CONTRIBUTION 6.3

An Assessment of the Reproductive Activity of Queen Conch (*Aliger gigas*) in Captive and Wild Populations in the Discovery Bay Special Fishery Conservation Area, Jamaica

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Abstract

Jamaica's Queen conch closed-season is based on a temperature-influenced annual spawning activity derived using data from other Caribbean countries. No reproductive and spawning season determination had previously been done for Jamaica. With rising sea surface temperatures and increasing temperature variability across the region, it may be necessary to revise annual closed seasons. Our study therefore sought to design assessments of conch reproductive activity in relation to sea temperatures. Adult Queen conch (mean lip thickness 16.9 mm) were tagged and stocked at a ratio of 2:3 males to females in 50m^2 pens in substrate consisting of seagrass, rubble and coarse sand within the Discovery Bay Fish Sanctuary. These were observed for 7 months in 2022 to indicate densities and temperatures at which spawning occurred. Prior to stocking, conch abundance surveys were conducted between July and August 2020 at six sites in the bay and these were repeated at the end of the stocking experiment in November 2022. Data collected from the penned conch included the number of occurrences of mating, pairing and spawning, the presence of egg masses, and temperature for both captive and wild conch (found adjacent to the pens). Conch displayed 8 occasions of spawning (one female spawning 5 times) with 2 occasions of pairing and 1 mating occasion. Peak spawning activity was recorded in August and September, with maximum sea water temperature of 30.65°C. Mean temperatures across Jamaica's north coast showed an increase between May to October, and decreased thereafter. Conch abundance surveys conducted in 2021 and 2022 in the bay indicated densities of 10.1 ha^{-1} and 7.5 ha^{-1} respectively with populations dominated by juveniles and sub-adults. The protocols developed in Discovery Bay will be expanded to other areas around Jamaica with the expectation that these findings will help inform measures to manage conch stocks in Jamaica's SFCAs towards sustainable harvesting in nearby fishing grounds.

KEYWORDS: Queen conch, Aliger gigas, reproduction, temperature, Discovery Bay, Jamaica

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1. INTRODUCTION

Queen conch *(Aliger gigas)* is a commercially important marine gastropod found throughout the Caribbean. These organisms reach sexual maturity at around 3-4 years old and are generally known to aggregate in appropriate (higher) densities around the breeding season when they migrate to the shallows to spawn; making them susceptible to over exploitation. Due to their high commercial value, in areas where adult conch populations have declined, sub-adults and larger juveniles are fished before they ever mate, which reduces the breeding population, exacerbates the effects of over exploitation, and makes the resource difficult to manage. For these reasons, the species was listed in Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) with measures and actions proposed to improve understanding, sustainability and management of the species.

Abundance surveys have been useful in estimating the stock size to manage the species. An assessment of the Queen conch stocks at Pedro Bank (off Jamaica's coast) in 2018, conducted by the National Fisheries Authority (NFA) of the Ministry of Agriculture, Fisheries and Mining, indicated that the numbers fell below the Limit Reference Point (as determined by the NFA) and confirmed that the stocks were critically low. Consequently, the NFA imposed a ban on the fishery between March 2019 and February 2021. The stock assessment also indicated that the densities observed may not bring about successful reproduction to replenish the stock. According to Stoner and Ray-Culp (2000), mating and spawning of this species is unsuccessful below densities of 56 conch ha^{-1} (mating) and 48 conch ha^{-1} (spawning). They further indicated that over exploited populations in the Caribbean have been slow to recover despite the closure of the fishery, due to spawning densities declining to a level where the 'Allee effect' starts to operate on the reproductive behaviour of the conch.

The establishment of a closed season allows for mature species to breed and replenish its population, as within this period it is illegal to fish, hunt or capture a specified animal. The closed-season therefore typically coincides with the peak breeding season of a specified animal. Seasonal closures have been identified as effective conservation tools for overfished species (Owusu et al., 2023).

Queen conch reproduces seasonally with a typical 6-8 month spawning period between March and October (Davis et al., 1984, Davis & Stoner, 1994) but has shown variations throughout its geographic range. In some areas, reproductive activity has been documented to occur throughout the year (Egan, 1985, Stoner et al., 1992), starting much earlier in the year and extending much later than in other areas (Randall, 1964). Peak activity has been observed in the warmer summer months between July and September.

Jamaica's closed-season (August 8, 2023, to February 29, 2024) is based on temperature-influenced annual spawning activity from other Caribbean countries, since little reproductive behaviour assessment and spawning season determination had been done for Jamaica. Aldana Aranda et al. (2014) suggests that a biologically meaningful period for a closed season, that would offer protection to spawners would need to include the months June to September for the Western central Atlantic. The primary objectives of the 2-year project as outlined in the agreement between the Discovery Bay Marine Laboratory (DBML) and the Jamaica Conservation Partners (JCP), were to (i) survey the relative abundance and collect information on the Queen conch population within the Discovery Bay Special Fishery Conservation Area (DBSFCA), and (ii) observe and document the exact period (and temperatures) over which reproductive activity for Queen conch takes place by monitoring adult conch in containment pens across their expected breeding season.

2. METHODS

2.1 Abundance surveys

Surveys were conducted in two years, at six sites within the DBSFCA (Figure1). Three of the sites were located within the western section of the bay and the remaining three were in the eastern section. The selections were based on previous studies and literature reviews which indicated the ecological preference of the species (Randal, 1964, Prada et al., 2009, Stoner & Davis, 2010). The 2020 surveys were conducted between July 15 and August 28, 2020 while the 2022 surveys were conducted between November 7 and 14, 2022.

For each site, a 100 x100 m plot was established parallel to the coastline using a Garmin GPS device and surface marker floats (to indicate the corners of the quadrat). The waypoints were recorded for each corner of the plot. A team of 6-8 surveyors using a mixture of snorkel gear and scuba gear spread out evenly along one side of the plot to span its entire length. Surveyors travelled simultaneously from one side of the plot to the opposite end, searching for Queen Conch. For each live Queen conch encountered, the shell length and shell width were measured using a ruler. The measurement for lip thickness was determined using a calliper and was taken two-thirds the way up the flared lip, in its thickest region, approximately 2-3 centimetres from the lip edge. After measuring, each conch was marked by tying yarn around the spire, before being returned to the substrate. The substrate type and depth at which each conch was found were also noted. For the recapture exercise, the sites were revisited (no less than 7 days after the capture exercise) using the GPS coordinates. The team of 6–8 snorkelers checked the plots, applying the same methods and with the same effort/time, collecting, counting and recording both marked an unmarked conch.

Following data collection, the conch were classified as juvenile or adult based on their lip thickness and shell length (Morris 2016) as follows:

a. Small juveniles (<150mm SL)
b. Medium juvenile (151-200mm SL)
c. Large juvenile (>200mm SL, no flared lip)
d. Sub-adult (Flared lip >4mm),
e. Adult (Flared lip, fully formed > 3 years),
f. Stoned Conch (Heavy erosion, thick lip, >15mm).

The juvenile categories were grouped as one.

2.2 Establishment of Conch containment pens

Factors that were critical to site selection were related to the requirements of the species with regards to food availability, space, substrate type and depth. Conch normally select shallow habitats comprised of coarse sand and very fine pebbles (also referred to as reef rubble) for spawning or laying egg masses and seagrass areas for feeding, they are also often found in areas that are a mosaic of sand, rubble, and seagrass (Randall 1964, Glazer & Kidney 2004). The site selection attempted to replicate similar conditions required for reproduction; breeding and feeding, as closely as possible.

Containment pens (each measuring 50 m^2) were constructed at the DBML Jetty and Fortlands Point in March 2021 and April 2022, respectively (Figure 1). Pens were constructed using 1.25m tall, 3/8” steel rebars as fence posts and biaxial geogrid mesh to create the perimeter.

Gaps in the lower section of the pen (near the substrate) were sealed with pieces of BRC fabric. Each of these two sites had a minimum of two pens which were used in rotation.

Figure 1. Location of six survey sites and location of the two conch containment pens/areas within the Discovery Bay Special Fishery Conservation Area. Image source: Google Earth 2022

The sexing and tagging process took place ex-situ in the shallow troughs in the UWI-DBML Wetlab. Conch were sexed by orienting the shell lip facing upwards to identify the male vs female organs. Once the conch extended its muscular foot to right itself, the male or female organs are exposed, and its gender can be identified. The males have a verge (intromittent organ/penis), while the females have an egg groove (Figure 2).

Once the gender was identified, shell metric data was collected. This included weight, lip thickness, measured with a calliper, and shell length measured with an osteometric board. Each conch was tagged with a unique 3-digit number on a round aluminium tag, attached to coloured yarn and wrapped around the spire. Male conch were assigned tags with uneven numbers, and green yarn, while the female conch were assigned even numbers and pink yarn. In case tags were lost/ separated from the string, the colour of the string could be used to easily identify the gender of the conch (Figure 3).

Figure 2. Queen conch (Aliger gigas) external sex organs- the male has a verge (left) and the female has an egg groove (right). Photo source: Javel Noble (top left), Jhenessa Rankine (bottom left) and Shanna- Lee Thomas (right)

Figure 3. Yarn and aluminum tag tied around the spire to mark the conch before stocking the pens. Photo source: Abigail Richards.

Pens were stocked at a density of 1 or 2 males to 3 females, to increase the probability of mating and spawning (i.e., more females, higher chances of seeing egg masses). Pens were also stocked based on the recommended natural spacing requirement of an undisturbed conch population of 1 conch per 10 m^2 (Megan Davis, Florida Atlantic University, personal communication). The second pen in each location was used in rotation with the others to provide the conch with adequate food throughout the breeding season. That is, once the conch grazed through one pen they were moved to their alternate pen).

The conch pens were monitored, at minimum, twice per week for reproductive activity. Each check involved counting the number of conch in the pens, then noting the reproductive activity under one of the following categories: Mating/Copulation: shells in contact (male usually behind female) and male verge observed passing sperm to female (A), Pairing: conch are in mating position, may be touching but not mating (B), Spawning: laying of egg mass or the presence of egg mass (C) or no reproductive activity such as feeding (Figure 4). For the makeshift (fenceless pens) at Fortlands point south, the same monitoring was conducted within 1m of the perimeter of the pens. Photographs and video footage were recorded once reproductive activity was observed.

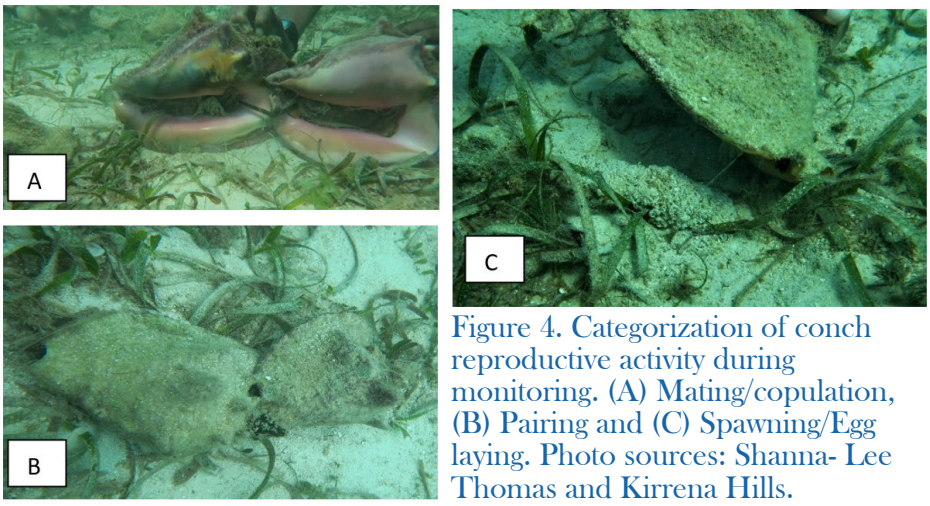

Figure 4. Categorization of conch reproductive activity during monitoring. (A) Mating/copulation, (B) Pairing and (C) Spawning/Egg laying. Photo sources: Shanna- Lee Thomas and Kirrena Hills.

3. RESULTS

3.1 Abundance surveys

In 2020, the highest densities of Queen conch were found on the eastern side of Discovery Bay at the Fortlands Point site (28 ha^{-1}), and Portside Villas (23 ha^{-1}) (Table 1). Both sites also had similar depths (4.2-4.5m) but varied in the type of substrate with sand and rubble dominating the Fortlands point site while the Portside Villas site consisted of a mix of sand and seagrass. Old Folly had 8 individuals and West of Blue Hole had 2 individuals. No live conch was observed at Top Bay Fishing Beach and East of the Blue Hole. Contrastingly, conch were present at all sites in 2022, with the highest densities (72 ha^{-1}) being recorded in the western side of Discovery Bay in the East Blue Hole site and only (1) recorded for the West of the Blue Hole.

Table 1. Results of Queen Conch density survey conducted within the Discovery Bay SFCA

Site	Average depth (m)	Density ha^{-1} (2020)	Density ha^{-1} (2022)
Fortlands Point	4.2	28	12
Portside Villas	4.5	23	6
Top Bay Fishing Beach	5	0	4
West of Blue Hole (DBML Docks)	3.5	2	1
East Blue Hole	3	0	72
Old Folly	2.5	8	10
Average	**3.7**	**10.1**	**17.5**

The density at Fortlands Point in 2020 was 28 ha^{-1} of this number 7 were juveniles, 11 were sub-adults and 10 were adult conch. The Portside Villas site was dominated by adults (16), followed by sub-adults (4) and juveniles (2). No conch was found at the Top Bay Beach and East Blue Hole sites. Blue Hole West had 1 adult and 1 sub-adult conch. Of the 8-conch found at Blue Hole, 5 were sub-adults and 2 were juveniles (Figure 5).

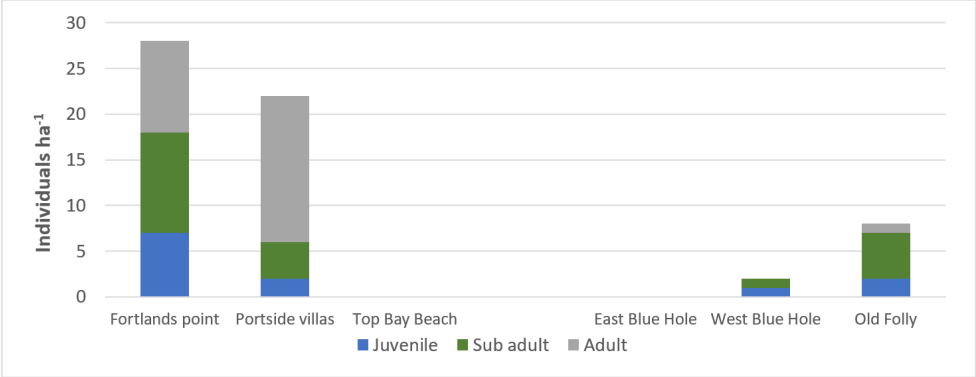

Figure 3. Density distribution according to life stage (juvenile, sub-adult and adult) of conch in 2020

In the 2022 survey, Fortlands Point had 12 ha^{-1}, 10 of which were juveniles, while the remaining 2 were sub-adults. Portside only had 6 sub-adults, while Top Bay Beach had 3 juveniles and 1 adult. East of Blue Hole had the highest conch density 72 ha^{-1}, with the majority (46) being juveniles followed by 17 sub-adults and 9 adults. West blue hole had 1 juvenile, while Old Folly had 7 juveniles and 3 adults (Figure 6).

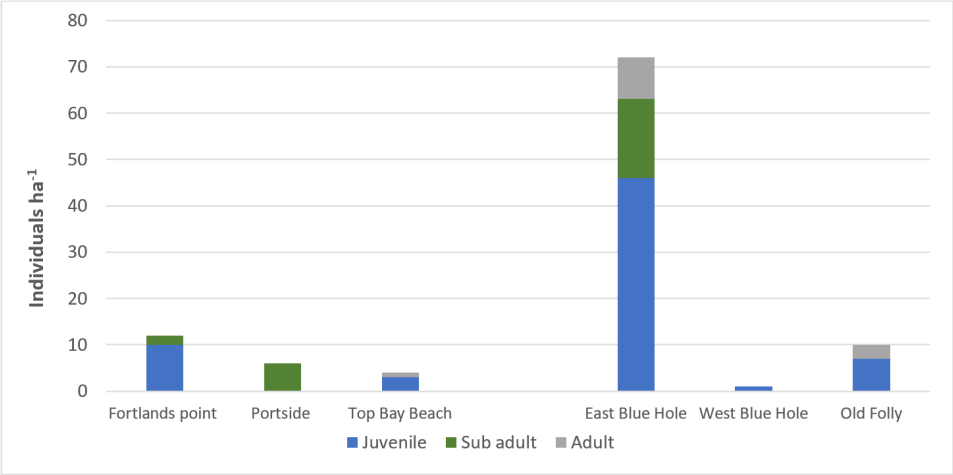

Figure 4. Density distribution according to life stage (juvenile, sub-adult and adult) of conch in 2022

The population estimate using the capture-mark-recapture method was calculated from a total of 61 individuals being encountered and marked across the six survey sites in 2020. For the recapture exercise, only 1 marked individual was recaptured, while 43 individuals were recaptured without a mark. In 2022, a total of 106 individuals were captured and marked (Table 2). Subsequently, 37 individuals were recaptured with a mark and 109 recaptured without the mark. The population estimate in 2020 was therefore 2684 individuals, while in 2022 the estimate was 418 individuals, however this is based on the capture-mark-recapture method which also assumes no 'loss' to the population (e.g., by poaching).

Table 2. Summary of Abundance survey (using Capture-mark-recapture Method)

	No. Individuals Captured + Marked	**No. of Individuals Recaptured w/ Mark**	**No. of Individuals Recaptured w/out Mark**	**Population abundance estimate**
2020	61	1	43	**2684**
2022	106	37	109	**418**

Abundance calculation *Population total* ***(N):*** *No. of Individuals captured and marked* ***(M)*** *x No. Individuals captured on second occasion (marked +unmarked)* ***(C)*** */ No. Individual recaptured* ***(R)***. Formula: **N= (M x C)/R**

Surveys conducted in 2021 and 2022 at six sites in the bay indicated densities of 10.1 ha^{-1} and 7.5 ha^{-1} respectively, with populations dominated by juveniles and sub-adults. These populations provided the source for the stocking of the pens for both locations.

3.2 Monitoring of Queen Conch in containment pens

Shell metrics

A total of conch (55) were collected for the duration of the study, 33 females and 22 males. Females appeared to be larger than the males in terms of shell length and width, however, the males typically had greater mean values for lip thickness, which is reflected in the shell measurements. The average shell length for the females was 24.43 cm, shell width 12.86 cm and lip thickness 15.24 mm, for the males the average shell length was 23.19 cm, shell width 11.43 cm and lip thickness 15.36 mm. The conch selected for stocking had ~15mm lip thickness. Studies in the Caribbean used lip thickness is a good indicator of sexual maturity in conch, more so than shell length. For example, male conch at reproductive activity in the Bahamas had a minimum lip thickness of 9 mm, while for females a minimum lip thickness of 12 mm (Stoner et al., 2012). It was further suggested that the minimum shell lip thickness for harvest should be no less than 15 mm.

The females that were found mating and spawning were #724, #794, #736 and #770, their lip thickness varied between 11mm and 21.5mm, with three of these female conch having a lip thickness over 15mm. The males that were either observed mating or in the pens were #733, #723, and #779, the lip thickness for these varied between 12mm- 21.2mm. The mean LT for these individuals was 16.9mm.

Table 3. List of Conch (and their shell metrics) that were recorded mating/spawning

Conch ID	Shell length (cm)	Shell Width (cm)	Lip thickness (mm)	Note
724	23.5	15.1	21.5	Pairing
794	25.5	11.5	18	Spawning (recovered outside)
736	24.8	10.9	16.7	Spawning
770	22	13	11	Spawning (5 times)
733	19.4	13	12	Mating
723	23.2	17.4	18	Pairing
779	22	9.7	21.2	Pairing (found outside)
Means	22.9	12.9	16.9	

Reproductive activity

The conch at the Jetty location were most often observed feeding on epiphytes on the *Thalassia testudium* in the pen, particularly along the boundary of the pen (where the epiphytes were also growing on the enclosure). For the majority 329 of the 396 (83.08%) monitoring occasions, no reproductive activity was observed, conch were either stationary along the pen boundary for long periods or moving and feeding. For the remaining (67) 16.9% of the observations, conch were paired as the shells were touching end to end as in breeding position but not copulating after closer inspection. In 2022, three (3) of the 53 occasions of the observations were of pairing, while the majority 50 (94.3%) of the observations were of non-reproductive activity/ feeding. Despite the observations of pairing, no copulation or evidence of spawning (egg masses) was ever noticed in the Jetty pens.

On the other hand, the conch in the pens at the Fortlands point north location displayed more reproductive activity than the conch at the Jetty. Mating, pairing and spawning were noted on different occasions. There were 8 (13.6%) occasions of spawning, 2 (3.4%) occasions of pairing, and 1 (1.7%) mating, the remaining 44 (74.6%) observations were of general movement and feeding in the pens. The conch at the Fortlands Point north location were also more often found in different locations inside the pen, as opposed to solely lining and grouping at the boundaries of the pens.

Spawning frequency

The spawning activity for the captive conch began (was first observed) on the 24th of August 2022 and through the 23rd of September (Figure 7). One female (#770) spawned 5 times, while female #736 was observed spawning only once (Figure 8). Egg masses were noticed twice, close to females #724 and #732, however, the egg masses might not necessarily have been laid by these two specific females. There were 2 occasions of mating/pairing – pairing in September and mating in October. One spawning event took place on the 26th of November for #736. No spawning or mating was noted thereafter, attempts to conduct further monitoring were disrupted by rough sea conditions and resulting poor visibility.

Figure 5. Female conch (ID 770) laying egg mass at Fortlands point site, August 24, 2022. Photo source: Shanna- Lee Thomas

Figure 6. Female (ID770) laying eggs at Fortlands Point site, September 12, 2022. Photo source: Kirrena Hills

Temperature variation

The associated temperature variation for this period is shown below (Figure 9). The minimum temperature for July was 28.7°C, while the maximum was 30.46°C. The minimum and maximum temperatures for August were 29.05°C and 30.86°C respectively. In September the minimum temperature was 29.4°C and the maximum was 30.9°C (Table 4). Table 5 indicates the list of spawning events, the average daily temperature and the temperature at the time of spawning. The minimum temperature recorded during observation of conch spawning in captivity was 29.75°C and the maximum temperature was 30.65°C.

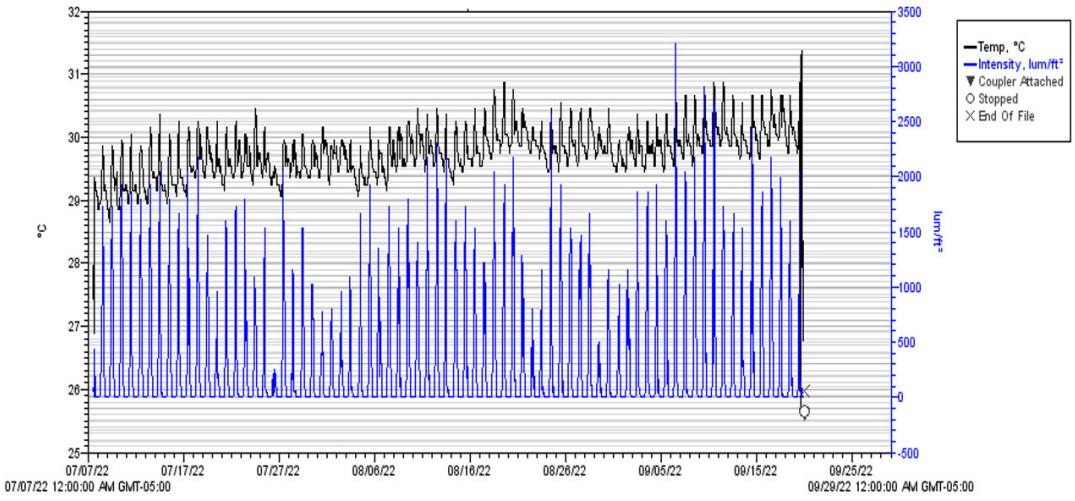

Figure 7. Temperatures recorded for spawning period- July, August and September 2022 at Fortlands Point

Table 4. Minimum and maximum temperatures recorded for July, August and September 2022

Date	Activity	Temperature at time of observation	Avg daily temperature
August 24	Spawning	30.05	29.77
August 30	Spawning	29.75	29.86
August 31	Egg mass observed	30.25	29.64
September 8	Egg mass observed	30.35	29.9
September 9	Pairing & Spawning	30.45	30.08
September 12	Spawning	30.65	30.06
September 19	Egg mass observed	30.35	29.67
September 23	Spawning	N/A	N/A
October 10	Mating	N/A	N/A
November 26	Spawning	N/A	N/A

Table 5. List of spawning events and associated temperatures at the time of observation

	Min Temp	Max Temp
July	28.7°C	30.46°C.
August	29.05°C	30.86°C
September	29.4 °C	30.9°C

Mean temperatures recorded across the north coast showed a steady increase between May to September, temperatures decreased thereafter (Figure 10). The highest mean temperature for the period was 30.1°C and this was recorded for the month of September. Highest temperatures were recorded between August-October, this corresponded with the peak in spawning activity.

Figure 8. Mean seawater temperatures between May-December 2022 on Jamaica's north coast

3.3 Wild Conch Population

Observations of reproductive activity in the wild population were also noted for the duration of the study (2021 to 2022). DBML visitors (divers/snorkelers and swimmers) were asked to indicate sightings of conch reproductive activity type of activity and location. Since the sightings are typically spontaneous, temperature data are unknown for many of these events. Mating was first recorded on June 14, 2021, near the Fortlands point site, as indicated below. Subsequently, spawning was observed on the 16th of August and the 16th of September 2021 in the same location. Mating in captivity was first recorded on the 16th of June in the DBML Wet-lab where the conch were temporarily being held before stocking them in *in-situ* pens.

For 2022, spawning was first observed on the 29th of April, following this there were 6 other occasions of spawning and mating at various locations across the bay including 2 near the DBML, 1 at Old Folly, and 3 others at Fortlands Point. Notably, an aggregation of both Queen conch and Milk Conch was located on the eastern side of the bay with well over 60 conch spawning and mating at a depth of 5.18 m and water temperature at 29°C. The last spawning in the wild was observed on the 8th of November 2022 and the last spawning in the pen was on the 26th of November.

4. DISCUSSION

Queen conch population within the Discovery Bay Special Fishery Conservation Area appears variable in time and space with maximum densities being lower or similar to other Caribbean countries. Caribbean surveys with conch densities included two sites in Barbados with14.4 conch ha^{-1} and 4.3 conch ha^{-1} (Valles & Oxenford 2012), Antigua and Barbuda with 17.2 conch ha^{-1} (Tewfik et al., 2001) and Anguilla with 29 conch ha $^{-1}$ (Izioka 2016). Based on these abundance surveys, the density at five of the 6 sites in DBSFCA was determined to be less than half the minimum densities that would result in successful spawning (Stoner and Ray-Culp, 2000), with the exception being the East Blue Hole site with a density of 72 individuals ha^{-1} in 2022. In 2020, Fortlands point had the highest density of 28 conch ha^{-1} in comparison to the other sites surveyed, in 2022 density at Fortlands point decreased to 12 conch ha^{-1}, and there was also a decrease at the Portside villas site. Contrastingly, there were no conch recorded for the East Blue Hole site in 2022, however there was a drastic increase in 2022 to 72 conch ha^{-1}. Other sites showing an increase were Top Bay and Old Folly. The shift (decrease in density) at Fortlands point, which typically has higher densities, is likely due to the seasonal movement of adult conch from the area surveyed to the breeding aggregation close by, leaving behind few younger conch. Most of the conch found during the second year of surveys were juveniles and sub-adults. More adults were observed at both Fortlands point and Portside Villas in 2020. The increase in density in other sites such as East Blue hole could be attributed to the increase in surveillance and monitoring of this area due to its closeness to the DBML Jetty Pens and associated decrease in poaching pressure. Two female conchs (#704 and #800) initially tagged in 2020 were retrieved from the East Blue Hole site during the 2022 density surveys.

The population estimate derived from the abundance calculation (capture-mark-recapture) indicates a decline in the conch population in Discovery Bay, however this might not necessarily be the case. During the initial surveys, a total of 106 individuals were encountered across the six survey sites. For the recapture exercise a week later a total of 37 marked individuals were found, 35 of these individuals were found at the East Blue Hole site. This large proportion of a little over half of the individuals initially recorded at the site (72) may be indicative of the low dispersal rate of the conch species, however data from the other sites do not mirror this observation. Despite this increase in surveillance and density at this particular

site, there continues to be poaching (though far less frequent) in other areas of the bay as evidenced by shells of recently killed conch found during surveys.

The abundance of adult conch, available for reproduction, determined by shell length and lip thickness, presents a limitation to population stability and growth. However, shell length and lip thickness are affected by environmental conditions such as water quality and differences in nutrition, therefore the relationship between lip thickness, shell length, age and maturity may vary by region and would need further research for confirmation locally.

The reproductive activity for Queen conch especially related to sea water temperature has been described and documented for the first time in Jamaica both in situ as well as in the wet-lab facility at the DBML. The expected direct relationship between spawning and increased water temperature was demonstrated. Typically, conch spawn during the summer months when the temperature is warmest- between 28-29°C and in some cases 30°C. While spawning of captive conch was first recorded on August 24, 2022, it should be noted that females can retain the sperm of males for up to 6 weeks after copulation and lay 9.4 egg masses throughout this period (D'Asaro 1965, Davis et al. 1984). Therefore, with spawning occurring when it did, it is likely that mating took place between May and July. The observations of the wild population showed much earlier spawning in both 2021 and 2022. The typical spawning period throughout the Caribbean is between March and October, with a narrower range in the warmest months, these being between July to September (Aldana Aranda et al., 2014).

The results from these experiments would also suggest that there is a peak in spawning activity in the warmest months August to September for both the captive and wild population. Observations of wild conch within the bay indicate a much broader spawning period, from April to November, which is an earlier start (by 4 months) to the current closed season which spans August 8, 2023, to February 29, 2024.

A further consideration is that of increased sea temperatures associated with global warming, where the breeding period may have been shorter in previous years, higher temperatures may result in the extension of the breeding season. Reproductive activity may occur all year round (Blakesley, 1977 Stoner et al., 1992). The occurrence of egg masses being deposited or found throughout the year has been documented in Belize and Mexico (Theile, 2001, Egan, 1985) however, this would require a follow-up to this study to further investigate the activities of the wild population. Continued research over multiple spawning periods is now required to produce sufficient data to guide determination of the close-season for Queen conch in Jamaican waters.

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LITERATURE CITED

Aldana Aranda.D., Oxenford. H., Bissada. C., Enriquez. M., Brulé. T., Delgado. G., Martinez M. I., & Frenkiel. L. (2014). Reproductive patterns of queen conch, *Strombus gigas* (Mollusca, Gastropoda), across the Wider Caribbean Region. *Bulletin of Marine Science*. 90. 10.5343/bms.2013.1072.

Blakesley, H.L. (1977). A contribution to the fisheries and biology of the Queen conch, *Strombus gigas* L., in Belize. Abstract of paper presented at American Fisheries Society, 107th Annual Meeting, Vancouver, B.C. September 15-17, 1977.

Davis. M., Mitchell B.A., & Brown J.L. (1984). Breeding behavior of the queen conch *Strombus gigas* Linné held in a natural enclosed habitat. *Journal of Shellfish Research* 4:17—21

Davis. M. & Stoner. A., (1994). Trophic cues induce metamorphosis of queen conch larvae (*Strombus gigas* Linnaeus). *Journal of Experimental Marine Biology and Ecology* 180:83-102

D'Asaro, C. (1965). Organogenesis, Development, and Metamorphosis in the Queen Conch, *Strombus Gigas*, with Notes on Breeding Habits. Bulletin of Marine Science, *Bulletin of Marine Science*, Volume 15, Number 2, June 1965, pp. 359-416(58)

Egan, B.D. (1985). Aspects of the Reproductive Biology of *Strombus Gigas*. Master's Thesis. University of British Columbia, Vancouver, B.C., Canada

Glazer, R. & Kidney, J. A. (2004). Habitat associations of adult queen conch (*Strombus gigas* L.) in an unfished Florida Keys back reef: applications to essential fish habitat. *Bulletin of Marine Science*. 75: 205-224.

Izioka, A. (2016). Population status and distribution of the Queen conch (Lobatus gigas) in the waters of Anguilla.

Morris, R.A. (2016). Distribution of Queen conch (*Strombus gigas*) on the Pedro Bank, Jamaica: Descriptive and Predictive distribution models.

Owusu, V., Adu-Boahen, K., Kyeremeh, S., Demalie, I., & Eshun, P. (2023). Factors influencing compliance of closed fishing seasons: lessons from small-scale coastal fisheries in the Central Region of Ghana. *Humanit Soc Sci Commun* 10, 20. https://doi.org/10.1057/s41599-023-01513-4

Prada, M., Castro, E., Taylor, E., Puentes, V., Appledorn., & Daves, N. (2009). Non-Detriment Findings for the Queen Conch in Colombia. 51 pp

Randall, J.E. (1964). Contributions to the biology of the queen conch *Strombus gigas*. *Bulletin of Marine Science* 14(2):246-295.

Stoner. A., Sandt. V., & Boidron-Metairon. I.F. (1992). Seasonality of reproductive activity and abundance of veligers in queen conch, *Strombus gigas*. *Fishery Bulletin.* 90. 161-170.

Stoner, A.W., & Ray-Culp, M. (2000). Evidence for Allee effects in an over-harvested marine gastropod: density-dependent mating and egg production. *Marine Ecology Progress Series* 202: 297-302

Stoner, A.W., & Davis, M. (2010). Queen conch stock assessment historical fishing grounds Andros Island, Bahamas. Community Conch report for the Nature Conservancy Northern Caribbean Office Nassau, Bahamas.

Tewfik, A.S., Archibald, S., James, P., & Horsford, I. (2001). Antigua and Barbuda Queen Conch Abundance Survey 1999. *CARICOM Fishery Report No. 7*. 30 pp

Theile, S. (2001): Queen Conch fisheries and their management in the Caribbean. TRAFFIC Europe

Vallès, H., & Oxenford, H. (2012). Queen Conch (*Strombus gigas*) in Barbados: Density, Distribution, and Habitat Correlates. *Bulletin of Marine Science*. 88(4): 947-969.

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