How Queen Conch Are Distributed by Depth and Distance from Shore: Growth and Population Patterns Near Eleuthera, Bahamas

David Lozado, Devan RK, Naoki Izumi, Dennis Riley

Abstract

The Queen Conch (*Lobatus gigas*), a keystone species in the Bahamas, faces population declines from overfishing, habitat degradation, and climate change. Queen Conch populations exhibit variable distribution patterns based on habitat depth and distance from shore, yet a comprehensive understanding remains limited in the Bahamas. This study investigated how depth and distance from shore affect Queen Conch population density, age structure, and mating zones at two Eleuthera sites. The research compared populations between deeper offshore seagrass habitats and shallower nearshore sandbar habitats, recognizing that juveniles prefer shallow seagrass areas with currents while adult distributions vary. Swimmers collected conch specimens from boats or sandbars, measuring siphonal length and shell lip thickness, as shell lip thickness is the most reliable proxy for sexual maturity in Queen Conch. Results revealed contrasting population structures: the offshore seagrass site contained predominantly juveniles with no adults, while the nearshore sandbar site contained higher proportions of adults and sub-adults. Mean shell lip thickness was significantly greater at the sandbar site, indicating older populations in shallower waters. These findings suggest spatial segregation by life stage, with juveniles preferring deeper seagrass habitats and mature adults congregating in shallower, sandy areas, potentially for mating purposes. This research provides insights for Queen Conch

conservation in the Bahamas, emphasizing protection of both shallow and deep habitats to support complete life cycles.

Introduction

The Queen Conch (Strombus gigas, also known as Aliger gigas or Lobatus gigas) represents one of the most ecologically and economically significant marine gastropods in the Caribbean region. This large marine snail inhabits shallow tropical waters throughout the Caribbean Sea, Gulf of Mexico, and the tropical western Atlantic, including the extensive archipelago of the Bahamas. As stated in the NOAA Fisheries educational resource, "Queen conch are herbivorous gastropod mollusks" that "feed on algae, seagrass, and other organic material found in seagrass beds" (NOAA Fisheries). The species plays a vital role in maintaining the health and balance of seagrass bed ecosystems, contributing to overall marine biodiversity and supporting local fisheries that depend on these snails for economic stability (Island School).

The Bahamas archipelago, comprising over 700 islands and 2,400 cays spread across approximately 250,000 square kilometers of ocean, provides extensive shallow-water habitats ideal for Queen Conch populations. Beyond its ecological importance, the Queen Conch holds profound cultural significance in Bahamian society, serving as both a dietary staple and economic driver for centuries. The species is so central to Bahamian identity that it appears on the national flag, symbolizing the marine heritage of the nation. As documented by the Nature Conservancy, "Queen Conch provides employment within the fishing and tourism sectors and is also used in iconic dishes and even building materials" (Bahamian Queen Conch). Additionally, the Conch is a national symbol, a dietary staple, and a major export product of the Bahamas, as the conch industry generates approximately $ 7 million annually in the Bahamas (The Nature

Conservancy). Traditional Bahamian cuisine features conch prominently, with dishes such as conch salad, cracked conch, conch fritters, and stewed conch demonstrating the versatility and centrality of this species to local culinary traditions. The conch fishing industry supports thousands of Bahamian families, with fishermen employing traditional free-diving techniques passed down through generations to harvest these mollusks from the extensive shallow carbonate banks surrounding the islands. However, many fishers are now reporting that they must go farther out to find conch. One fisherman remarked, “When I was a child, we never had to go that far to get conch” (AP News), showing the increasing challenges faced by local fishers due to overfishing and other issues.

Queen Conch exhibits complex life history patterns characterized by distinct ontogenetic habitat shifts—changes in habitat preference as individuals develop from larvae through juvenile stages to reproductive adults. The Southern Regional Aquaculture Center's species profile details that "Queen conch have a complex life cycle with several distinct stages... The planktonic larval stage lasts 18-40 days," after which "newly metamorphosed juveniles settle in shallow seagrass beds where they remain buried in sediment for their first year of life" (Davis). As they grow, juveniles emerge and begin migrating to different habitats based on food availability, predation pressure, and reproductive needs. The educational presentation "The Queen Conch Bahamas BJC Review" explains that "Juvenile conchs bury themselves in the sand during the day and come out to feed at night," demonstrating early behavioral adaptations (Treco-Hanna).

Research has consistently shown that Queen Conch populations exhibit depth-related distribution patterns, though the specific relationships between depth, distance from shore, and population structure remain incompletely understood. Studies from various Caribbean locations have found that "juveniles prefer shallow, seagrass areas with currents," while adult distributions are influenced by multiple factors, including food availability, sediment type, and reproductive requirements (Posada et al). Wikipedia corroborates various research papers, stating that "Juveniles inhabit shallow, inshore seagrass meadows, while adults favor deeper algal plains and seagrass meadows" (Wikipedia). These varying depth distributions suggest complex habitat requirements throughout the conch life cycle.

The determination of age and sexual maturity in Queen Conch has been a critical area of research for both ecological understanding and fisheries management. Unlike many mollusks that add growth rings to their shells, Queen Conch ceases shell length growth upon reaching sexual maturity, instead diverting energy to thickening the shell lip. Stoner et al. conducted comprehensive research establishing that "Queen conch (Strombus gigas) maturity is associated with shell lip thickness. Minimum shell lip thickness for maturity was 12 mm for females and 9 mm for males" (Stoner et al). This biological characteristic has made shell lip thickness a widely used proxy for age and maturity assessment across the Caribbean region.

The reliability of shell lip thickness as a maturity indicator has been further validated through recent research. Foley and Takahashi definitively stated that "Shell Lip Thickness Is the Most Reliable Proxy to Sexual Maturity in Queen Conch," noting that "lip thickness explained 96% of the variability in predicting sexual maturity" in their study populations (Foley and Takahashi). These findings have important implications for management strategies, as many Caribbean nations now use minimum shell lip thickness criteria to regulate harvest, with regulations ranging from 5 mm in some areas to 9.5 mm in others (Federal Register 10798).

Reproductive behavior in Queen Conch shows distinct spatial and temporal patterns that appear linked to depth and habitat characteristics. Recent research found that "low probability of mate finding associated with decreased population density is the primary driver behind observed breeding behavior," and that "adult movement and aggregation are likely adaptations to maintain reproductive success in low-density populations" (NOAA). During Island School ecology lessons, we learned that successful mating zones require a minimum density of 450 conch per hectare (100m × 100m area). For our study's smaller sampling areas, we would find the population density of our searched area and compare it to the population density of a hectare with 450 conchs.

The relationship between habitat type and Queen Conch population structure has significant implications for conservation and management. Research has consistently shown distinct patterns, with Posada et al. reporting that "Juvenile density was highest on mixed seagrass beds (73.9 conchs/ha) and below 7 m depth," while "adult conch occurred mainly in sandy and coral rubble areas" (Posada et al.). This spatial segregation by life stage reflects the species' changing ecological requirements as individuals mature.

Understanding Queen Conch ecology has become increasingly urgent as populations throughout the Caribbean have experienced significant declines. Queen conch can reach up to a foot in length and live for 30 years, but populations have declined by up to 90% in some areas due to overfishing and habitat loss (Sherman et al.). The species' vulnerability stems from multiple factors, including its slow growth rate, late sexual maturity (typically 3.5-5 years), and dependence on high population densities for successful reproduction. In response to these conservation concerns, Queen Conch was listed under Appendix II of CITES in 1992, and on February 14, 2024, "NOAA Fisheries published a final listing determination to list the queen conch (Aliger gigas) as threatened under the Endangered Species Act" (Federal Register 10796).

Despite extensive research on Queen Conch biology and ecology, significant knowledge gaps remain regarding fine-scale habitat use patterns and the factors driving spatial segregation of different life stages. Previous studies have often focused on single habitat types or broad-scale surveys, leaving questions about how conch populations utilize the mosaic of habitats available in areas like the Bahamas. Historical evidence shows that Queen Conch has been an important food source in the Caribbean for thousands of years, including use by pre-Columbian Lucayans, highlighting the long history of human-conch interactions that must be considered in management (Keegan).

This research addresses critical gaps in our understanding of Queen Conch ecology by examining how depth and distance from shore influence population density, age structure, and potential mating zones. By comparing populations between a deeper offshore seagrass habitat and a shallower nearshore sandbar environment, this study tests the hypothesis that Queen Conch exhibits predictable patterns of habitat use based on life stage, with juveniles predominantly occupying deeper seagrass beds while adults aggregate in shallower sandy areas. It is believed that the deeper seagrass beds provide necessary cover and protection from predators for vulnerable juvenile conchs, while the shallower sandy areas may offer better access to mating opportunities and abundant food sources, which are critical for adult conchs. We further hypothesize that these distribution patterns reflect the species' complex life history requirements, including the need for protective nursery habitats for juveniles and suitable aggregation sites for adult mating. Understanding these spatial patterns is crucial for developing effective conservation strategies that protect the full range of habitats necessary for the persistence of Queen Conch populations in the Bahamas and throughout the Caribbean region.

Materials and Methodologies

To investigate Queen Conch (*Lobatus gigas*) distribution in Eleuthera, Bahamas, we conducted a systematic survey at two sites—an offshore area (Site 1, depth 2 m) and a shallow sandbar (Site 2, depth 0.35 m). We used a dissolved oxygen test kit, thermometer, Secchi disc, test strips, salinity meter, sample containers for gathering water, a field notepad, two transect lines, and a caliper provided by the Island School to measure siphonal length, as our original caliper was too small for conch measurements. Additional equipment included a GoPro Akaso underwater camera with case and all-weather notebooks, which served as our field notebooks. Environmental parameters were measured first: depth was determined by lowering the Secchi disc until it was visible at the bottom (m); salinity was measured using a salinity meter probe submerged in collected water samples for 30 seconds (ppt); water and air temperature were recorded using a thermometer placed in collected water samples for 1 minute (°C); we assessed water chemistry by dipping a 5-in-1 test strip into the water and comparing its colors to an API color chart to record Carbonate Hardness (KH, ppm), pH, nitrite (NO_2, ppm), and nitrate (NO_3, ppm); and dissolved oxygen was evaluated by adding reagents to a water sample according to the test kit's protocol (mg/L). Swimmers searched for conch within approximately 2,827 m^2 at Site 1 and a 1,257 m^2 area at Site 2. We calculated these areas using a transect line to measure the radius of each circular search zone in meters. Search efforts were conducted in parallel transects, where we recorded Queen Conch and other species (e.g., Milk Conch, Tulip Snail, Horse Conch) in notebooks and on the diver slate, capturing footage and pictures with the GoPro. For each Queen conch, siphonal length (cm, from siphon tip to shell apex) and shell lip thickness (mm, at the thickest flared part) were measured using a caliper. We assessed lip maturity (Flared or Unflared), classified maturity (Juvenile: <15 cm, non-flared; Sub-Adult: 15–22 cm; Adult: >22 cm, flared, >15 mm lip), and noted observations (e.g., "Transparent Lip"). After collecting all data, we calculated population density using the formula: number of Queen conchs found divided by total search area. We compared these densities to the established mating zone threshold of 450 conch per hectare (0.045 conch/m^2). Areas with densities equal to or greater than this threshold would be classified as mating zones, while areas with lower densities would not. To assess biodiversity, we calculated Simpson's Diversity Index using the formula: $D = 1 - \Sigma(n/N)^2$, where (n) is the count of each species and (N) is the total number of all individuals found. A flowchart detailing our data collection process is provided for clarity. Please click the link here to view the flowchart.

Figures

A

Depth (m)	Salinity (ppt)	Temp (℃)	Kh (mg/L)	ph	Nitrate ($N0_3$, mg/L)	Nitrite ($N0_2$, mg/L)	Dissolved Oxygen (mg/L)	Search Area (m^2)
2	40	15	120	8.5	20	.5	4	2827

B

Queen Conch	Maturity	Siphonal Length (cm)	Shell Lip Thickness (mm)	Lip Maturity	Extra Notes
1	Sub-Adult	21.3	8	Non-Flared	Fish Inside
2	Sub-Adult	19.5	8	Non-Flared	N/A
3	Juvenile	18	5	Non-Flared	N/A
4	Juvenile	19	4	Non-Flared	N/A
5	Juvenile	19	3	Non-Flared	N/A
6	Juvenile	17	2	Non-Flared	Transparent

					Lip
7	Juvenile	14	5	Non-Flared	N/A
8	Sub-Adult	21	2	Flared	N/A
9	Sub-Adult	22	12	Flared	N/A
10	Sub-Adult	20	8	Flared	N/A
11	Sub-Adult	18	5	Flared	Transparent Lip
12	Juvenile	12	1	Non-Flared	Transparent Lip
13	Sub-Adult	16	13	Flared	N/A
14	Sub-Adult	22	5	Flared	N/A
15	Juvenile	16	4	Non-Flared	N/A
16	Juvenile	18	2	Non-Flared	N/A
17	Juvenile	18	2	Non-Flared	N/A
18	Juvenile	17	3	Non-Flared	N/A
19	Juvenile	18	2	Non-Flared	N/A
20	Juvenile	17	1	Non-Flared	N/A
21	Juvenile	12	1	Non-Flared	N/A
22	Juvenile	16	2	Non-Flared	N/A
23	Juvenile	14	3	Non-Flared	N/A
24	Juvenile	19	3	Non-Flared	N/A
25	Juvenile	18	4	Non-Flared	N/A
26	Juvenile	14	3	Non-Flared	N/A
27	Juvenile	19	2	Non-Flared	N/A
28	Juvenile	19	3	Non-Flared	N/A
29	Juvenile	15	3	Non-Flared	N/A

C

Species	**Count**	**n/N**	**$(n/N)^2$**
Queen Conch	29	29/33	.77
Milk Conch	3	3/33	.008
Tulip Snail	1	1/33	.0009
Total Count =	33	Diversity =	.22

Table 1. Environmental conditions and conch details at Site 1 (seagrass bed). A) Measurements of water and habitat: depth (2 m), salinity (40 ppt), temperature (15°C), water hardness (120 mg/L), pH (8.5), nitrate (20 mg/L), nitrite (0.5 mg/L), dissolved oxygen (4 mg/L), and search area (2,827 m²). B) Details of Queen Conch: juvenile/subadult status, shell length, shell thickness, flare status, and any other notes. C) Counts of snails collected: Queen Conch (33), Milk Conch (3), and Tulip Snail (1).

A

Depth (m)	**Salinity (ppt)**	**Temp (℃)**	**Kh (mg/L)**	**ph**	**Nitrate ($N0_3$, mg/L)**	**Nitrite ($N0_2$, mg/L)**	**Dissolved Oxygen (mg/L)**	**Search Area (m²)**
.35	37	20	70	8	20	.5	8	1257

B

Queen Conch	**Maturity**	**Siphonal Length (cm)**	**Shell Lip Thickness (mm)**	**Lip Maturity**	**Extra Notes**
1	Sub-Adult	17	13	Flared	N/A
2	Adult	16	16	Flared	N/A
3	Sub-Adult	19	9	Flared	N/A
4	Sub-Adult	19	10	Non-Flared	N/A
5	Sub-Adult	18	9	Flared	N/A

6	Adult	16	22	Flared	N/A
7	Juvenile	11	1	Non-Flared	N/A
8	Juvenile	10	3	Non-Flared	N/A
9	Juvenile	10	3	Non-Flared	N/A
10	Sub-Adult	22	12	Flared	N/A
11	Juvenile	18	1	Non-Flared	N/A
12	Juvenile	9	2	Non-Flared	N/A
13	Juvenile	11	6	Non-Flared	N/A
14	Adult	20	18	Flared	N/A
15	Adult	18	21	Flared	N/A
16	Juvenile	13	6	Non-Flared	N/A
17	Adult	21	15	Flared	N/A
18	Juvenile	17	7	Non-Flared	N/A
19	Sub-Adult	18	1	Flared	N/A
20	Juvenile	14	3	Non-Flared	N/A
21	Juvenile	17	3	Non-Flared	N/A
22	Juvenile	13	3	Non-Flared	N/A
23	Juvenile	11	4	Non-Flared	N/A

C

Species	**Count**	**n/N**	**$(n/N)^2$**
Queen Conch	23	23/34	.46
Horse Conch	3	3/34	.0078
Milk Conch	5	5/34	.022
Tulip Snail	3	3/34	.0078
Total Count =	34	Diversity =	.50

Table 2. Water conditions, conch details, and animal diversity at Site 2 (sand flat). A) Water and habitat measurements: depth (0.35 m), salinity (37 ppt), temperature (20°C), water hardness (70 mg/L), pH (8), nitrate (20 mg/L), nitrite (0.5 mg/L), dissolved oxygen (8 mg/L), and search area (1,257 m^2). B) Queen Conch measurements: classification (juvenile, sub-adult, adult), shell length, shell lip thickness, and flare status; this site included a mix of juveniles, sub-adults, and adults, with several having thick, flared shell lips. C) Counts of large snails and conch: 23 Queen Conch, 3 Horse Conch, 5 Milk Conch, and 3 Tulip Snails from a total of 34, providing a diversity score of 0.50.

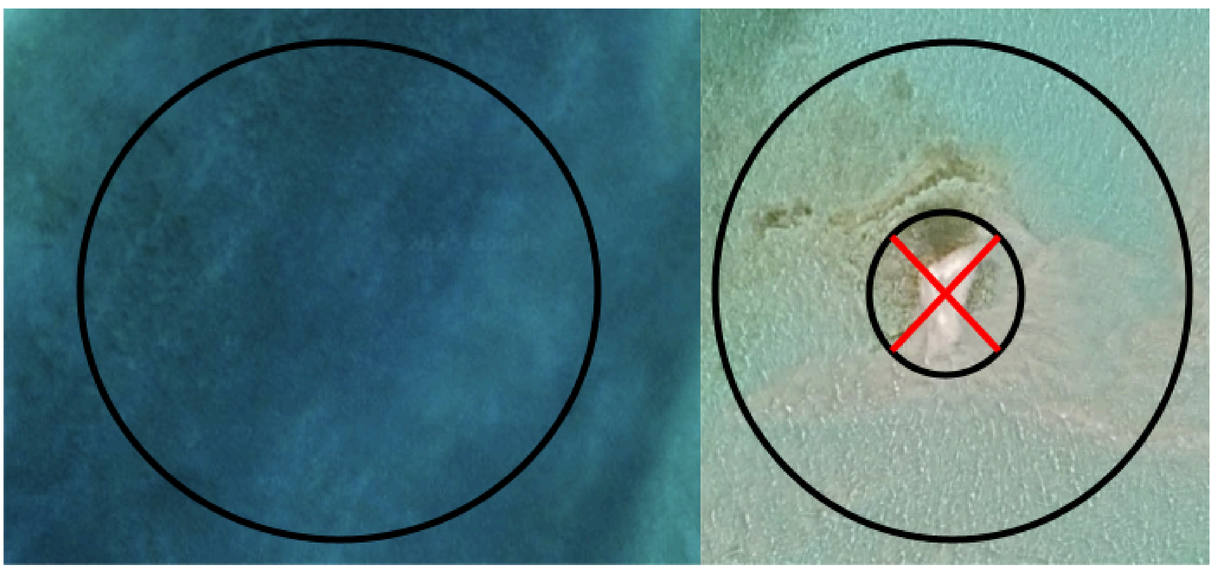

Figure 1. GIS map showing the areas searched by swimmers at Site 1, the seagrass bed (left), and Site 2, the sandbar (right) during the queen conch survey. The black circles outline the total area covered at each site, with the red “X” marking the sand bar itself, which was not searched for conch. The map was created by the Conch Group in Browning Biology Class B.

Figure 2. GIS map showing approximate distances from the two sites we visited to the nearest shore point in Eleuthera, Bahamas. The conch float (blue marker) is located roughly 5,854 meters from the main shore, while the sandbar (red marker) is about 2,674 meters from shore. Distances are approximate but indicate that the conch float is much farther from the main shore compared to the sandbar.

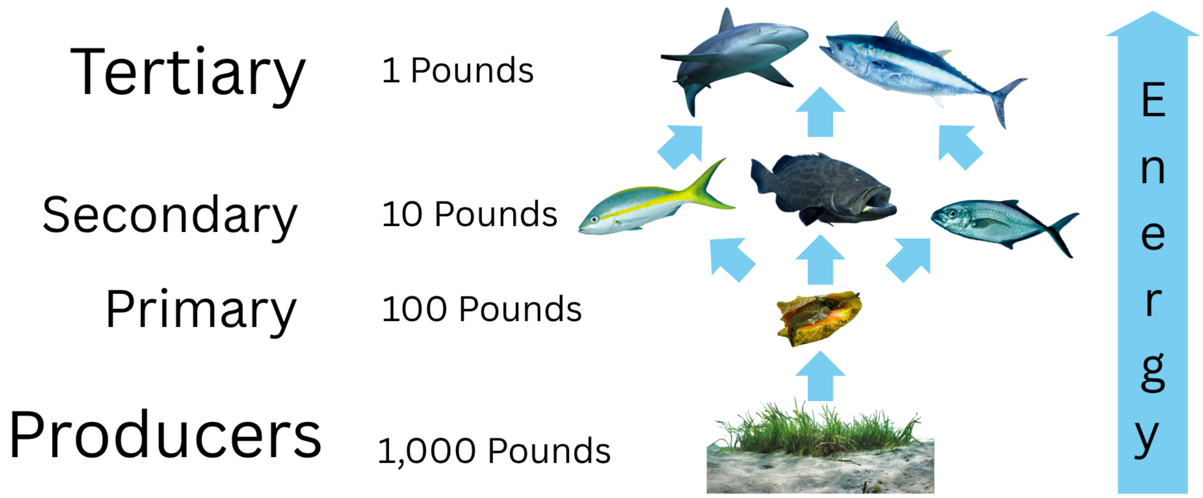

Figure 3. Seagrass bed food web illustrating the trophic levels and relative biomass of key organisms. Primary producers such as seagrass form the base with the greatest biomass (1,000 pounds). Primary consumers, such as queen conch, occupy the next level (100 pounds). Secondary consumers such as bar jack, black grouper, and yellow-tail snapper represent the next tier (10 pounds), followed by top predators, bluefin tuna and gray reef shark at the apex (1 pound).

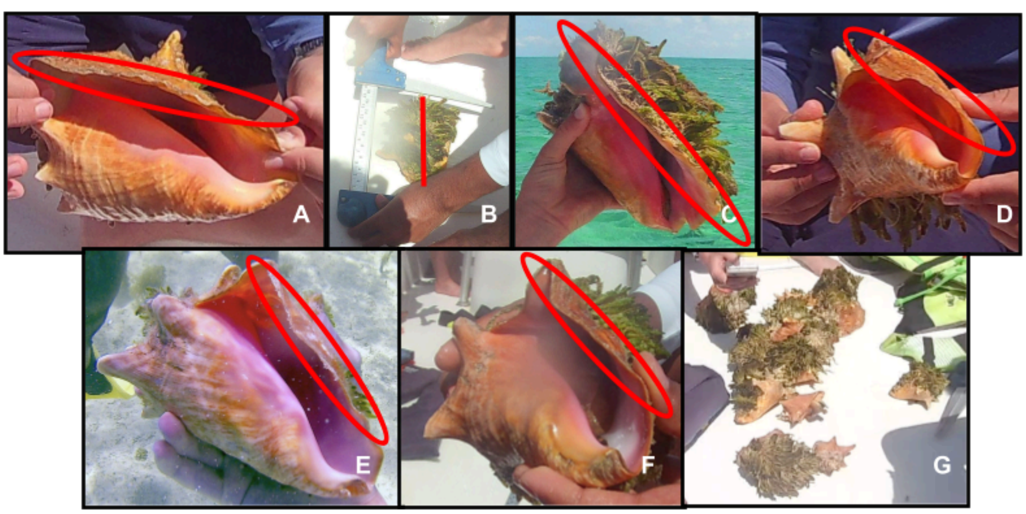

Figure 4. Images depicting queen conches found in the seagrass bed, with various lip maturity stages, are used to assess age classes. (A) Juvenile conch with non-flared lip, (B) measurement of

siphonal length indicated by the red line, (C) sub-adult conch with partially flared lip, (D) juvenile with non-flared lip, (E) juvenile conch with non-flared lip, (F) juvenile with a non-flared lip, and (G) comparison of juvenile and sub-adult conches by size. The red circles in all images except (B) highlight the conch's lip, a key indicator of maturity. Figure created by the Conch Group in Browning Biology Class B.

Figure 5. Queen conch samples found in the sandflat habitat show various maturity stages. (A) Adult conch with a 15 mm flared lip, (B) adult conch with a 15 mm flared lip held next to a juvenile conch on the left with a non-flared lip, and (C) juvenile conch with a non-flared lip. The red circles highlight the conchs' lips, which are used to determine maturity. Figure created by the Conch Group in Browning Biology Class B.

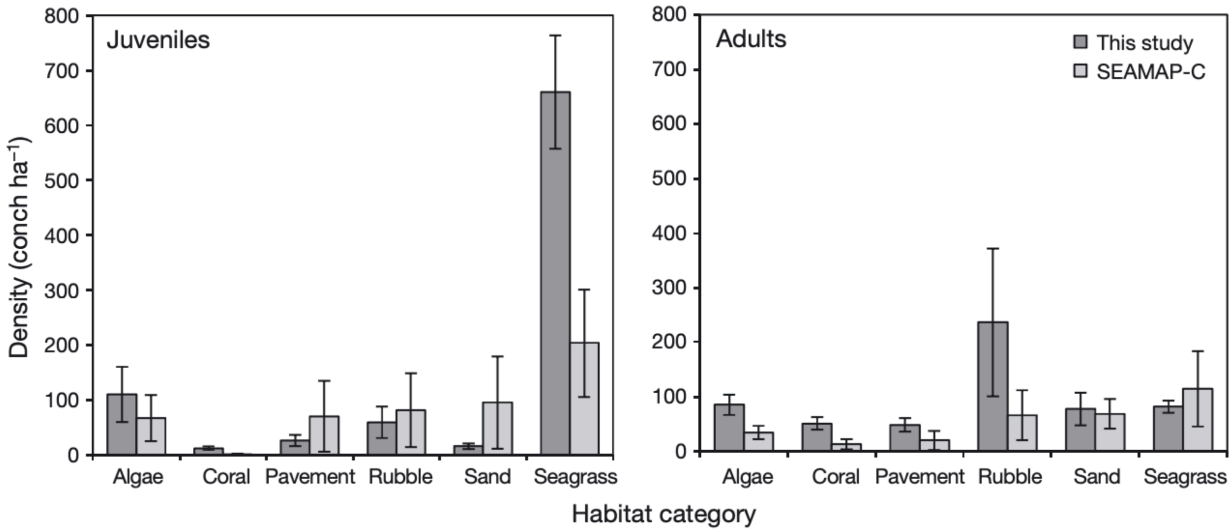

Figure 6: Density (conch ha^{-1}) of juvenile (left) and adult (right) Queen Conch (*Strombus gigas*) across various habitat categories, including algae, coral, pavement, rubble, sand, and seagrass. The juvenile conch shows a significantly higher density in seagrass compared to adults, who display a more even distribution across habitat types. Data presented from this study (darker gray bars/right) is compared with previous findings from the SEAMAP-C program (lighter gray bars/left). Sourced from Doerr, J. C., and Hill, R. L. (2018). *Spatial distribution, density, and habitat associations of queen conch Strombus gigas in St. Croix, US Virgin Islands*.

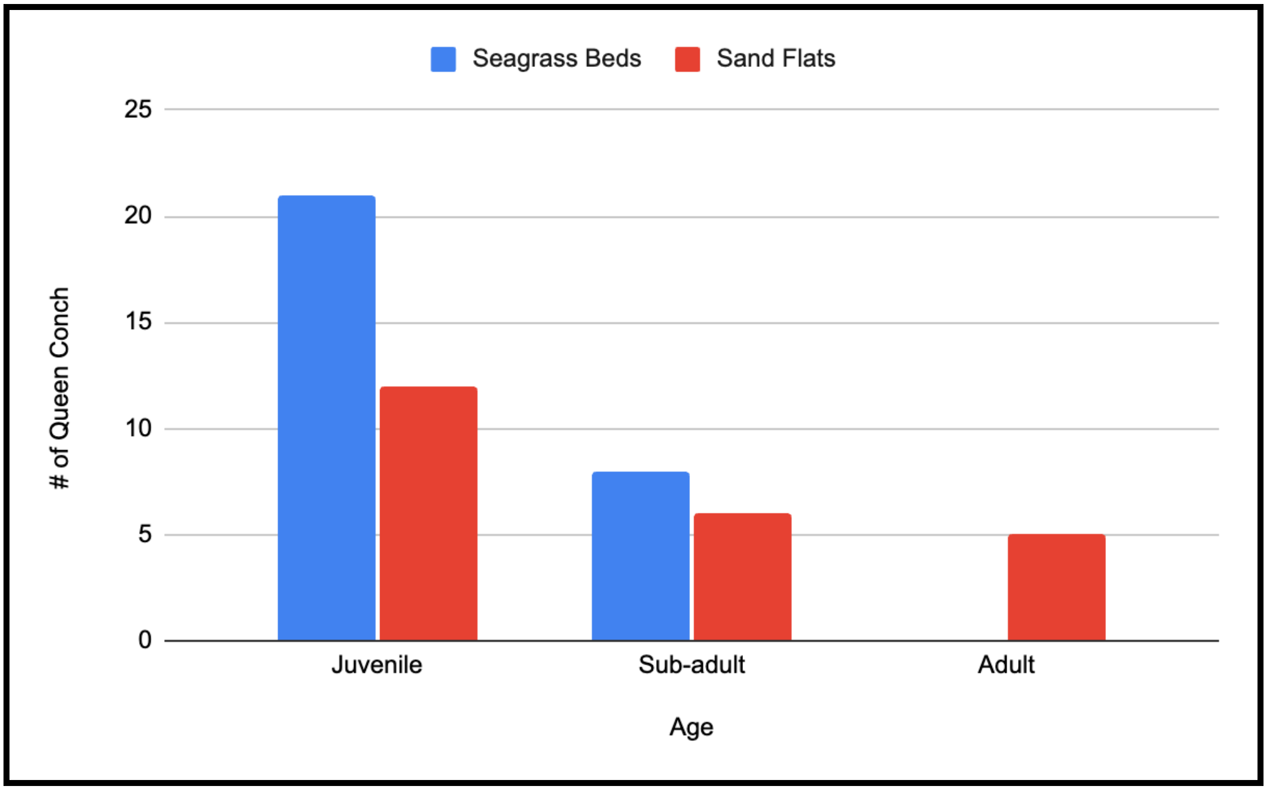

Figure 7. Bar graph showing the number of queen conch by age class across two habitats: Site 1 (Seagrass Beds) and Site 2 (Sand Flats). Site 1, located farther from shore and in deeper water, had higher numbers of juvenile and sub-adult conch, while Site 2, the shallower sand flats, had fewer juveniles but a higher number of sub-adults and more adults. Figure created by the Conch Group in Browning Biology Class B.

Result

During the survey period, a total of 52 queen conch (*Strombus gigas*) were observed across both study sites. Site 1, located in seagrass beds at 2 meters depth, yielded 29 conch specimens, while Site 2, situated in sand flats at 0.35 meters depth, contained 23 specimens (Figure 7). The age distribution of conch varied markedly between habitats. In the seagrass beds (Site 1), juveniles comprised the largest age class with 21 individuals, followed by 8 sub-adults and no adults observed. In contrast, the sand flats (Site 2) showed a more even distribution with 12 juveniles, 6 sub-adults, and 5 adults (Figure 8). The presence of adult conch was exclusive to the shallower sand flat habitat. Shell structure assessments revealed distinct lip development patterns across age classes. Juvenile specimens displayed non-flared lips with no measurable lip thickness (Figures 4A, 4E, 4C, 4D). Sub-adult conch exhibited partially flared lips ranging from 5-10 mm in thickness (Figure 4C). Adult specimens, found only in sand flats, possessed fully flared lips measuring 15 mm or greater (Figures 4D, 4F, 5A, 5B). The spatial distribution of sites relative to shore showed Site 1 (conch float) positioned approximately 5,854 meters from the main shore of Eleuthera, while Site 2 (sandbar) was located approximately 2,674 meters from shore (Figure 2). This positioning placed Site 1 in a more isolated, deeper water environment compared to the nearshore characteristics of Site 2.

Discussion

The observed distribution patterns of Queen Conch across seagrass beds and sand flats support the hypothesis that habitat type influences population structure in *Strombus gigas*. The predominance of juvenile conch in deeper seagrass beds (72.4% of Site 1 population) compared to sand flats (52.2% of Site 2 population) (Figure 7) aligns with established nursery habitat preferences documented in previous studies, such as Stoner and Ray. In contrast, Figure 6, sourced from a study by Jennifer C. Doerr and Ronald L. Hill, shows a significantly higher density of juvenile conch in seagrass, reaching about 660 conch per hectare, compared to lower densities of adults that peak at approximately 150 conch per hectare in sand flats. This relationship reinforces the idea of seagrass beds as critical nursery habitats. The complete absence of adult conch in seagrass beds and their exclusive presence in sand flats (Figure 7) suggests that ontogenetic habitat shifts occur as conch mature. This finding corroborates research by Glazer and Berg, who documented similar age-specific habitat utilization patterns in Florida Keys conch populations. The deeper water and greater distance from shore characteristic of Site 1 (Figure 2) may provide enhanced protection from predation and wave action, creating optimal conditions for juvenile development (Glazer and Berg). Additionally, the remote location and deeper waters of Site 1 offer natural protection from fishing pressure, as commercial and recreational fishermen face significant constraints diving at greater depths and traveling such distances due to increasing fuel costs, making exploitation of these juvenile populations economically unfeasible.

The significance of these findings extends beyond basic habitat preferences to broader implications for conch conservation and management strategies. The identification of seagrass beds as critical juvenile nursery habitat emphasizes the need for targeted protection of these ecosystems, particularly given ongoing seagrass decline throughout the Caribbean (Waycott et al.). The presence of reproductive adults exclusively in shallow sand flats (Figures 5A, 5B) indicates these areas serve as essential spawning grounds, requiring equally stringent protection measures. Figure 6 corroborates this by showing lower densities of adults across various habitats, particularly in seagrass, highlighting their reliance on specific areas for reproduction. This reliance underscores the ecological importance of maintaining healthy sand flat environments to support adult conch populations and their reproductive success.

However, our population density assessment reveals concerning patterns regarding reproductive viability. Site 1 surveyed an area of 2,827 square meters with 29 conch, yielding a density of 103 conch per hectare. Site 2 covered 1,257 square meters with 23 conch, resulting in 183 conch per hectare. Both sites fall substantially below the 450 conch per hectare threshold identified by the Island School as necessary for successful mating aggregations. This low density may compromise reproductive success due to Allee effects, where reduced encounter rates between mature adults limit mating opportunities (Stoner and Ray-Culp).

Furthermore, the distribution patterns evident in Figure 6 suggest that effective conch management must consider the entire seascape mosaic rather than isolated habitat patches. As noted by Acosta, the connectivity between juvenile and adult habitats through migration corridors is crucial for maintaining healthy population dynamics (Acosta). Our results support implementing habitat-based management zones that protect both deep-seagrass nurseries and shallow sand flat spawning areas.

Several potential sources of error may have influenced our data collection and subsequent findings. The limited survey duration of one day may not have captured temporal variations in conch distribution, as previous studies indicate conch exhibit diurnal movement patterns and seasonal migrations (Stoner and Sandt). The relatively small sample size (n=52) and restriction to two survey sites may not fully represent the habitat complexity and conch distribution patterns across the broader Eleuthera region. Additionally, the snorkel-based survey method limited observations to visible conch, potentially underestimating populations as juveniles often bury in sediment during daylight hours (Iversen et al.). Weather conditions, water clarity, and observer experience may have also affected detection rates differentially between the shallow sand flats and deeper seagrass beds.

To address these methodological limitations and improve data collection accuracy, future studies should implement several modifications. Extending the survey period to encompass multiple days across different seasons would capture temporal variability in conch distribution and behavior patterns. Incorporating SCUBA equipment would enable more thorough surveys of deeper seagrass beds and improve detection of buried individuals. Standardizing transect methodology with fixed belt widths and GPS-marked locations would enhance repeatability and allow for precise density calculations. Training all observers in standardized conch identification techniques and conducting inter-observer reliability tests would minimize detection bias. Additionally, implementing nocturnal surveys when conchs are more active could reveal different distribution patterns (SRAC).

Future research should expand upon these preliminary findings through several avenues of investigation. Long-term monitoring studies tracking individual conch movement between habitats using acoustic telemetry would definitively establish ontogenetic migration patterns and habitat connectivity requirements. Examining the relationship between seagrass density, blade height, and juvenile conch abundance could refine our understanding of optimal nursery habitat characteristics. Investigating the role of intermediate habitats such as sand-seagrass edges in facilitating juvenile-to-adult transitions would provide crucial information for corridor protection. Assessing population densities across larger spatial scales would determine whether observed low densities represent localized depletion or region-wide population decline. Additionally, evaluating the impact of environmental factors, including temperature, salinity, and current patterns, on habitat selection across different life stages would enhance predictive modeling capabilities. Comparative studies across multiple Caribbean islands experiencing varying levels of fishing pressure could elucidate how exploitation influences natural habitat utilization patterns, informing region-specific management strategies that account for both ecological requirements and socioeconomic realities of artisanal fishing communities.

References

Acosta, C. “Spatially Explicit Dispersal Dynamics and Equilibrium Population Sizes in Marine Harvest Refuges.” *ICES Journal of Marine Science*, vol. 59, no. 3, June 2002, pp. 458–468, academic.oup.com/icesjms/article/59/3/458/610816, https://doi.org/10.1006/jmsc.2002.1196. Accessed 29 Oct. 2019.

“Aliger Gigas.” *Wikipedia*, 15 July 2020, en.wikipedia.org/wiki/Aliger_gigas. Accessed 2 June 2025.

Cash, Erin. *Assessment of Queen Conch, Lobatus Gigas, Density, Middens and Permitting Requirements, in South Eleuthera, Bahamas*. 4 May 2013.

Davis, Megan. *Species Profile Queen Conch, Strombus Gigas*. SRAC, Oct. 2005.

“Endangered and Threatened Wildlife and Plants: Listing the Queen Conch as Threatened under the Endangered Species Act (ESA).” *Federal Register*, 14 Feb. 2024, www.federalregister.gov/documents/2024/02/14/2024-02966/endangered-and-threatened-wildlife-and-plants-listing-the-queen-conch-as-threatened-under-the. Accessed 2 June 2025.

Foley, James R., and Miwa Takahashi. “Shell Lip Thickness Is the Most Reliable Proxy to Sexual Maturity in Queen Conch (Lobatus Gigas) of Port Honduras Marine Reserve, Belize; Informing Management to Reduce the Risk of Growth Overfishing.” *Frontiers in Marine Science*, vol. 4, 9 June 2017, www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2017.00179/full, https://doi.org/10.3389/fmars.2017.00179. Accessed 1 Oct. 2021.

Gilbert, Megan. “Island School Semester Students Dive into Queen Conch Research - the Island School.” *The Island School*, 28 Mar. 2025, islandschool.org/news/the-island-school/student-conch-research/. Accessed 2 June 2025.

Iversen, Edwin S., et al. “Evidence of Survival Value Related to Burying Behavior in Queen Conch Strombus gigas.” Fishery Bulletin, vol. 88, no. 2, 1990, pp. 383-387, http://spo.nmfs.noaa.gov/sites/default/files/pdf-content/1990/882/iversen.pdf.

Keegan, William F. The People Who Discovered Columbus: The Prehistory of the Bahamas. University Press of Florida, 1992.

Posada, Juan M., et al. “Distribution and Abundance of Strombus gigas (Mesogastropoda: Strombidae) Larvae During Their Reproductive Period in the Caribbean Coast.” Revista de Biología Tropical, vol. 46, no. 4, 1998, pp. 859-870, https://core.ac.uk/download/pdf/19208723.pdf.

Sherman, Krista D., et al. “Contemporary and Emerging Fisheries in The Bahamas—Conservation and Management Challenges, Achievements and Future Directions.” Fisheries Management and Ecology, vol. 25, no. 5, 2018, pp. 319-331.

. “Spring 2025 Student Research Project: Queen Conch - the Island School.” *The Island School*, 25 Apr. 2025, islandschool.org/news/the-island-school/spring-2025-student-research-project-queen-conch/. Accessed 2 June 2025.

Glazer, R.A., and C.J. Berg Jr. *Queen Conch Research in Florida: An Overview.” Proceedings of the 1st Latin American Malacological Conference. Special Workshop on the Management and Culture of Queen Conch*. 1994.

Hausheer, Justine E. “Bahamian Queen Conch: Fishers & Scientists Share Knowledge for a Sustainable Fishery.” *Cool Green Science*, The Nature Conservancy, 8 June 2020, blog.nature.org/2020/06/08/bahamian-queen-conch-fishers-scientists-share-knowledge-for-a-sustainable-fishery/. Accessed 2 June 2025.

NOAA Fisheries. “Limiting Factors for Queen Conch (Lobatus Gigas) Reproduction: A Simulation-Based Evaluation.” *NOAA*, 9 Mar. 2022, www.fisheries.noaa.gov/resource/peer-reviewed-research/limiting-factors-queen-conch-lobatus-gigas-reproduction-simulation. Accessed 2 June 2025.

---. “Queen Conch.” *NOAA*, 2020, www.fisheries.noaa.gov/species/queen-conch. Accessed 2 June 2025.

“Protecting the Bahamian Queen Conch Fishery.” *The Nature Conservancy*, www.nature.org/en-us/about-us/where-we-work/caribbean/stories-in-caribbean/bahamas-queen-conch-fishery/. Accessed 2 June 2025.

Stoner, Allan W., and Maria Ray. “Queen Conch, Strombus gigas, in Fished and Unfished Locations of the Bahamas: Effects of a Marine Fishery Reserve on Adults, Juveniles, and Larval Production.” Fishery Bulletin, vol. 94, no. 3, 1996, pp. 551-565, https://spo.nmfs.noaa.gov/sites/default/files/pdf-content/1996/943/stoner.pdf.

Stoner, Allan W., and Martha Davis. “Queen Conch Stock Assessment: Historical Fishing Grounds Andros Island, Bahamas.” Community Conch, 2010, https://ftp.crfm.int/~uwohxjxf/images/Community_Conch_Queen_Conch_Stock_Assessment_Berry_Islands_2009.pdf.

Stoner, Allan W., and Melody Ray-Culp. “Evidence for Allee Effects in an Over-harvested Marine Gastropod: Density-dependent Mating and Egg Production.” Marine Ecology

Progress Series, vol. 202, 2000, pp. 297-302, https://www.int-res.com/articles/meps/202/m202p297.pdf.

Stoner, Allan W., and Vincent J. Sandt. “Population Structure, Seasonal Movements and Feeding of Queen Conch, Strombus gigas, in Deep-water Habitats of the Bahamas.” Bulletin of Marine Science, vol. 51, no. 3, 1992, pp. 287-300, https://spo.nmfs.noaa.gov/sites/default/files/pdf-content/1992/901/stoner.pdf.

Stoner, Allan W., et al. “Maturation and Age in Queen Conch (Strombus gigas): Urgent Need for Changes in Harvest Criteria.” Fisheries Research, vol. 131-133, 2012, pp. 76-84, https://www.sciencedirect.com/science/article/abs/pii/S0165783612002238.

Stoner, Allan W., et al. “Relationships between Fishing Pressure and Stock Structure in Queen Conch (Lobatus gigas) Populations: Synthesis of Long-Term Surveys and Evidence for Overfishing in the Bahamas.” Reviews in Fisheries Science & Aquaculture, vol. 27, no. 1, 2019, pp. 51-71, https://www.researchgate.net/publication/328085525_Relationships_between_Fishing_Pressure_and_Stock_Structure_in_Queen_Conch_Lobatus_gigas_Populations_Synthesis_of_Long-Term_Surveys_and_Evidence_for_Overfishing_in_The_Bahamas.

Stoner, Allan W., et al. “Surveys of Queen Conch Populations and Reproductive Biology on the Little Bahama Bank, The Bahamas.” Community Conch, 2020, https://www.communityconch.org/wp-content/uploads/2014/12/Little-Bahama-Bank-FINAL-report1.pdf

Treco-Hanna, Lyric. “The Queen Conch Bahamas BJC Review.” *SlideShare*, Slideshare, 10 May 2018, www.slideshare.net/slideshow/the-queen-conch-bahamas-bjc-review/96645147. Accessed 2 June 2025.

Waycott, Michelle, et al. "Accelerating Loss of Seagrasses across the Globe Threatens Coastal Ecosystems." Proceedings of the National Academy of Sciences, vol. 106, no. 30, 2009, pp. 12377-12381, https://www.pnas.org/doi/10.1073/pnas.0905620106

Whittle, Patrick. "AP Photos." *AP Photos* , 10 Apr. 2023, apimagesblog.com/blog/2023/4/9/in-bahamas-conch-fishing-is-way-of-life-but-for-how-long. Accessed 2 June 2025.

Acknowledgements

Thank you, Mr. Wong, Ms. Brown, Ms. Bancroft, Mr. Willson, and Mr. Lopez, for everything you have done over this trip. Thank you for all the preparation and guidance you gave us, and for taking time out of your personal lives. We would also like to thank the Island school staff for being with us throughout the week, and especially the people who were on the boat with us during conch data collection. Overall, this group has grown from an unorganized group of young men to a semi-unorganized group of young men. There were some points during our writing and data collection where we all thought our hypothesis was proven wrong, and in some way it was, but we learned that we can still make a great lab report even if our hypothesis was semi-proven wrong. We are all extremely grateful for this trip, as we all know that we are lucky to be in this position. Thank you again to all the Browning teachers and Island school staff who helped make this trip both educational and fun. We hope that in the future, Browning boys can keep making trips like these, because they really are something special.