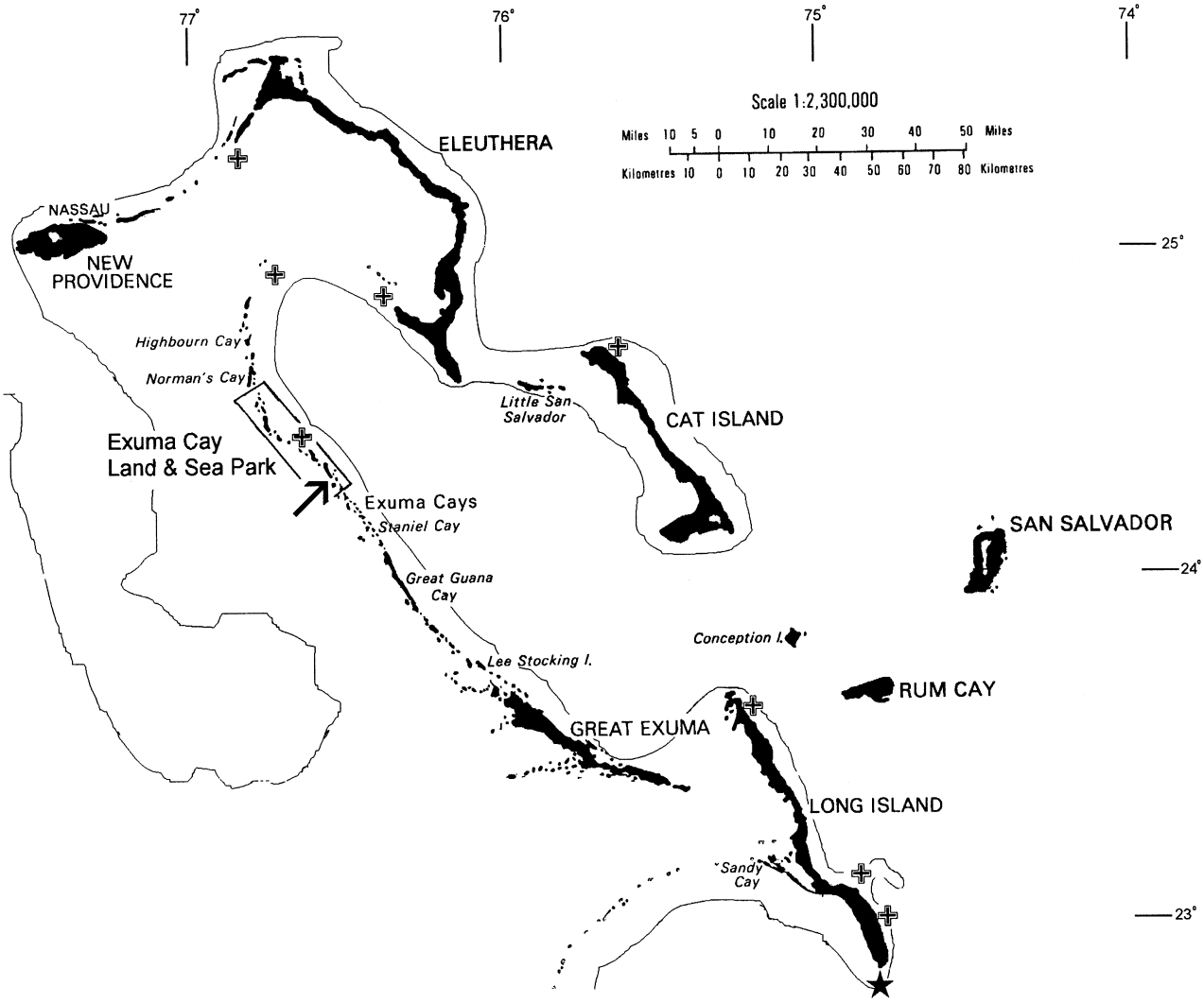

Figure 1

Map of the central Bahamas showing locations of tag and return sites of Nassau grouper (*Epinephelus striatus*). Longitude is west; latitude is north. The Exuma Cay Land and Sea Park is enclosed by a box. The site where the fish was captured, tagged, and released is designated by an arrow (↑); recapture site—denoted as the "south point aggregations site by Colin, 1992—by a star (★). Other possible *E. striatus* spawning sites noted by Bahamian government, local fishermen, and scientific literature are designated by a cross (✚). The 500-fathom depth contour, as determined by NOAA chart no. 23605, is designated by a solid line. This figure is modified with permission from a map produced by Department of Lands and Surveys for the Government of the Bahamas B.L.S. 1100.

Mean monthly water temperatures at CMRC dock were 23.94°C ±1.41 for February 1998, and $\bar{x}$ = 24.68°C ±0.75 for February 1989. Mean water temperature for the full moon period from 11 February 1998 to date of capture (16 February 1998) was 23.83°C ±0.63. The wide standard deviation for the February 1998 monthly mean was due to a 7-day (18–24 February) period of warm water temperature (>25°C every day).

[1] Cartwright, Capt. A. 1998. Personal commun. P.O. Box CB 11039, Nassau, Bahamas.

Discussion

Site fidelity for the recaptured Nassau grouper was 46 days; and perhaps a year for the three Nassau grouper at large, tagged in 1997 and resighted in 1998. Sexual maturity for *E. striatus* is reached at about 42 cm SL and 40 cm SL, for males and females respectively (Colin et al., 1987), thus the two larger fish seen again in 1998 were theoretically sexually mature. These two fish should have joined a spawning aggregation: they had either left the area and returned "home," or they were remarkably steadfast to that reef.

The south point aggregation site (where the tagged *E. striatus* was recaptured) has supported a seasonal fishery (fish trap, and hook and line) since before 1900 (Colin, 1992). During spawning aggregation periods, the site draws 2000–3000 *E. striatus*; density decreases during nonspawning periods (Colin, 1992). Notably, an *E. striatus* spawning aggregation site is known to have previously existed within the ECLSP boundaries at the "Wide Opening," approximately 20 km to the NNW of the tagging site.[2] However, it is not known if the site currently sustains spawning Nassau grouper. If this and other nearby spawning sites do exist (denoted by a cross (✚) in Fig. 1), one can only speculate as to why a fish would migrate a considerably greater distance to spawn.

I suggest that *E. striatus* learn the routes to historic spawning sites by local enhancement from older individuals (i.e. older animal directs attention of younger animal to a particular part or object in the environment), perhaps by socially transmitted traditions (see Helfman and Schultz, 1984, for definitions). The fact that traditions differ among subpopulations would account for both the number of spawning sites in an area and their historical nature. If spawning sites are learned from older individuals, then one could conjecture how this learning behavior affects recovering *E. striatus* populations; older individuals are required to socially transmit the location of spawning sites, and young adults need to be present to learn. Current and future studies of sensory systems and migration should provide insight into these hypotheses.

Because actual spawning was not observed and gonads were not available, the reproductive status of the recaptured *E. striatus* is unknown. Hence, fishermen reports and water temperature data were used to investigate the likelihood of *E. striatus* spawning at time of recapture. The recaptured fish was captured on 16 February from a spawning "school" five days after the full moon.[3] Local fishermen believe that spawning was occurring at this time because catches of *E. striatus* were abundant, the fishermen were targeting a known spawning site, and the fish were "full [of eggs]".[2] Spawning is usually synchronous with the full moon; thus it is speculated that the Nassau grouper use the moon as a visual cue in migrating to common spawning areas.

The geographic differences in spawning season of *E. striatus* are thought to correlate with water temperatures, of which optimal spawning temperature is most likely in the range of 25–26°C (Colin, 1992; Tucker et al., 1993). Mean monthly water temperature at the Long Island south point aggregation site was 24.68°C in February 1988 (no spawning; Colin, 1992) and 23.94°C in February 1998 (presumed spawning; present study). If spawning is correlated only with water temperature, then it is unlikely that the recaptured *E. striatus* grouper was actively spawning. However it is more likely that temperature is only one of many physical attributes influencing the spawning of *E. striatus* and if the fishermen reports are correct, it is entirely possible that the recaptured *E. striatus* was removed from a spawning aggregation.

ECLSP is a marine reserve for the preservation of animals, plant, and other marine life. For management purposes, the intent of a marine reserve is to provide spatial refuge from fishing, whereas the intent of traditional fishery restrictions on the resource is to allow a sufficient number of animals to reproduce. (Bohnsack, 1998). Evidence provided in the present study indicates that spatial refuge alone may be insufficient because the ECLSP reserve provided protection only until the animal migrated to spawn and thus was captured. If the Nassau grouper stock are to be preserved, protection throughout the animal's life history including spawning needs to be considered. Possible ways to provide this protection include closing documented spawning aggregation sites to fishing, enforcing seasonal closures, or providing protection for migrating and spawning individuals.

[2] Darville R. 1998. Personal commun. ECLSP Park Warden, P.O. Box N-4105 Nassau, Bahamas.

[3] Fishermen refer to the aggregations as "schools" because a large number of fishes are present in reproductive condition.

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