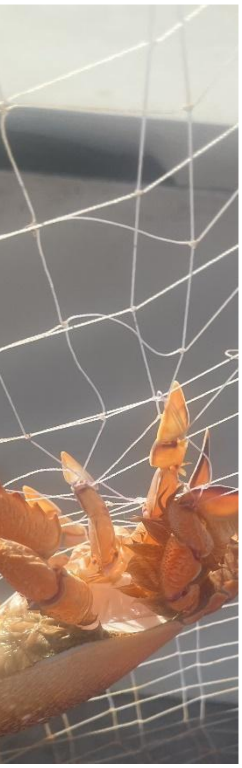
# ASSESSMENT OF SPANNER CRAB (*RANINA RANINA*) – “KRAB ZIRAF” ON MAHÉ PLATEAU (ZONES 2 & 3)



## FINAL REPORT


*Prepared by:*

Mrs Kettyna Gabriel

*Assisted by:*

SFA: Ms Sabrena Lawrence, Mr Rodney Govinden

FishPath: Dr Rich Bell (TNC), Dr Ameer Ebrahim, Dr Natalie Dowling (CSIRO)



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# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

## GLOSSARY AND ACRONYMS

| | |
|---|---|
| BERI | Blue Economy Research Institute |
| Cor-frontale | Anterior accessory circulatory pump that helps maintain blood pressure in large or active crustaceans. |
| CPUE | Catch per Unit of Effort (Number of crabs caught per net lift) |
| EU -SFA | European Union Sustainable Fisheries Agreement |
| Extrusion | Release of larvae into the water column |
| Force majeure | Unscheduled emergency port stop |
| Haemolymph | A fluid similar to blood, found in most invertebrates |
| IKI | International Climate Initiative |
| Oviparous | Females with eggs under the abdomen |
| Random stratified sampling | The process of creating subgroups or stratification based on shared characteristics, e.g., depth |
| SeyCCAT | Seychelles’ Conservation and Climate Adaptation Trust |
| SFA | Seychelles Fishing Authority |
| Tangle nets or “kale” | Circular metal hoop tangle nets used in the fishery |
| WPUE | Weight per Unit of Effort (Weight of crabs caught per net lift) |

## ACKNOWLEDGEMENT

The successful completion of the Spanner Crab Fishery Independent Assessment Survey was made possible by the invaluable contributions of various parties. This work falls under 'Component 3: Enhance fishery assessment, monitoring and management regimes to support fisheries reforms and transparency' of the SeyCCAT Oceans 5 project led by the Seychelles Fishing Authority (SFA). This project benefited from financial support through Seychelles' Conservation and Climate Adaptation Trust (SeyCCAT) through the support of Oceans 5. Oceans 5 is a sponsored project of Rockefeller Philanthropy Advisors. The SFA also contributed to the funding of this project through its recurrent budget and the European Union Sectoral support fund under the EU Sustainable Fisheries Agreement (EU -SFA). The funding significantly aided in achieving the project's objectives and improved our understanding of the spanner crab fishery. We are thankful for the capacity-building gained under the International Climate Initiative (IKI). Their guidance and expertise were indispensable, from implementation to statistical analysis and reporting. We would like to extend our heartfelt appreciation to all the spanner crab fishers who generously spared their valuable time participating in the spanner crab questionnaire. The SFA Fisheries Research staff also deserve credit for their invaluable assistance and support throughout this assessment. Their unwavering dedication and commitment played a critical role in the project's success. We would like to acknowledge the crew and scientific team of R/V L'Amitie for their assistance during the field sampling process. Their contributions were instrumental in advancing our research and analysis. We thank the Blue Economy Research Institute (BERI) at the University of Seychelles for providing a drop camera to conduct the habitat component of the fishery-independent survey. Their cooperation has been essential in facilitating the successful completion of the research. A well-deserved appreciation is extended to the fishermen who constructed the fishing gear used in the fishery-independent survey. Lastly, we extend our gratitude to everyone who contributed to this project in any capacity.

## ABSTRACT

The aim of this study was to investigate the abundance and spatial distribution of spanner crab (*Ranina ranina*) within the Mahé Plateau, Seychelles. The survey legs were strategically located to capture variations in crab populations across different areas. A total of 6 surveys were undertaken from December 2022 to June 2023. Survey leg 4, situated in the Eastern part of the Mahé Plateau near Owen Bank, emerged as the most productive area on the Plateau, exhibiting the highest Catch Per Unit Effort (CPUE) and Weight Per Unit Effort (WPUE), recording both a higher number and relatively heavier crabs caught per net lift. Female and male spanner crabs in survey leg 4 showed the highest CPUE and WPUE values. Survey leg 3, located in the Southeast of the Mahé Plateau near Topaz Bank, exhibited the second-highest catch of crabs compared to legs 4, 2 and 5. No significant difference was observed in the carapace length of oviparous females between the recent and 1995 surveys, suggesting a relative stability in the size distribution of oviparous females over time. Analysis of sexual dimorphism revealed that male spanner crabs sampled were significantly larger and heavier than females. All three groups (all crabs combined, female and male) exhibited a negative allometric growth, indicating that spanner crabs are lighter in weight relative to carapace length. The observed sex ratio was close to 1:1, suggesting a more balanced distribution between male and female spanner crabs. The study noted a significant reduction in the size of spanner crabs caught during the 2022/23 survey compared to those caught in 1995, with crabs caught in the 1995 survey being larger and heavier. Given the uncertainties surrounding spanner crab biology, ecology, behaviour, and reproductive dynamics, as well as the potential impacts of environmental factors and human activities such as fishing, additional research is necessary to better understand the dynamics driving distribution patterns in spanner crab populations on the Mahé Plateau. This would contribute to more informed management strategies for a sustainable spanner crab fishery in Seychelles.

# 1. BACKGROUND

## 1.1. LIFE HISTORY

*Ranina ranina* (Linnaeus, 1758), commonly known as the "spanner crab" (Australia), "krab ziraf" (Seychelles), "curacha" (Philippines), or "kona crab" (Hawaii), is a species of large marine crustacean from the family Raninidae (Matondo and Demayo, 2015), characterised by its frog-like appearance, reddish-orange colour, vertical eyestalks and elongated carapace with 10 – 12 white spots on the anterior part of the carapace (Thomas et al., 2015; Tito and Alanano, 2008). The carapace is hard, flat, anteriorly broad, and ovate in shape (Thomas et al., 2015; Mohan et al., n.d.) and covered with low rounded spines (tubercles), which tend to grow longer and sharper as they mature (Matondo and Demayo, 2015). The orbitofrontal and lateral-anterior margin of the carapace has 21 rostrums resembling small horns. Rostrums are an extension of the carapace and vary between male and female spanner crabs (Matondo and Demayo, 2015).

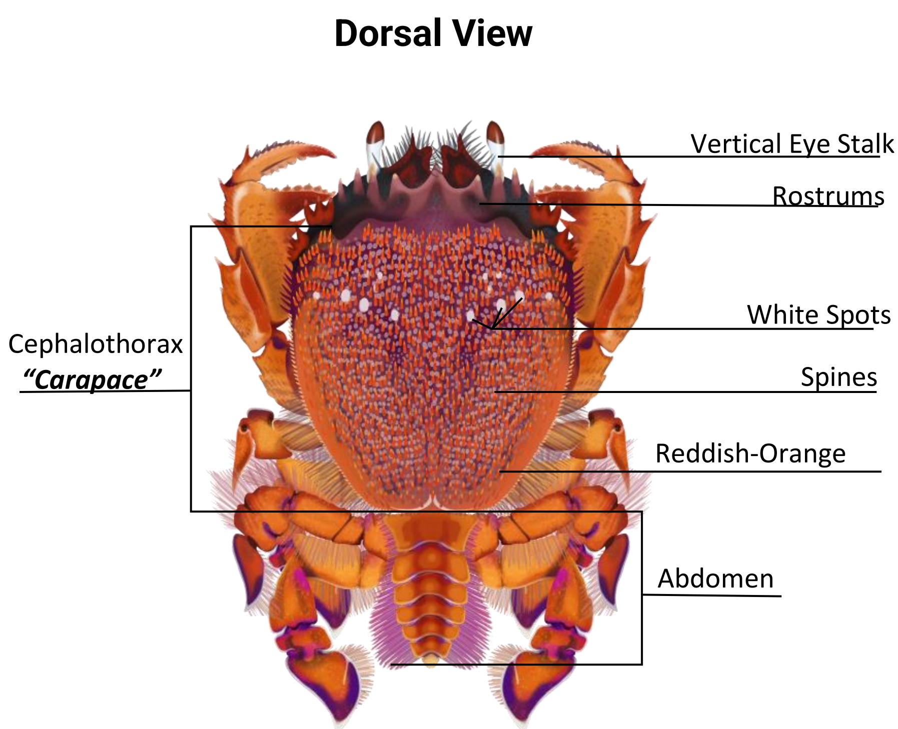



*Figure 1: Spanner Crab morphological features.* ***Source:*** *Marine Wise website.*

Spanner crabs inhabit offshore sandy-muddy areas ranging from depths 10 metres (m) to over 100m. They spend 95% of their time buried, only emerging to feed and mate (Kirkwood et al., 2005; Baylon and Tito, 2012; Matondo and Demayo, 2015). Since spanner crabs stay buried beneath the sandy substrate, they are more susceptible to predators with the ability to detect electrical pulses underneath the sand (sharks or rays) (Brown et al., 1999; Kasinathan et al., 2007). As such, spanner crabs have adopted an anti-predatory response by stopping their heart for 20 minutes, allowing them to remain undetectable (Brown et al., 1999). During this time, they use a pulsating structure known as cor-frontale to circulate haemolymph (fluid similar to blood) to their brain, eyestalks, and antennae (Brown et al., 1999). This behaviour also acts as an energy conservation strategy in which energy can be invested in other mechanical expenses such as reproduction, brooding of eggs, or moulting (Brown et al., 1999; Griffen, 2018).

Sexual maturity in spanner crabs varies by region and sex. Studies from Basilan Province, Philippines, have suggested that female spanner crabs require about two years to mature, reaching an active breeding size of 8-9 centimetres (cm) in carapace length (Tito and Alanano, 2008), though these estimates may not be applicable to spanner crab in Seychelles. In contrast, males are considered mature when sperm is apparent in the "vas deferentia" or "sperm ducts", usually when their carapace length exceeds 6 cm (Fielding and Hayley, 1976). Before a female's first mating season, it undergoes a 'puberty moult' (Minagawa, 1993). Moulting then becomes a continuous event that occurs seasonally before spawning. Following moulting, the male spanner crab mates with the female, and the female stores the sperm for later use (Fielding and Hayley, 1976). Sperm from a single mate can fertilise eggs for one season or a lifetime (Christy, 1987). Female spanner crabs externally brood their eggs for 4 to 5 weeks. Upon hatching, the larvae undergo a planktonic phase before settling as benthic juveniles after a few months and eventually maturing into adults (Kasinthan et al., 2007; Thomas et al., 2015).

*Ranina ranina* is widely distributed throughout the tropical and subtropical Indo-Pacific regions of Seychelles, Mauritius, Reunion, China, Southern Japan, Western Thailand, the Philippines, and Australia (Tyndale-Biscoe, 1962; Brown et al., 2001; Dichmont and Brown, 2010; Matondo and Demayo, 2015). Within the Raninidae family, the spanner crab is the only species with significant commercial value, primarily because of its size compared to other Raninidae species (Brown et al., 2001). Various fishing gears, ranging from trawl nets, bottom gill nets, and baited tangle nets, can be used to catch spanner crabs, with the latter technique being the most effective (Tito and Alanano, 2008). The spanner crab fishery is reportedly operational, and the species is actively exploited in Thailand, Japan, Seychelles, Hawaii, and Australia. The two latter countries are known for their deep-rooted exploitation since the 1950s and 1970s, respectively. Queensland's spanner crab fishery in Australia is the largest commercial crab fishery to date (De Moussac and De San, 1987; Dichmont and Brown, 2010).

## 1.2. OVERVIEW OF SPANNER CRAB FISHERIES IN SEYCHELLES

In Seychelles, spanner crab fishery is presumed to be a single stock; nevertheless, the absence of genetic data for analysing the population's structure complicates definitive conclusions. The fishery remained untapped until a preliminary fishing expedition was undertaken from 1973 to 1976 (Boullé, 1995). The expedition was designed to test different fishing gears ranging from trammel nets to bottom gillnets off the Western coast of Mahé (Boullé, 1995), as opposed to targeting spanner crab per se. As a result, a total of 44 kilograms (kg) of spanner crabs were caught as bycatch, indicating the presence of this species within the Seychelles waters (Boullé, 1995).

Almost a decade later, the Seychelles Fishing Authority [SFA] initiated a comprehensive research program between 1986 and 1987 to investigate the spanner crab fishery resources and potential fishing locations on the Mahé and Amirantes plateaus (De Moussac and De San, 1987). Since this was a new fishery with no existing scientific or fishery data, a fishing technique from the Mauritian fishery was adopted (Boullé, 1995). This consisted of a series of metal hoops, tangle nets and baits, and this fishing gear was deployed on the benthic substratum at depths of 30 to 70 m using trip lines attached to the main fishing line for easy retrieval (Boullé, 1995). Boullé (1995) recognised that the habitat preference of the local spanner crab was flat sandy substrate associated with coral and/or seagrass beds. Owing to the promising survey results (total catch of approximately 2.2 tons (t)), commercial exploitation started in early 1987 with two fishing vessels (De Moussac and De San, 1987). De Moussac (1988) reported that 18 t of spanner crabs were landed between December 1986 and March 1988. The market for spanner crab was mainly concentrated locally, with few reports of international exportation, specifically to Reunion Island (De Moussac and De San, 1987; De Moussac,1988).

Between 1990 and 1992, an extensive fishery-independent survey on the Mahé Plateau was carried out to determine the abundance and distribution of spanner crab (Boullé,1995). The estimated biomass was between 2460.40 t and 4486.82 t, with a Maximum Sustainable Yield (MSY) of 381.36 t to 919.80 t (Boullé,1995). The assessment also mapped the spanner crab distribution: 17,332 $km^2$ of the Mahé Plateau was reported as potentially exploitable (Boullé,1995).

The species has not been further studied or surveyed, but the fishery has been active on various levels, fluctuating in intensity, scale, and frequency over time. In 2021, the SFA initiated the incorporation of the spanner crab as part of its research work plan and collecting data on the fishery. A questionnaire was designed to gather data on the operational characteristics of the spanner crab fishery and to seek fisher's opinion regarding the stock status. The survey revealed a marked shift in fishing practices with respect to fleet size, fishing gear, and fishing duration (Antha, 2022, unpublished). Fishers reported a decline in the size and catch of spanner crabs over time, raising concerns about the sustainability of the fishery, particularly as crabs aggregate in specific, known locations. While environmental factors may play a role in the apparent decline of the stock, the possibility of fishing pressure cannot be overlooked.

The spanner crab fishery is currently faced with a lack of coherent data, as the majority of the information concerning this fishery is derived from surveys conducted between 1986 and 1995 by De Moussac and De San (1987), De Moussac (1988), and Boullé (1995).

In 2021, a monitoring programme for the fishery was initiated by SFA to collect fishery-dependent data throughout the fishing season. These include landing details such as the number and type of gear used, fishing locations, size, weight, sex composition of crabs caught and the total catch from commercial fishers.

To better understand the current status of the spanner crabs, the SFA carried out a fishery-independent survey from December 2022 to June 2023, the findings from which are reported here. The objectives of this survey were 1) to assess spanner crab abundance and distribution on the Mahé Plateau; 2) to collect ecological parameters on spanner crab habitat; and 3) collect biological This survey will help provide evidence-based recommendations for management. As a first step toward sustainability, a licensing framework was introduced in 2023.

# 2. MATERIALS AND METHODS

## 2.1. SURVEY AREA

The survey focused mainly on the Mahé Plateau, an underwater plateau located in the Seychelles archipelago, covering an area of 40,000 square kilometres ($km^2$) around the inner Seychelles islands (**Figure 2**). The Mahé Plateau is steep-sided, rising from around 1000 m and is characterised by its rich and complex topography. It is surrounded by an incomplete shallow rim of 10-20 m, which surrounds an area of about 50-65 m with subsurface granite and coral outcrops forming small banks (SFA, 2019). Two coral islands located on the north of the rim and the plateau are classified as granitic islands (Mees, 1992).

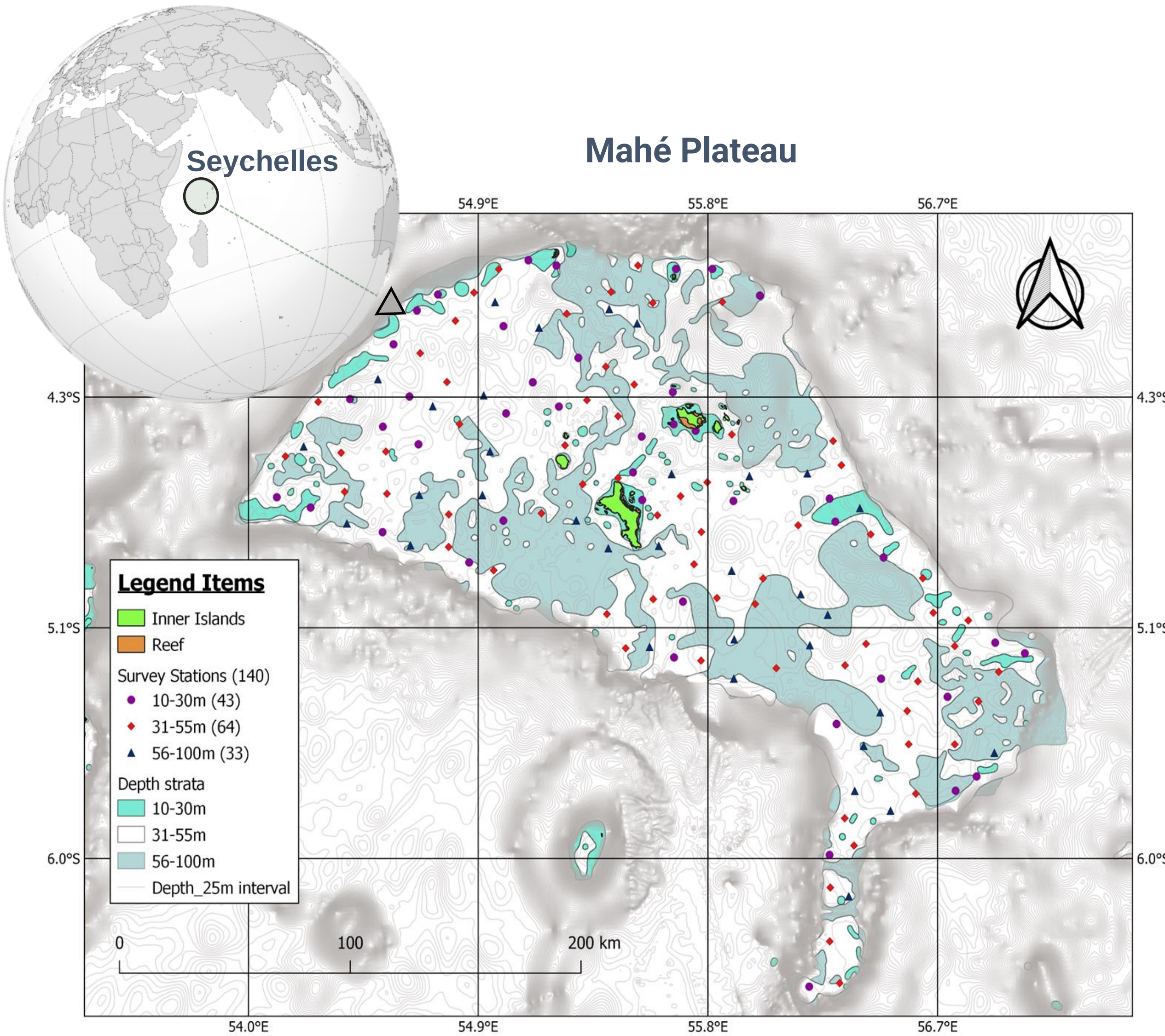



***Figure 2:*** *Map of sampling stations on the Mahé Plateau (Seychelles, Western Indian Ocean) according to the different depth classifications. The number of stations per depth is indicated in the legend.*

**Table 1:** Sampling stations by depth strata.

| Strata code | Strata Classification | Main stations | Additional stations | Total |
|---|---|---|---|---|
| ○ | 10 – 30 m | 39 | 4 | 43 |
| ◆ | 31 – 55 m | 59 | 5 | 64 |
| ▲ | 56 – 100 m | 28 | 5 | 33 |
| | | **126** | **14** | **140** |

## 2.2. SURVEY SITE SELECTION

Before conducting the survey, a series of consultations with fishermen was held to gather details on the type of gear used, gear specifications, and depth ranges, all of which were incorporated in the survey design and site selection.

The survey sites were selected using a grid-based approach. This method provided equal representation of sampling stations across the plateau and allowed for homogenous distribution by depth and area for maximum coverage. Using Geographic Information System Software (QGIS) version 3.26.3, a survey grid of dimension 20 x 20 kilometres (km) or approximately (~) 11 nautical miles (nm) was overlaid onto the plateau. The survey grid was converted into points using the option available in QGIS. Subsequently, the survey points, referred to herein as survey stations, were slightly adjusted from the initial position according to the following criteria:

- Firstly, survey stations were relocated if they were situated in areas where the isobath exceeded 100 m or the contour line was steeper. This was because, according to Baylon and Tito (2012) and Kirkwood et al. (2005), spanner crabs are found inhabiting depths ranging from 10 m to over 100 m.
- Secondly, the survey stations were moved closer together while keeping the distance between them within 11 nm to reduce travel time between stations. This was necessary due to the limited number of days available for the survey.
- Thirdly, more points were selected in flatter areas, as spanner crabs predominantly inhabit flat sandy mud areas (Skinner and Hill, 1986).

Survey sites were selected using random stratified sampling, where the Mahé Plateau was stratified by 3 depth categories of 10–30 m, 31-55 m, and 56–100 m (**Figure 2**). The allocation of depth strata was mainly based on the reported habitat depth of the spanner crab in the literature, which ranges from 10 m to over 100 m (Baylon and Tito, 2012; Kirkwood et al., 2005). Additional adjustments were made to reduce variance in data by assigning more survey stations to the depth range predominantly targeted in the fishery, which is 31-55m. There was a particular focus on the depth range of 30-100 m based on the questionnaire outcomes and analysis of the VMS (Vessel Monitoring System) position of active spanner crab vessels under the biological sampling programme. A total of 140 survey stations (126 main and 14 additional) were identified (**Table 1**). A minimum of 2 stations were surveyed each day based on available research personnel, time and weather conditions. The survey was divided into 7 survey legs and undertaken from December 2022 to June 2023, coinciding with the Northwest and Southeast Monsoon.

## 2.3. FISHING OPERATION

### 2.3.1. FISHING GEAR

Since the fishery's inception, fishers have used tangle nets or 'kale', which are baited circular traps with a diameter of ~1 m. These tangle nets are deployed by local fishers using a mainline, with multiple baited traps attached to it by a trip line. The tangle nets are then kept on the seafloor by two sets of sinkers, one attached at the beginning and the other at the rear of the mainline. This method of fishing is well known and has been widely adopted by local spanner crab fishers due to its effectiveness in capturing spanner crabs.

***Figure 3:*** *Squared tangle nets used during the survey.*

For this survey, the shape of the fishing gear was slightly modified (squared instead of circular) and adapted according to the resources available on the local market. The tangle nets were constructed using an 8 mm rebar square frame measuring 1 x 1 m in diameter (**Figure 3**). The squared frames were then covered with a double layer of 2.5-inch net (multifilament nylon). The tangle nets were evenly spaced at 5m intervals and strung on a ~300 m mainline by a 2 m long trip line rope. A 20-millimetre (mm) stainless-steel snap was used to connect the trip line to the mainline through a loop knot, keeping the tangle nets firm (**Figure 4**). Two sets of sinkers were attached at the beginning and the rearmost of the mainline. The tangle nets were then organised as a set, with each set comprising 30 tangle nets, with designated surface buoys to identify location.

### 2.3.2. FISHING GEAR DEPLOYMENT

On each survey station, two sets of 30 tangle nets (60 tangle nets) were deployed by hand against the current at a minimum distance of 500 m apart. Before deployment, each tangle net was baited with 250 to 500 grams (g) of bonito, securely fastened on the central line in the centre of the tangle nets.

Gear was deployed by releasing the first sinker, which facilitated the gradual unfolding of the mainline. As this occurred, the tangle nets were attached sequentially on the unfolding mainline. Once all 30 tangle nets were deployed, the second sinker was then released. To ensure proper submergence of the tangle nets, 25% of extra rope was included in addition to the 300 m mainline. This extra rope was to compensate for variables such as current drag and varying depths, ensuring effective submergence of the gears. The gears were allowed to soak for a maximum of 60 minutes. To ensure equal soaking time for both sets, a ~ 10 to 20 minute interval was left between successive sets. During hauling, the tangle nets were individually inspected for any spanner crab and by-catch. The spanner crabs were carefully untangled and transferred to a sampling container, and any by-catch was released. The tangle nets were then subsequently stacked at the vessel's aft, ready for the next set deployment, where the same procedure was repeated.

Detailed information on each fishing deployment was collected, including the exact fishing latitude and longitude, depth, time of setting and hauling gear, direction and strength of the current, the sea state (calm, rough, etc.), and the temperature of the sea surface.

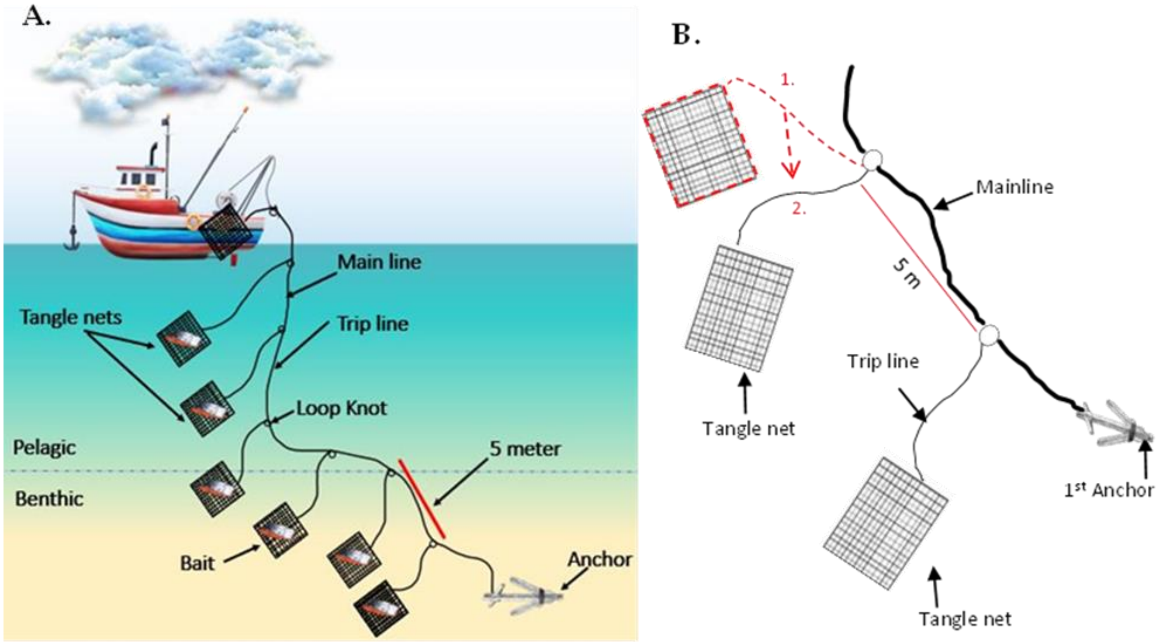



***Figure 4:*** *Schematic demonstrating the manner of deployment of the sets. A) Deployment of baited tangle nets. Dash horizontal blue line representing separation between substratum (sandish colour) and water column (bluish colour). B) The dashed red line illustrates the attachment of the tangle nets to the mainline upon deployment. The solid red line shows the distance between each tangle net.* ***N.B.*** *Squared frame tangle nets were used instead of circular tangle nets. Schematic adopted and modified from Boullé (1995).*

## 2.4. HABITAT SURVEY

To survey the habitat, random sampling of the benthic substrate along the mainline was conducted subsequent to the deployment of the gear. Depending on the depth of the location, either a drop-down camera (Model 6000HD Seaviewer) was used to capture high-resolution images and video footage of the seabed, or an Ekman sediment grabber (152 x 152 x 152mm, 3.5 L capacity) was submerged to collect bottom sediment samples. The drop-down camera was used for stations shallower than 45 m and was deployed for about 15 minutes to video the area. It was positioned approximately 1.5 m off the bottom to attain the largest viewing angle whilst the vessel drifted alongside the deployed gear on the seafloor. An Ekman sediment grabber was used for sites deeper than 46m, and three random substrate samples were taken along the mainline of each fishing set. Habitat sampling was conducted near the fishing area where the tangle nets were deployed.

In total, there were 12 habitat type classifications: sand, sandy mud, mud, coral, coral rubble, boulders, consolidated rubble, hard substrate, turf algae, fleshy algae, seagrass and seaweed. For the drop-down camera, the percentage of the substrate type observed was recorded, while only the substrate type was recorded for the sediment grabber. The same information for each set was also recorded for the habitat sampling: latitude and longitude, date, station number, set number, depth, direction and strength of the current, the state of the sea, and the temperature of the sea surface.

## 2.5. BIOLOGICAL SAMPLING

Spanner crabs (henceforth referred to as crabs) caught were meticulously removed from the gear and sorted into individual sampling containers. The weight of the total number of crabs for each set was recorded. Morphological attributes, including individual body weight (g), carapace length (mm) and sex (M/F), were measured and recorded for all spanner crabs caught. Reproductive markers like the oviparous (berried state), egg colour, sperm plaque, and setae hair were also recorded. The sex was also distinguished based on the shape of the abdomen. Male crabs were identified by their narrow-shaped abdomen (**Figure 5A**), while female crabs have a broader and rounded abdomen (**Figure 5B**). For each oviparous female caught, the colouration of the egg mass (i.e., post extrusion stage) was recorded using an egg colour spectrum from orange in newly fertilised individuals to brownish colour before hatching. The carapace length (mm) was measured from the rostrum tip to the posterior carapace margin with a vernier caliper (Model: 150 Vernier Caliper Locking Screw, Range mm – 200, Jaw mm – 40, precision ±0.05 mm) (**Figure 5C**). The body weight (g) was obtained using a high-precision digital scale (Model: Jadever - JWP, accuracy ±0.01 g). After sampling, all the berried females were released, and the remaining crabs were retained and stored.


***Figure 5:*** *Spanner crab (R. ranina) male and female. A) The dorsal view of a male spanner crab. B) The dorsal view of a female spanner crab. C) Dorsal and vertical views of the carapace length measurement location are depicted by the red lines.*

## 2.6. DATA ANALYSIS

The R software (version 4.2.2) and Microsoft Office Excel software (Windows 10) were used for the statistical analysis and production of graphs. A significance threshold of $p < 0.05$ with 95% confidence interval was applied.

### 2.6.1. STANDARDISING THE DATA

#### 2.6.1.1. CATCH AND WEIGHT PER UNIT EFFORT (CPUE) & (WPUE).

At each station, two sets of identical fishing gear were used, each consisting of one string of 22-30[1] tangle nets. To ensure consistency in data analysis, the abundance and weight measurements obtained from both sets were combined to derive a single value per station. Each station's catch per unit effort (CPUE in terms of numbers per net and weight per net lift) was calculated as a proxy abundance indicator. This enabled comparison between stations and an overall aggregate of abundance. Sex-specific CPUEs were also

[1] The CPUE was calculated based on the number of nets that were set and lifted. The data revealed that there were fluctuations in the number of nets set and lifted during the process, with the lowest number being 22 and the highest being 30. This was taken into consideration to account for any traps that were lost during the process.

calculated. CPUE was calculated by summing the number of crabs caught across both sets at each station and dividing them by the total number of lifted tangle nets (net lift) from both sets[(1)]. The same steps were used to obtain body weight per unit effort (WPUE)[(2)]:

$$1)\quad CPUE_{sta} = \frac{\sum Number\ of\ Crabs_{sta}}{\sum Number\ of\ netlifts_{sta}} \qquad 2)\ WPUE_{sta} = \frac{\sum Body\ Weight\ of\ Crabs_{sta}}{\sum Number\ of\ netlifts_{sta}}$$

The Kruskal-Wallis test (non-parametric) was employed to assess differences in CPUE and WPUE between females and males across survey legs, with the post hoc Dunn test conducted upon significance, revealing specific sex-based disparities in catch rates.

#### 2.6.1.2. MEAN PROXY ABUNDANCE AND WEIGHT PER SURVEY LEG.

The mean proxy abundance and weight in each leg were calculated by summing the CPUE and WPUE across stations in each leg and dividing by the total number of stations in each leg. This provides the relative abundance and weight of crabs per station in each leg. The mean standardised abundance per leg and mean standardised weight per leg were calculated [(3)]:

$$3)\sum_{i\,=\,1}^{nj} = \ CPUEi\ X\ WPUEi$$

Where $nj$ is the number of stations in leg $j$; $CPUEi$ represents the Catch per unit effort at station $i$; $WPUEi$ represents the Weight per unit effort at station $i$.

### 2.6.2. LENGTH WEIGHT RELATIONSHIP

The length-weight relationship (LWR) is an important parameter in providing a general understanding of individual growth (Ndiaye et al., 2015). The length-weight relationship is typically exponential: $W = aL^b$. This equation can be linearised for easier computation by taking the natural log of both sides ln(W) = ln(a) + b*ln(L)[(4)]:

$$4)\ \ln(\text{weight (g)}) = \beta_0 + \beta_1 \ln(\text{carapace length (cm)})$$

where, ln (weight (g)): log-transformed weight of the crabs; ln (carapace length (cm)): ln-transformed carapace length of crabs (rostrum tip - posterior carapace margin); $\beta_0$:= ln(a) = intercept; $\beta_1$=b: slope.

A linear regression analysis was conducted to fit the relationship between carapace length and body weight. The degree of correlation between the data and the modelled values was quantified using the R-squared (r^2) value. The F-test was assessed to evaluate, using the non-parametric Kruskal-Wallis test, the statistical significance of the variance explained by the regression model. Growth patterns were determined by the value of 'b' the slope. If 'b' = 3 the growth is isometric (shape stays consistent as individuals grow). If 'b' $<$ or $>$ 3 the growth is allometric (Moslen and Miebaka, 2018). The allometric growth can be positive ($>$ 3; larger body with increasing length) or negative $<$ 3 (slimmer body with increasing length) (Moslen and Miebaka, 2018). A two-tailed t-test with 5% significance level was used to determine the significance of the coefficients for carapace length in relation to allometric growth analysis.

### 2.6.3. SIZE FREQUENCY DISTRIBUTION

Length frequency histograms were used to summarise the distribution of carapace lengths for all individual crabs combined and sexes. Crabs were categorised into carapace length size classes, ranging from 4 to 16 cm with 1 cm bin size. Visual comparison was made between the sizes of crabs surveyed in 1995 and 2022/23 to assess potential differences in crab size. The differences between sexes across survey leg and between 1995 and 2022/23 surveys were examined using the Kruskal-Wallis test, followed by post hoc Dunn Test analysis upon significance. Kruskal-Wallis test was used as the data did not meet the normality assumptions for a parametric test. The proportion of crabs below the proposed minimum size limit of 8 cm carapace length was also calculated.

### 2.6.4. OVIPAROUS FEMALES

Carapace length size distribution of oviparous females was displayed using a histogram. Carapace lengths ranged from 8 to 11 cm with a 0.5 cm bin size. The extent of difference in size of oviparous females between the 1995 and 2022/23 surveys was evaluated using the ANOVA parametric test, as data met the normality distribution assumption.

### 2.6.5. WEIGHT DISTRIBUTION

Differences in weight distribution between sexes per survey leg and between the 1995 and 2022/23 surveys were assessed using the Kruskal-Wallis test. This test was used as the data failed to meet normality assumptions. The post hoc Dunn Test was used to determine where any significant differences occurred.

### 2.6.6. SEX RATIO

The sex ratio was calculated overall and across survey legs to provide insights into the species' reproductive potential under study[5]:

$$5)\ \text{Sex Ratio} = \frac{Nm}{Nf}$$

Where N$m$ is the number of males and N$f$ is the number of females.

### 2.6.7. HABITAT AND DEPTH COMPARISONS

We investigated whether crabs are more associated (either by numbers or weight) with specific habitat types or depths using the Kruskal-Wallis test. This test was used as the data failed to meet the normality assumptions of a parametric test. When considering the effect of habitat type on crab abundance, stations without habitat samples and with crab catch were excluded. In contrast, stations with habitat samples but no crab catch were included in the analysis. When considering the effect of depth, 3 depth range categories were considered: 10-30m, 31-55m, and 56-100m.

# 3. RESULTS

Due to logistical challenges, a total of 115 out of 140 stations were surveyed over 6 survey legs from December 2022 to June 2023. The initial plan had aimed for 7 survey legs from October 2022 to April 2023. As a result of delays, the survey was extended into the Southeast trade wind season which presented difficulties due to rough seas. Other unforeseen circumstances, such as force majeure (unscheduled emergency stops at port) and persistent strong currents, further complicate the effort to achieve the targeted stations. Ultimately, 82% of the intended stations were surveyed along the Mahé Plateau, with 23 of the 115 stations recording catch (**Table 2**). A total of 492 crabs, of 132kg total weight, were caught, comprising 249 females and 243 males. The highest catch (245 crabs) was recorded on survey leg 4, followed by survey leg 3 (138 crabs). Ninety-seven (97) crabs were caught on survey leg 2 and 12 on survey leg 5, and no crabs were caught on survey legs 1 and 6 (**Table 2**). Survey leg 7 was not undertaken due to the rough sea. Full details of the catch per station by survey leg are provided in **Appendix 2**.

**Table 2:** Summary of sampling effort and catch from December 2022 to June 2023.

| Survey legs | Station counts | Sampled stations | Replicates | +Net number set | +Net number lifts | № of stations with crabs | Female | Male | Total count | Total weight | % Catch in numbers | % weight |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20 | 15 | 2 | 885 | 885 | 0♦ | 0 | 0 | 0 | 0 | - | - |
| 2 | 20 | 20 | 2 | 1189 | 1184 | 10 | 32 | 65 | 97 | 36 | 8 | 3 |
| 3 | 20 | 20 | 2 | 1169 | 1168 | 8 | 71 | 67 | 138 | 33 | 12 | 2.7 |
| 4 | 20 | 20 | 2 | 1197 | 1193 | 3 | 142 | 103 | 245 | 59 | 21 | 4.9 |
| 5 | 20 | 20 | 2 | 1195 | 1191 | 2 | 4 | 8 | 12 | 4 | 1 | 0.3 |
| 6 | 20 | 20 | 2 | 1200 | 1200 | 0 | 0 | 0 | 0 | 0 | - | - |
| **Total** | **120** | **115** | **12** | **6835** | **6821** | **23** | **249** | **243** | **492** | | | |

**Note:** *Due to some delays, the survey expanded into the southeast monsoon, and the sea state was not favourable for undertaking survey leg 7. ♦ No catch. + The difference in the number of net sets and net lifts can be explained by lost nets and stations that were not surveyed. A complete set of nets comprises 1200 (60 tangle nets x 20 stations).

## 3.1. TOTAL CATCH AND WEIGHT PER UNIT EFFORT

The CPUE (number per net lift) and WPUE (weight per net lift) varied across the 6 survey legs, ranging from 0 to 8.2 crabs per net lift and 0 to 1.98 kg per net lift (**Figure 6**). The trends in CPUE and WPUE differ between survey legs, with survey leg 4 having the highest CPUE and WPUE, averaging 8.2 crabs and 1.9 kg per net lift, respectively. Survey leg 3 follows with the second-highest CPUE and third-highest WPUE, averaging 4 crabs and 1.09 kg per net lift. Survey leg 2 reported the third-lowest CPUE of 3.4 crabs and the highest WPUE of 1.23 kg per net lift. Despite yielding fewer, crabs on survey leg 2 was heavier than crabs on survey leg 3 (**Figure 6**). Conversely, survey leg 3 had more crabs on average per net lift but weighed less than crabs on survey leg 2 (**Figure 6**). The lowest CPUE and WPUE was observed in survey leg 5, with an average of 0.4 crabs and 0.13 kg per net lift. **Figures 7** and **8** visually represent the CPUE and WPUE per station and survey legs.

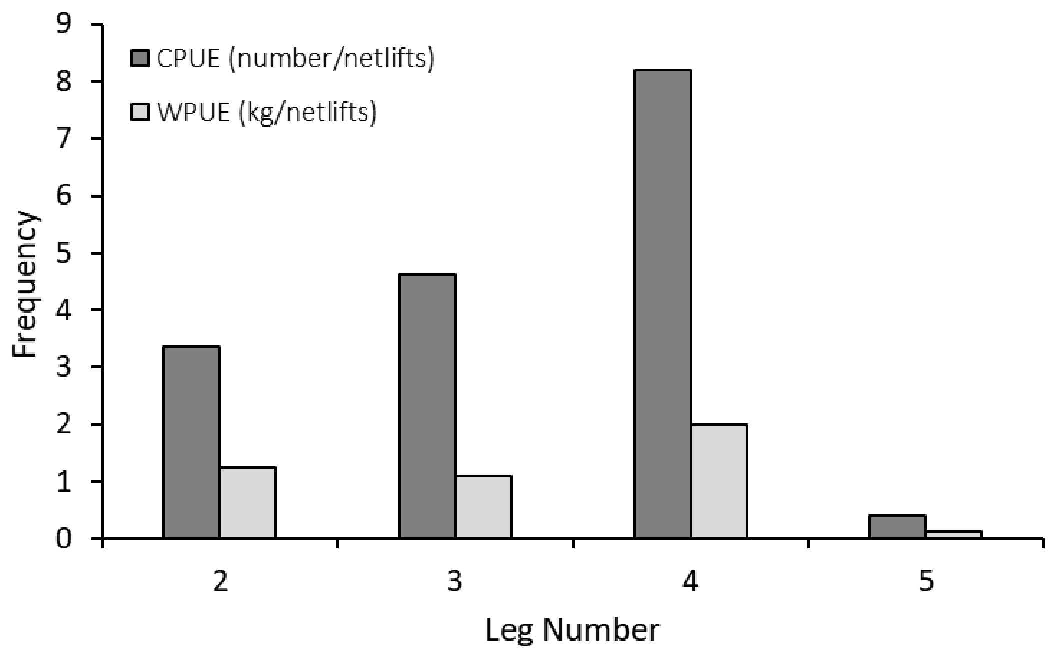



***Figure 6:*** *Total CPUE (number/net lift) and total WPUE (kg/net lift) over the 6 survey legs.* ***NB:*** *No crabs were caught on survey legs 1 and 6.*

### 3.1.1. CPUE PER SAMPLING STATION

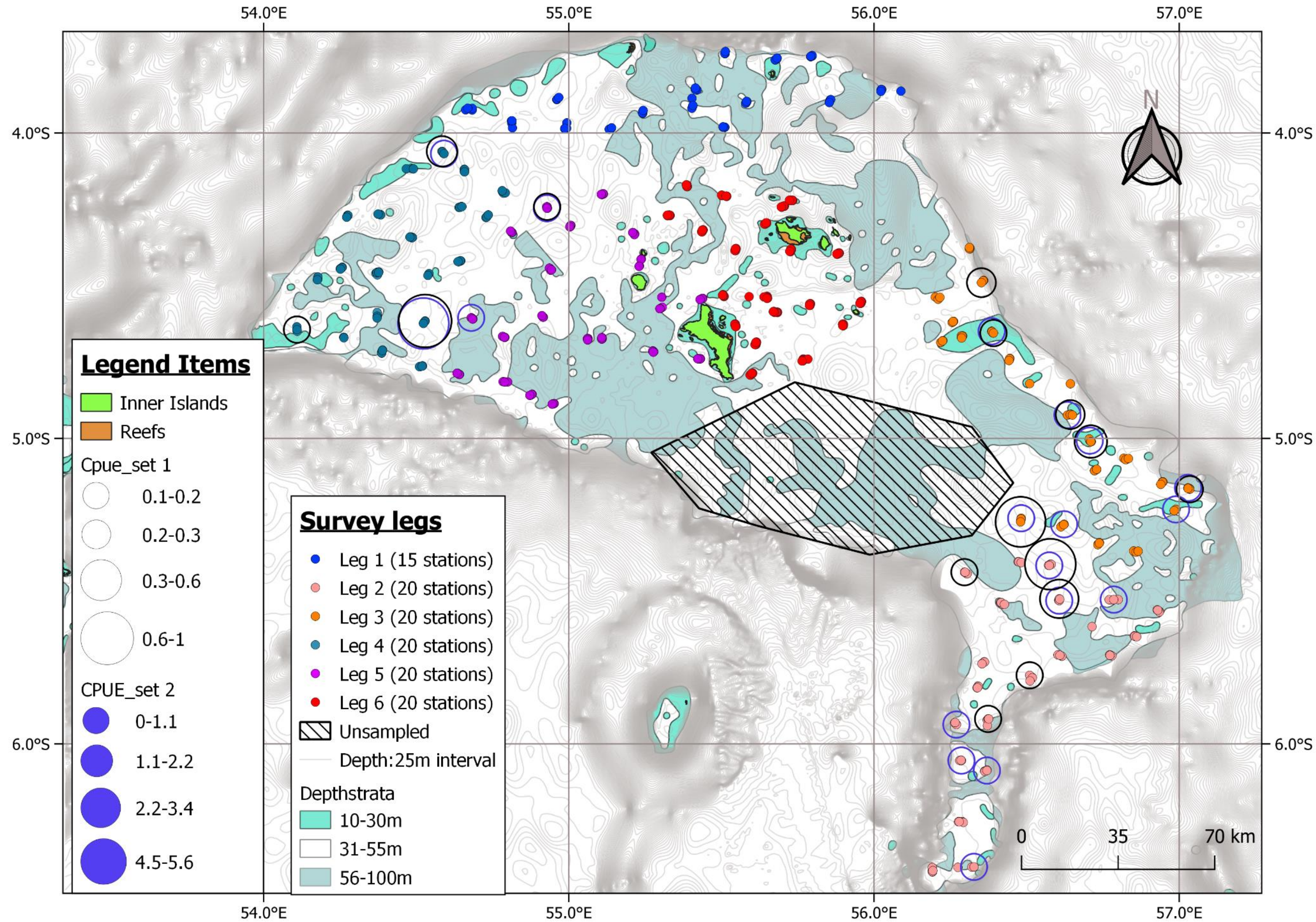



***Figure 7:*** *Map of CPUE (number of crabs/net lift) per survey station during the 2022/23 survey on the Mahé Plateau. CPUE for sets 1 (Black circle) and 2 (Blue circle) for each station surveyed. The size of the black circle indicates the intensity of CPUE on specific stations; larger circles indicate higher CPUE, while smaller circles indicate lower CPUE.*

## 3.1.2. WPUE PER SAMPLING STATION.

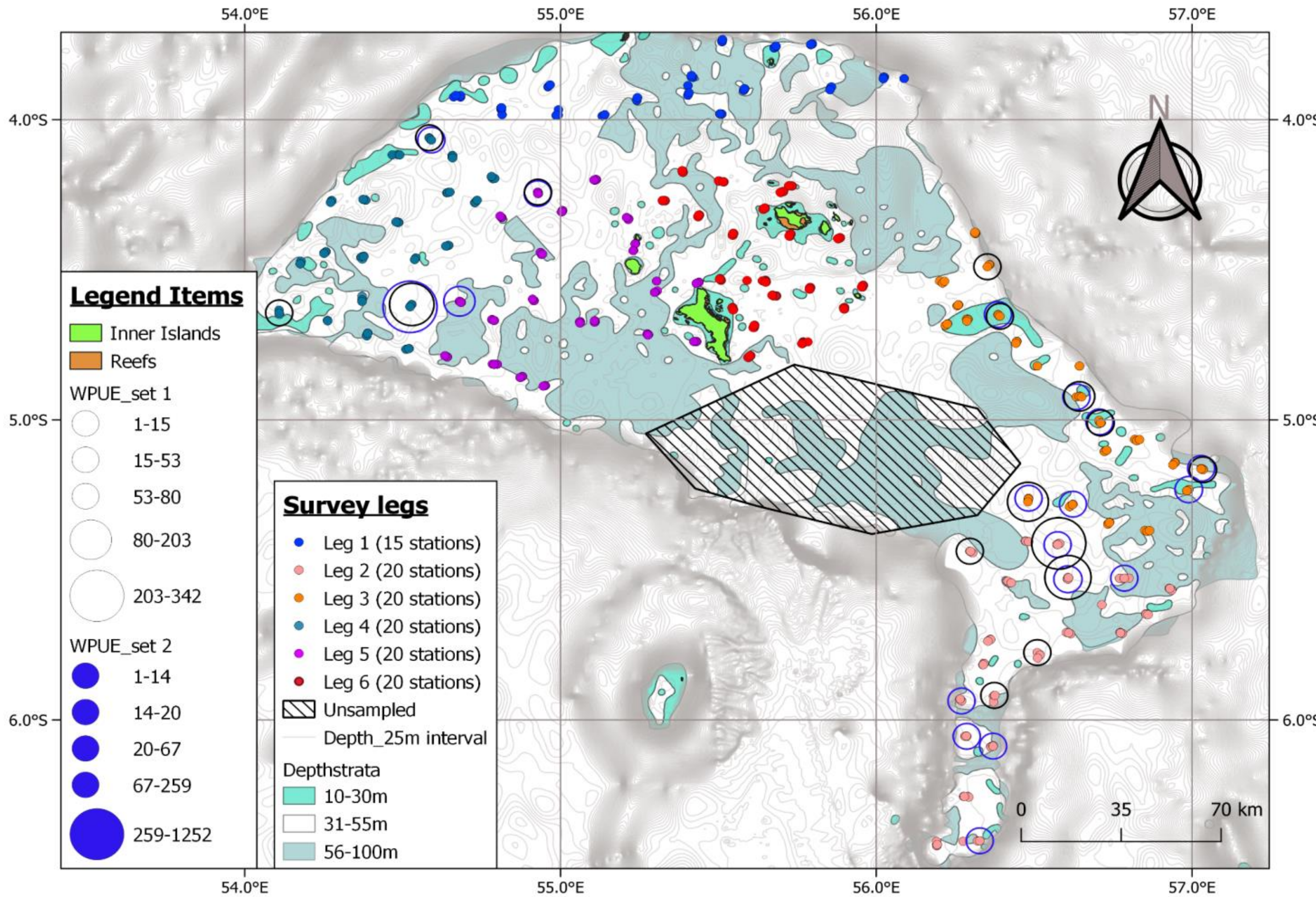
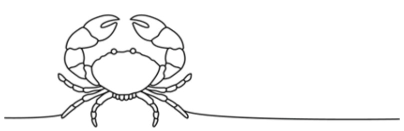



***Figure 8:*** *Map of WPUE (weight of crabs /net lift) per survey station during the 2022/23 survey on the Mahé Plateau. WPUE for sets 1 (Black circle) and 2 (Blue circle) for each station surveyed. The size of the black circle indicates the intensity of WPUE on specific stations; larger circles indicate higher WPUE, while smaller circles indicate lower WPUE.*



## 3.2. SEXES BY SURVEY LEG

Sex-specific CPUE and WPUE were highest for survey leg 4 (**Table 3**). Conversely, survey leg 5 reported the lowest CPUE and WPUE. The CPUE varies for each sexes, with females dominating survey legs 3 and 4, while males dominate legs 2 and 5. The male's WPUE dominated females throughout the survey.

### 3.2.1. FEMALE SPANNER CRABS

The female's CPUE for survey leg 2 was lower than that for survey legs 3 and 4 [2] but higher than that in survey leg 5 [2](**Table 6 Appendix 3**). Similarly, the female WPUE in survey leg 2 was lower than that from survey legs 3 and 4 [3] (**Table 7 Appendix 3**).

### 3.2.2. MALE SPANNER CRABS

Male CPUE from survey leg 2 was higher than that from survey legs 3 and 5 but lower than survey leg 4 [4] (**Table 8, Appendix 3**). Moreover, male WPUE in survey leg 4 was higher than that from survey legs 2 [5] (**Table 9 Appendix 3**), while male WPUE in survey leg 2 was higher than that from survey leg 3 [5] (**Table 9 Appendix 3**).

**Table 3:** CPUE (number/net lift), WPUE (kg/net lift), ratio for females and males spanner crabs across survey legs.

| Survey Leg | Female CPUE | Male CPUE | CPUE Ratio (M: F) | Female WPUE | Male WPUE | WPUE Ratio (M: F) |
|---|---|---|---|---|---|---|
| 2 | 1.105 | 2.256 | 1:0.49 | 0.31 | 0.93 | 1:0.3 |
| 3 | 2.378 | 2.238 | 1:1.1 | 0.50 | 0.60 | 1:0.8 |
| 4 | 4.751 | 3.449 | 1:1.4 | 0.92 | 1.06 | 1:0.9 |
| 5 | 0.133 | 0.269 | 1:0.5 | 0.03 | 0.11 | 1:0.3 |

[2] Kruskal-Wallis: $\chi2$ (3) = 35.129, p = < 01.144e-07
[3] Kruskal-Wallis: $\chi2$ (3) =12.065, p = < 0.007163
[4] Kruskal-Wallis: $\chi2$ (3) =72.913, p = < 1.015e-15
[5] Kruskal-Wallis: $\chi2$ (3) =31.082, p = < 8.168e-07

## 3.3. SEX RATIO

The sex ratio was close to 1:1, with the total catch comprising 51% females and 49% males. Variation in the male-to-female ratio was observed between survey legs. A higher proportion of female crabs was found on survey legs 4 and 3 (the legs that yielded the highest overall catches), with sex ratios of 1:1.4 and 1:1.1, respectively. In contrast, survey legs 2 and 3 had twice as many males as female crabs (i.e., sex ratio 1:0.5).

## 3.4. LENGTH FREQUENCY DISTRIBUTION

The size frequency distributions, both total and sex-specific, are shown in **Figure 9**. A unimodal distribution was observed for all three distributions with a slight positive skewness for total and female crabs, such that 8 – 8.5 cm is the modal size class.

For all crabs combined, the carapace length (cm) ranged from 5 to 15.6 cm, with a mean of 9.2 cm, a mode of 7.9 cm and a median of 8.8 cm. Female carapace length ranged from 5 to 14 cm, with a mean of 8.5 cm, a mode of 7.9 cm and a median of 8.3 cm. Male carapace length ranged from 5 to 15.6 cm, with a mean of 9.9 cm, mode of 8.7 cm and a median of 8.8 cm. Males were statistically significantly larger ($p < .05$) than female crabs [6].

The majority (81%) of crabs caught were above the proposed minimum legal length of 8 cm (**Figure 9A**). Seventy two percent (72%) of the female crabs caught were above the proposed size limit (**Figure 9B**), and 90% of male crabs were above the proposed size limit (**Figure 9C**).

[6] Kruskal-Wallis: $\chi 2$ (1) =118.5, p =< 2.2e-16

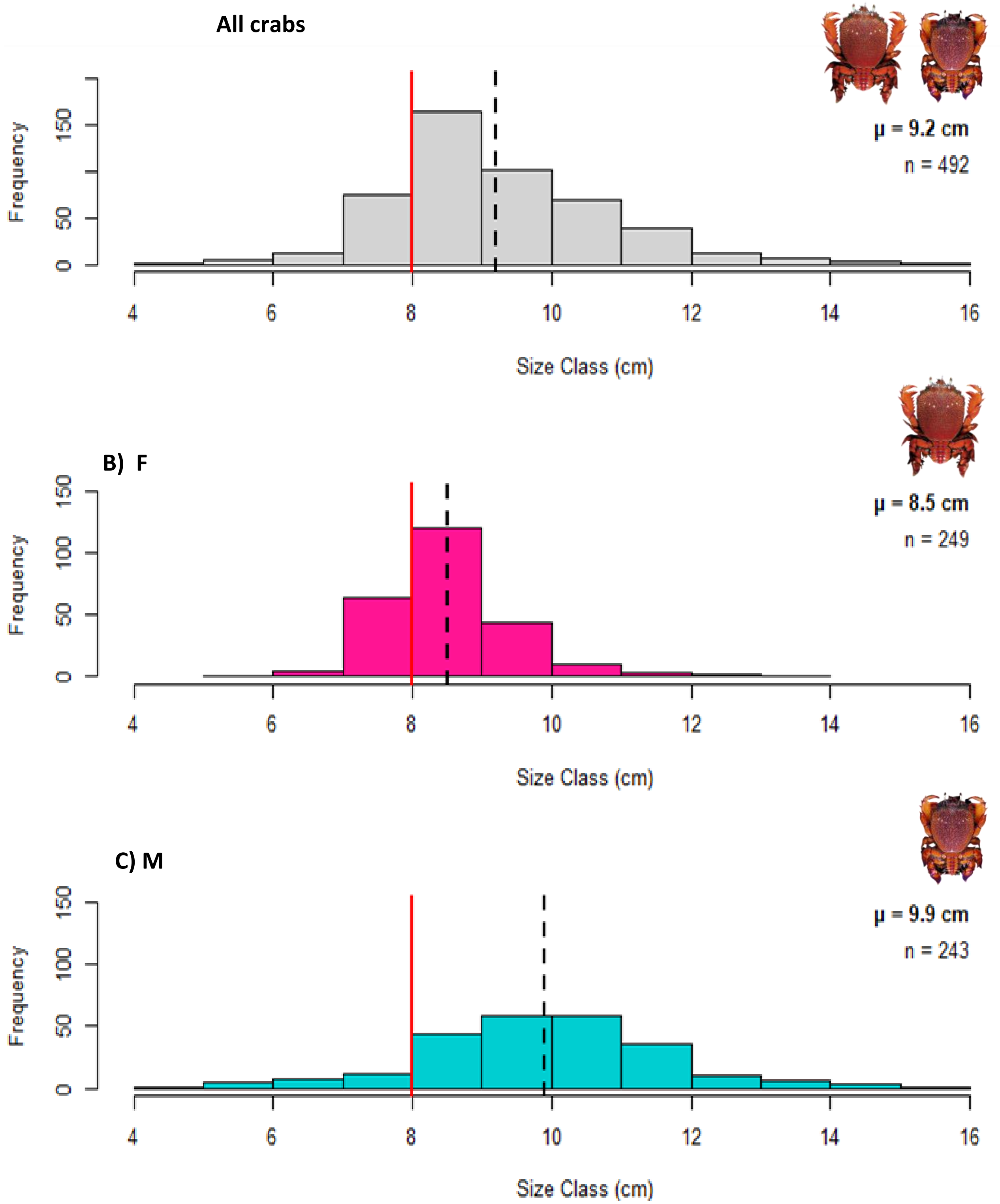



***Figure 9:*** *Length frequency distribution of spanner crab (R. ranina) sampled during the 2022/23 surveys. A) All spanner crabs. B) Female spanner crabs. C) Male spanner crabs. Black dashed line: μ= mean carapace length. Red solid line: proposed minimum legal size of 8 cm.*

Crabs caught in 1995 had carapace lengths ranging from 6 to 13 cm, with a mean of 9.1 cm for females and 5.8 to 14.4 cm with a mean of 11.1 cm for males (**Figure 10**). For the 2022/23 survey, female carapace length ranged from 5.2 to 13.7 cm with a mean of 8.5 cm, and male carapace length ranged from 4.9 to 15.5 cm with a mean of 9.9 cm. There was a statistically significant difference ($p < .05$) in mean carapace length for both sexes between the 1995 and 2022/23 surveys. Specifically, in 1995, male crabs had a larger mean carapace length of 11 cm ± SD = 1.95, which decreased to 9.9 cm ± SD = 1.7 in 2022/23 [7]. Similarly, female crabs exhibited a larger mean carapace length of 9.1 cm ± SD = 1.2 in 1995, compared to 8.5 cm ± SD = 1.0 in 2022/23 [8] (**Figure 10**).

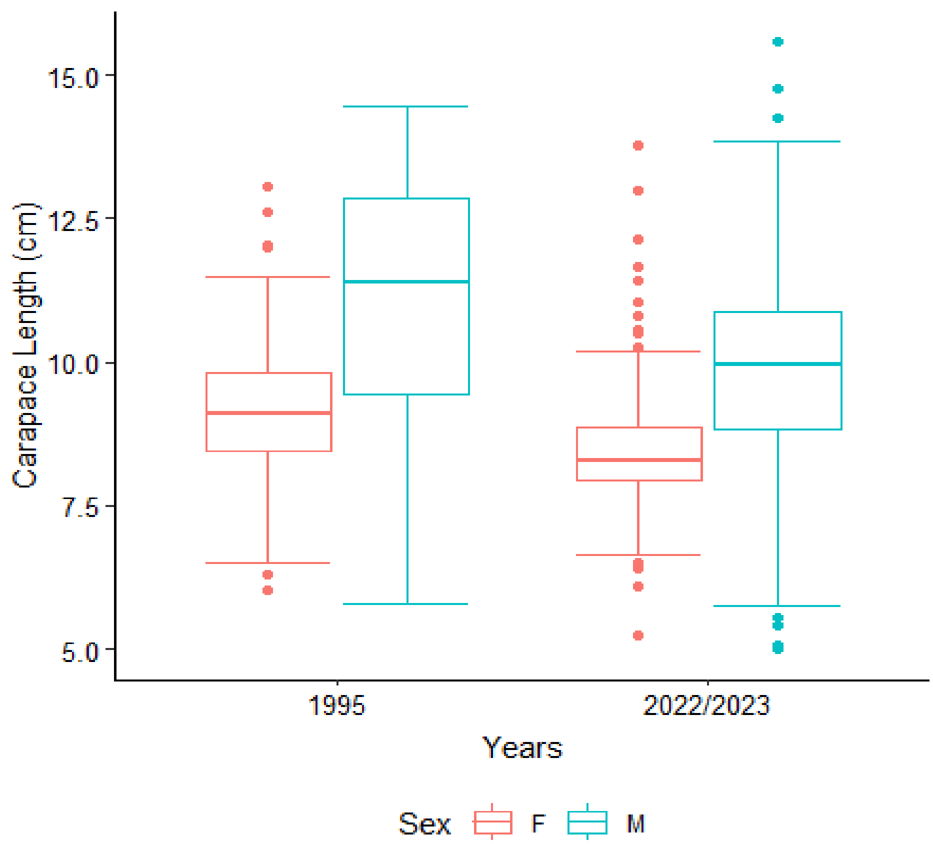
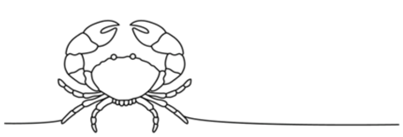



***Figure 10:*** *Box plot of the size distribution of female and male spanner crabs for the 1995 and 2022/23 surveys.*

[7] Kruskal-Wallis: $\chi^2_{(1)}$ =61.728, $p$ = 3.9e-15

[8] Kruskal-Wallis: $\chi^2_{(1)}$ =63.228, $p$ = 1.8e-15



## 3.5. WEIGHT DISTRIBUTION

The body weight of crabs ranged from 030 to 790 g, with a mean of 267 g, mode of 220 g and a median of 230 g. Female body weight ranged from 040 to 680 kg, with a mean of 209 g, mode of 220 g and a median of 200 g. Conversely, male crabs had body weights ranging from 030 to 790 g, with a mean of 327 g, mode of 230 g and a median of 315 g. Male crabs had significantly (*p <.05*) heavier body weights compared to their female counterparts[9].

Sex-specific differences in mean body weight were observed between survey legs (**Table 4**). Within a survey leg, female mean body weight ranged from 277 g ± SD = 0.14 to 208 g ± SD = 0.15, while male mean body weight ranged from 413 g ± SD =0.10 to 401 g ± SD = 0.16. The heaviest crabs of each sex were caught on survey leg 2.

Statistically significant differences (*p <.05*) was observed between the survey legs for both male and female crabs. Female crabs in survey leg 2 were heavier than those in survey leg 4[10] (**Table 12 Appendix 5**). Male crabs from survey leg 2 similarly were significantly heavier than males from survey legs 3 and 4[11] (**Table 13 Appendix 5**). As was observed overall, on any survey leg, female crabs had lower mean body weights compared to males, especially for survey legs 2, 4, and 5 (**Table 4**).

The sex-specific comparison between 1995 and 2022/23 surveys is shown in **Figure 11**. In 1995, male (μ = 1048 g ± SD = 0.33) and female (μ = 319 g ± SD = 1.11) crabs had significantly heavier body weights (*p < .05*) compared to those in 2022/23 (male: μ = 327 g ± SD = 0.153, female: μ = 209 g ± SD = 0.08; **Figure 11**) [12 &13].

[9] Kruskal-Wallis: $\chi^2_{(1)}$=272.86, *p* = < 2.2e-16
[10] Kruskal-Wallis: $\chi^2_{(3)}$=155.4, *p* = < 0.0214
[11] Kruskal-Wallis: $\chi^2_{(3)}$=126.905, *p* = < 6.2e-06
[12] Kruskal-Wallis: $\chi^2_{(1)}$=155.4, *p* = < 2.2e-16
[13] Kruskal-Wallis: $\chi^2_{(1)}$=146.65, *p* = < 2.2e-16

**Table 4:** Mean body weight (g) of female and male crabs by survey legs.

| Leg | Mean Weight (Female) | Mean Weight (Male) |
|---|---|---|
| **2** | 277 g ± SD = 0.14 | 413 g ± SD = 0.10 |
| **3** | 210 g ± SD = 0.17 | 268 g ± SD = 0.12 |
| **4** | 194 g ± SD = 0.10 | 308 g ± SD = 0.04 |
| **5** | 208 g ± SD = 0.15 | 401 g ± SD = 0.16 |

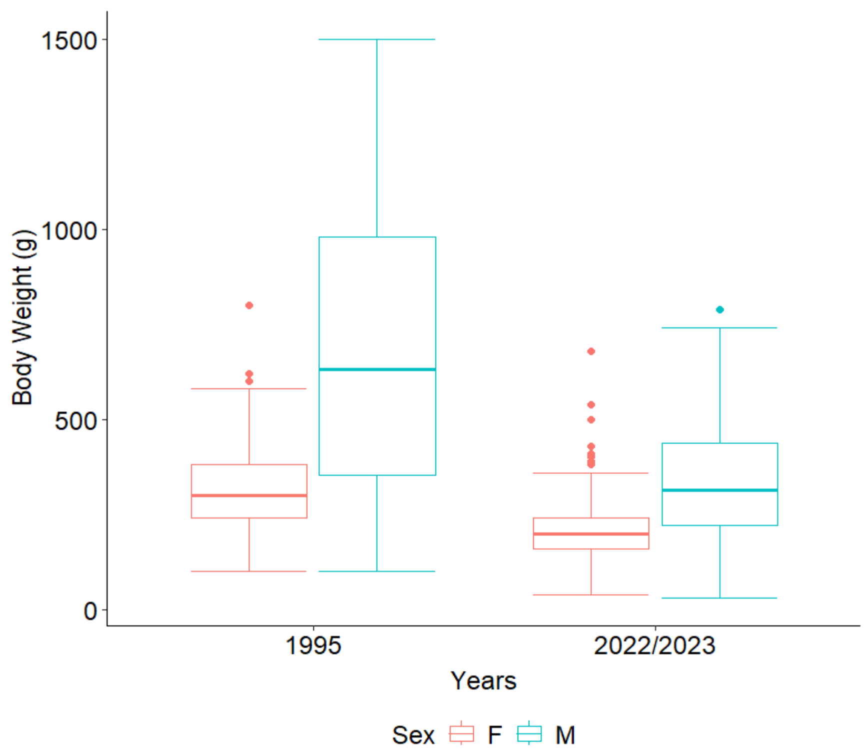



***Figure 11:*** *Box plot of the weight distribution of female and male crabs for the 1995 and 2022/23 surveys.*

## 3.6. MEAN CARAPACE LENGTH PER SURVEY LEG

Crabs caught on survey legs 3 (μ = 8.9 cm ± SD =1.4) and 4 (μ = 8.8 cm ± SD =1.1) were significantly smaller compared to crabs on survey leg 2[14] **(**μ = 10.5 cm ± SD =2.0; *p <.05*; **Table 10 Appendix 4; Figure 12A).** However, no significant differences in mean carapace

[14] Kruskal-Wallis: $\chi^2_{(3)}$=88.513, $p$ = <.05

length (cm) were observed between any other pairs of survey legs (**Table 10 Appendix 4; Figure 12A).**

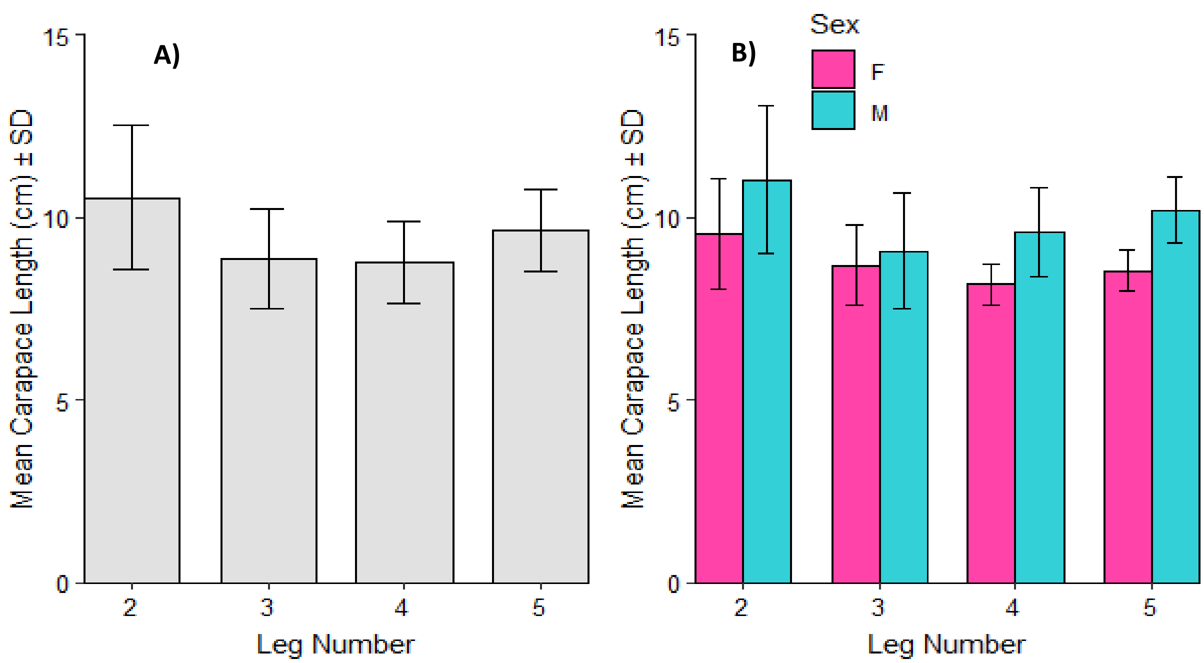



***Figure 12:*** *Mean carapace length (cm) of spanner crab sampled. A) All spanner crab per survey legs. Survey legs: 2 (n =97), 3 (n = 138), 4(n = 244) and 5 (n =12). B) Female and male spanner crab per survey legs. Leg 2 (n = F: 32, M:65), 3 (n = F: 71, M:67), 4 (n = F:142, M:103) and 5 (n = F:4, M:8).*

Male crabs caught on survey leg 3 (μ = 9.1 cm ± SD =1.6) and 4 (μ = 9.6 cm ± SD =1.2) had significantly smaller mean carapace lengths compared to male crabs on survey leg 2 (μ = 11 cm ± SD =0.2; *p <.05*; **Table 11 Appendix 4**)[15]. However, no significant differences in male mean size were observed between any other pairs of survey legs (**Table 11 Appendix 4**).

Female crabs in survey leg 2 exhibited the largest mean carapace length (μ = 9.5 cm ± SD = 1.5), significantly greater than those on survey legs 3 (μ = 8.7 cm ± SD = 1.1) and 4 (μ = 8.2 cm ± SD = 0.6; **Table 12 Appendix 4**)[16]. Females from survey leg 3 were also

[15] Kruskal-Wallis: $\chi^2_{(3)}$=43.700, $p$ = < 1.748e-09

[16] Kruskal-Wallis: $\chi^2_{(3)}$=73.364, $p$ = < 8.123e-16

significantly larger than females in survey leg 4. No significant differences were observed in female mean carapace lengths between survey legs 2 (μ = 9.5 cm ± SD =1.5), 3 (μ = 8.7 cm ± SD =1.1), 4 (μ = 8.2 cm ± SD =0.6) and 5 (μ = 8.5 cm ± SD =0.6; **(***p >.05*; **Table 12 Appendix 4)**.

## 3.7. OVIPAROUS FEMALES

Of the 249 female crabs caught, 7 (2.8%) were oviparous. Five had orange egg masses, indicating early embryonic development, while the remaining 2 were brown, indicating older embryonic development (**Figure 13**). These 7 oviparous females were all caught on survey leg 2, from the southern part of the Mahé plateau.

Oviparous females ranged from 8.1 to 11.4 cm CL, with a mean and median of 9.4 cm (**Figure 13**). The largest individual, measuring 11.4 cm, was identified with eggs in the later stage of development (B4; Dark brown), just before extrusion. The majority of females presented second-stage egg development (O2; light orange) and had carapace length of 9.5 cm.

There was no significant difference in carapace lengths between oviparous females from1995 (μ = 9.13 cm, SD = 1.45) and 2022/23 (μ = 9.43 cm, SD = 1.08; (*p > .05*; **Figure 14**)[17].

[17] ANOVA: $F_{(1,16)} = 2.22$, p = 0.645

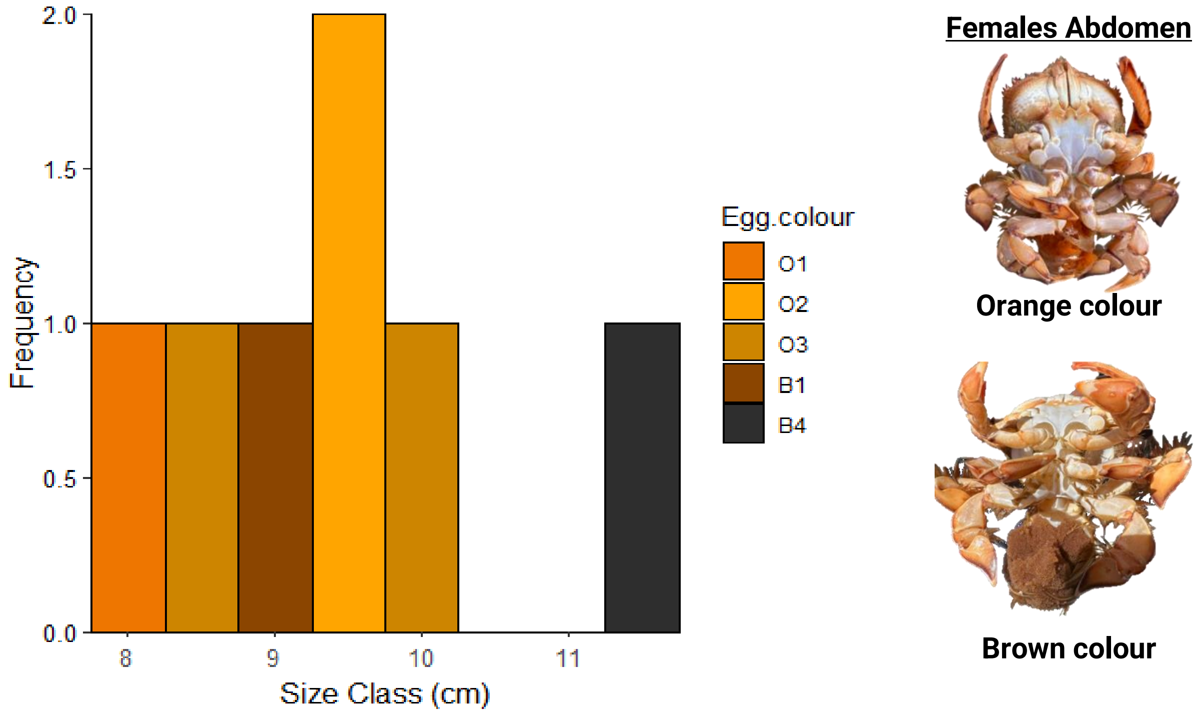



***Figure 13:*** *Length frequency of all the berried females (n =7) captured during the entire survey 2022/23. O1, bright orange newly formed, O2; lightish orange and O3; darkish orange B1; brownish B4; dark-brown ready for release.*

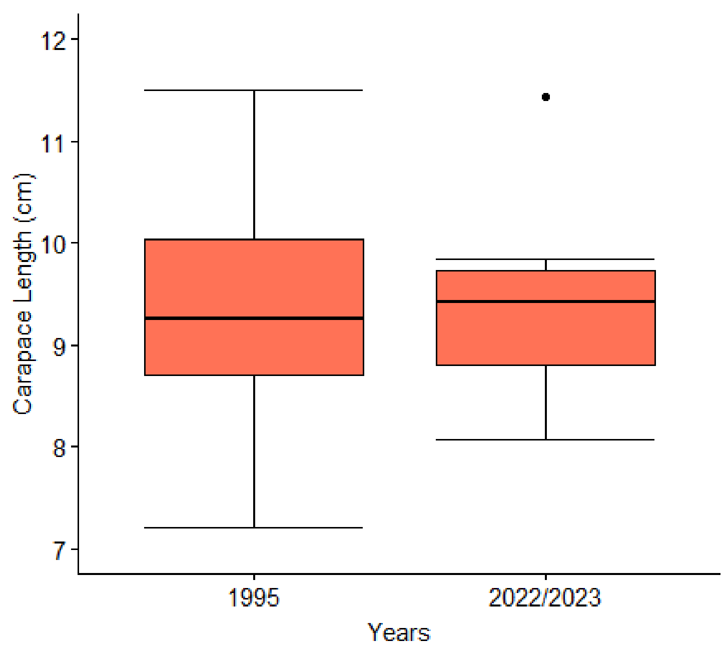



***Figure 14:*** *Box plot comparison of the carapace length (cm) of oviparous females in the 1995 and 2022/23 surveys.*

## 3.8. LENGTH-WEIGHT RELATIONSHIP

The relationship between carapace length and weight relationship was determined for both sexes and all crabs combined (**Figure 15**). The power relationship exponent, b, was estimated as 2.84, 2.56 and 2.84 for all crabs combined, females and males, respectively, and $r^2$ values of 0.73, 0.50 and 0.80. This indicates the proportion of variance in weight is explained by carapace length for all three categories. The overall model fit was assessed using the *F*-statistic, which supports the goodness of fit between carapace length (cm) and weight (g) as statistically significant for all three categories ($p < .05$)[18, 19 & 20]. The following length-weight power relationships were obtained in **Table 5**.

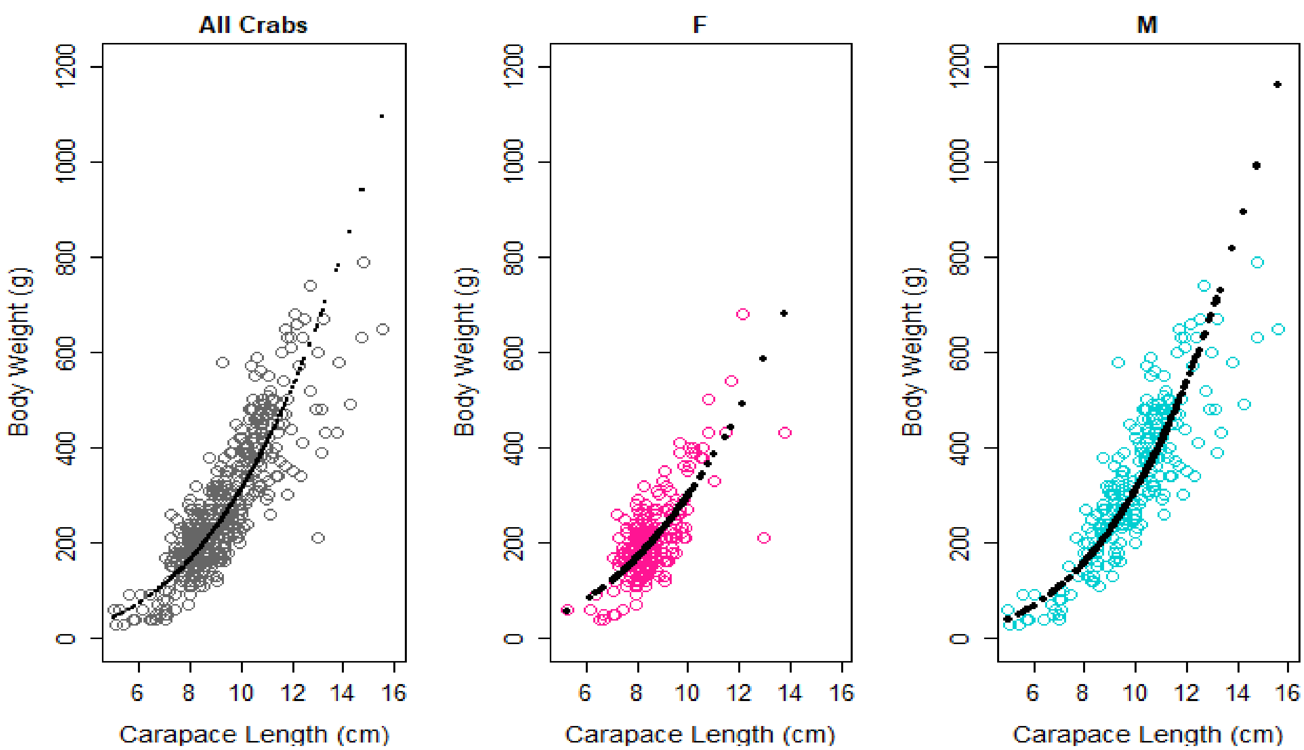



***Figure 15:*** *Length-weight relationship of male, female, and all crabs combined for spanner crabs. Number of samples: all crabs combined (n = 492); females (n =249;) and males (n =243).*

[18] $F_{(1, 489)}=1327$, $p = < .05$

[19] $F_{(1, 247)}=244.4$, $p = < .05$

[20] $F_{(1, 241)}=916.9$, $p = < .05$

The b exponent value was significantly differing from 3 ($p < .05$)[21, 22 & 23] for all three relationships, indicating that crabs generally have a negative allometric length-weight relationship (**Table 5**).

**Table 5:** Relationship between carapace length and weight for all crabs combined, male and female: a intercept; b, slope; A- negative allometric growth.

| Parameters | a | b | Allometry | Equation notation |
|---|---|---|---|---|
| All crabs | 0.440269 | 2.84 | A- | Weight (g)= 0.440269 × Carapace length (cm) $^{2.84}$ |
| Female | 0.80775 | 2.56 | A- | Weight (g) =0.8077522 X Carapace length(cm) $^{2.56}$ |
| Male | 0.31053 | 2.99 | A- | Weight (g) = 0. 0.31053 x Carapace length (cm) $^{2.99}$ |

## 3.9. HABITAT SAMPLE

### 3.9.1. HABITAT SAMPLING EFFORT

Five hundred and twenty-two (522) attempts were made to collect habitat samples. Of these, 303 from 97 stations were successful, comprising 48 from drop cameras and 255 from sediment grabbers, respectively. Two hundred and nineteen (219) sediment grabber deployments yielded no samples and were classified as unsuccessful.

### 3.9.2. HABITAT TYPE

Sand was the habitat type yielding the highest catch (209 crabs) (**Figure 16**). The sand/coral rubble combination yielded 100 crabs, while 46 crabs were caught in coral rubble habitat. Fewer crabs were caught in habitats characterised by mixed substrates: sand, sandy mud, coral rubble, algae, seagrass. Although variations in crab abundance across habitats is evident, with sand yielding the highest catches, the differences in crab

[21] T test $_{(1,491)} = 38.358$, $p = < .05$

[22] T test $_{(1,248)} = 18.535$, $p = < .05$

[23] T test $_{(1,242)} = 13.231$, $p = <.05$

catches (by number or weight) across the habitat classifications were not statistically significant ($p > .05$) [24 & 25].

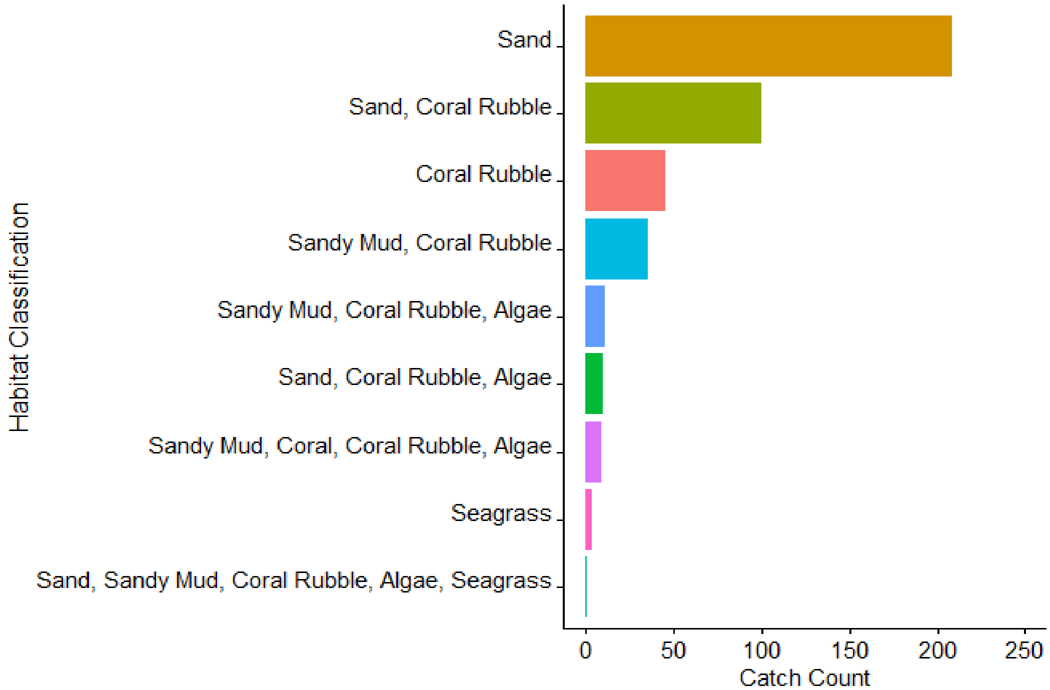



***Figure 16:*** *Total count of spanner crabs across different habitat types sampled during the survey 2022/23 (n= 426). Each bar represents a habitat, with the length of the bar corresponding to the count of catches recorded in that specific habitat.*

## 3.10. DEPTH RANGE

Crab catch was the highest in depth range of 31-55 m (300 crabs; 102 kg)(**Figure 17**). The 10-30 m depth range yielded 94 crabs (24 kg), and 18 crabs (5 kg) were caught between 56 and 100m. However, the catch within the 31-55 m depth range was not statistically significantly different (either by number or weight)from that of the other two depth zones ($p > .05$) [26 27].

[24] Kruskal-Wallis: $\chi^2_{(16)} = 15.541$, $p = 0.485$
[25] Kruskal-Wallis: $\chi^2_{(25)} = 35.548$, $p = 0.142$
[26] Kruskal-Wallis: $\chi^2_{(2)} = 1.525$, $p = 0.466$
[27] Kruskal-Wallis: $\chi^2_{(2)} = 1.580$, $p = 0.453$

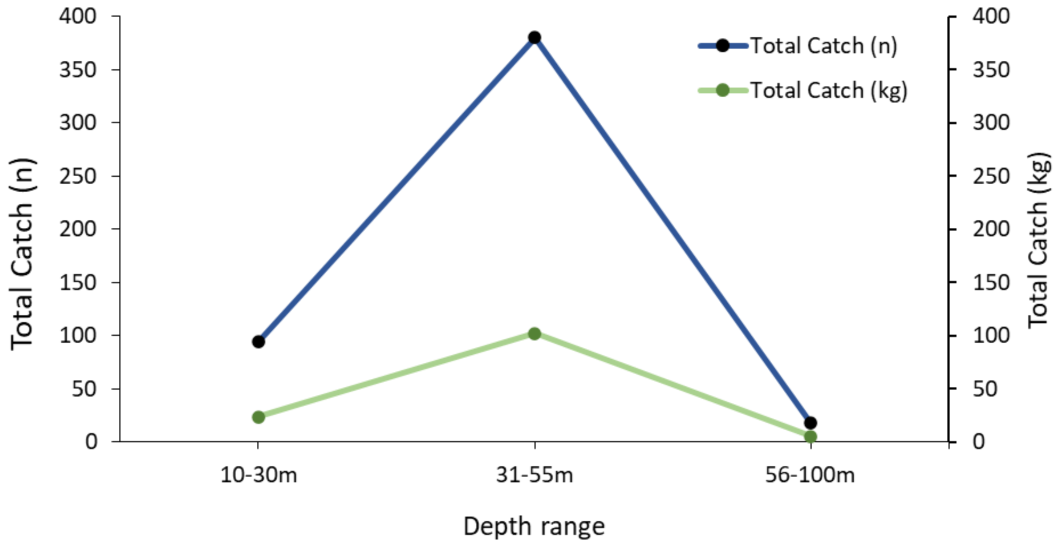



***Figure 17:*** *Total count (number of crabs) and Total catch (kg) of spanner crabs caught by depth range during the 2022/23 survey.*

## 4. KEY SURVEY RESULTS

- Overall, the study highlights spatial variations in abundance, impact of fishing pressure, sexual dimorphism, and growth dynamics in spanner crab populations.
- Survey covered 6 legs instead of 7 legs, with 115 stations surveyed instead of 140.
- Spanner crabs found in Southern, Southeast, and Eastern regions.
- Significant spatial variations across all survey legs were evident:
    - Survey leg 1 (Northern part of the Plateau) and survey leg 6 (Central part) recorded no catch. However, this does not mean no crabs are present during the survey.
    - Survey leg 2 (Southern part of the Plateau near Constant bank) had larger and heaviest mean carapace length and weight for all crabs combined and both sexes. Third highest relative catch but heavier crabs than survey leg 3.
    - Survey leg 3 (Southeastern part of the Plateau near Topaz Bank) had the second highest relative catch in numbers, third relative weight and smallest male mean carapace length.

   - Survey leg 4 (Western part of the Plateau near Owen Bank) had the highest CPUE, WPUE, mean relative catch, and weight compared to the other survey legs and was, therefore, the most productive. Survey leg 4 also had the lowest mean carapace length of all spanner crabs and females sampled.
   - Survey leg 5 (Western inner part of the Plateau) was the least productive area, however, the sample size was small with 12 crabs.
- Sexual dimorphism was observed, males were larger and heavier than females with non-proportional growth patterns.
- Comparison between 1995 and 2022/23 surveys shows decline in crab size and weight, potentially due to increased fishing pressure.
- Smallest berried female was recorded at 8.1 cm in carapace length.
- Overall, the sex ratio is balanced, indicating equal distribution between males and females.
- Spatial variation in sex ratio was observed, particularly for survey legs 2 and 3.
- Habitat and depth range need for further research incorporating additional variables.

# 5. DISCUSSION

Following the previous surveys of the spanner crab resource held in the late 1980s (Moussac, 1988) and early 1990s (Boullé, 1995), this study provides an updated insight into the state of the spanner crab resource on the Mahé Plateau.

## 5.1. ABUNDANCE AND WEIGHT ACROSS SURVEY LEGS

In 1995, Boullé (1995) estimated the highest abundance of crabs to occur in the Southeastern part of the Plateau, while the lowest abundance was estimated in the Northern and Western inner part of the Plateau. During the present survey, leg 4, which corresponds to the Western outer part of the Mahé Plateau near Owen Bank, was the area with the highest CPUE/WPUE for both sexes.

Based on information gathered from our sampling programme, it is presumed that the area surveyed in leg 4 is less visited or fished for crabs compared to leg 3 (Southeastern, near Topaz Bank). This could potentially explain the higher catch rates observed in leg 4. Bergström et al., (2022) observed that areas where fishing was prohibited had significantly higher numbers and biomass of some fish and decapod crustaceans compared to areas where fishing was permitted. Specifically, after three years of protection, the catch per unit effort (CPUE) was 2.6 times higher on average, and in comparison, to fished reference areas, it was 3.8 times higher (Bergström et al., 2022).

Interestingly, survey leg 3 (Southeastern part of the Plateau near Topaz Bank), the second most abundant area, exhibited lower average crab weights compared to those in survey legs 2 and 4. This observed change could be a result of consistent fishing in this area for more than 30 years (Boullé, 1995). Operational expenses associated with travelling to other parts of Mahé Plateau may prompt fishers to prioritise areas with higher availability of crabs to minimise searching efforts (fisher's personal comment), thus resulting in localised change in abundance and weight (Amaral et al., 2008).

## 5.2. SIZE INDICATORS

### 5.2.1. CARAPACE LENGTH AND WEIGHT

Although survey leg 2 (Southern part of the Plateau near Constant Bank) yielded a lower crab CPUE compared to survey leg 3 (Southeastern part of the Plateau near Topaz Bank), the weight of crabs there was higher. It is presumed that this area is relatively less affected by fishing activities due to the associated costs and distance from port. Fishers have indicated that the area in survey leg 2 is exposed to strong currents, and the survey recorded the strongest currents (3.4 knots) in this area. This factor could have contributed to lower spanner crab fishing in this region (Spencer et al., 2019).

Male crabs in survey leg 3 were the smallest across the survey legs. This area is highly targeted for spanner crab compared to other fishing areas. The selective fishing on one sex or localised targeting, along with the prohibition of retaining berried and undersized crabs, likely influences the removal of larger crabs (Thomas et al., 2013; Nillos et al., 2019). This could reduce the average weight of the remaining population, hence smaller male crabs. Similar studies have shown that populations of blue crabs (*Callinectes sapidus*) subjected to heavy fishing tend to exhibit smaller males (Carver et al., 2005). Moreover, it has been reported that fisheries can alter population structure, resulting in smaller adult body sizes or inducing earlier maturation (Forestier, et al. 2020; Bergström et al., 2022). Such changes can alter the mating potential by reducing ejaculate capacity due to diminished sperm availability (Carver et al., 2005). Smith (1994) further stated that the effects of selective fishing on male growth rates were observed at the genomic level over generations.

While survey leg 4 (Western outer part of the Plateau near Topaz Bank) had the highest CPUE/WPUE, it also had the smallest females. As the survey was conducted during the fishing season, larger individuals could have been removed, leading to smaller individuals being captured in those legs. This observation suggests that area leg 4 (Western outer part of the Plateau, near Owen Bank) may offer optimal ecological conditions (e.g., habitat and food availability) for crab reproduction and survival, leading to higher overall abundance.

The catch composition consisted mainly of larger individuals, which is similar to what the fishery catch data reports (68% females and 93% males above 8 cm carapace length; SFA, 2022). The absence of smaller individuals can likely be attributed to the selectivity of the fishing gear used. Similarly, in Australia, Kirkwood et al. 2005, noted that standard commercial spanner crab fishing gears (baited tangle nets) caught mostly larger crabs (above 60 mm CL). Furthermore, they suggested that the juvenile crabs may not be drawn to the bait, unable to access the baited traps or avoid being caught by the gear even if they are attracted to the bait (Kirkwood et. al. 2005).

### 5.2.2. SIZE COMPARISON 1995 AND 2022/23 SURVEYS

Larger and heavier crabs were observed in 1995 compared to those from the 2022/23 survey. Such changes in size can be related to fishing pressure (Jennings et al., 1999). Since its inception in 1987 through to 1995, spanner crab fishing was limited to 1-2 vessels operating for 1-4 days per trip, using 1-2 tangle nets consisting of 10-20 nets each (Antha, 2022. Unpublished.). Currently, the spanner crab fishery has 5-9 vessels operating on average 10 days per trip, with 2-3 sets of 100 tangle nets (Antha, 2022. Unpublished.). With rapid technological advancements and modern fishing vessels boasting greater capacity, vessels are more equipped to undertake approximately 10 trips per fishing season (Antha, 2022. Unpublished.). Krajangdara and Watanabe (2005) reported fishing in the Andaman Sea influenced the mean size of males and females spanner crab, with smaller individuals in 1999 than in 1998. The observed change in size distribution on the Mahé Plateau may potentially be related to increased fishing pressure due to a lack of management strategies or monitoring for over 30 years (Boullé, 1995; Charbonneau et al., 2019).

The 1995 survey was conducted over a two-year period, as opposed to the 2022/23 survey, which was conducted over a 6-month period. It is important to exercise caution when comparing the results due to potential differences in survey time, as well as locations and fishing techniques. It appears that there was minimal discernible impact of gear selectivity between the two surveys, as the smallest recorded sizes for each gender from each survey showed little difference (males 4.9 cm 2022/23, 5.8 cm 1995; females 5.2 cm 2022/23, 6.1 cm 1995), although they were consistently smaller in the more recent survey.

The size of oviparous females remained constant between the years 1995 and 2022/23, exhibiting no noticeable variation. This could mean the size distribution of oviparous females is relatively stable due to fishers releasing oviparous females. However, this is merely an assumption based on a small sample size and requires further investigation.

## 5.3. LENGTH-WEIGHT RELATIONSHIP

Generally, male crabs have clear distinctive morphological differences, characterised by a faster growth rate and by attaining larger, heavier sizes than females (Minagawa, 1993; Dichmont and Brown, 2010). Differences in sex-specific growth patterns can be related to several factors. Males are more aggressive and remain immersed longer and therefore have greater access to food resources (Skinner and Hill, 1987). This behaviour may be influenced by the more frequent moulting compared to females (Chen and Kennelly, 1999; Kennelly, 1992).

On the other hand, females invest more energy in reproduction as a strategy to enhance reproductive success. This includes storing sperm and allocating resources for fertilisation whilst suppressing growth and weight gain (Hartnoll, 2006; Kasinthan et al., 2007; Fielding and Hayley, 1976). Nonetheless, the length-weight relationship can be influenced by multiple alternative factors such as environmental changes, diet, gonad maturity, and seasonality (Bayhan et al., 2008; Ghailen et al., 2010; Franco-Lopez et al., 2010).

## 5.4. REPRODUCTION

### 5.4.1. SMALLEST OVIPAROUS FEMALE AND EGG COLOURATION

The smallest oviparous female was 8.1 cm in carapace length. However, earlier studies by Boullé (1995) and De Moussac (1988) identified oviparous female crabs as small as 6.5 cm and 6.3 cm in length, respectively. Size variation in female spanner crabs with eggs can be observed throughout the literature, from 6.2 cm (Philippines), 6.4 cm (Australia) and 6.7 cm (Thailand; Baylon and Tito, 2012). These findings suggest that female spanner crabs can attain maturity at smaller sizes. However, this depends on the L50, the length at which 50% of spanner crabs mature. De Moussac (1988) estimated the size at maturity in Seychelles to be 8.9 cm, and reported that 56% of female crabs caught were below this size. There are reported differences in size at maturity ranging from 7 cm (Australia), 7.2 cm (Thailand) to 8.6 cm (Hawaii) depending on the region (Fielding and Haley, 1976; Brown, et al., 1999; Krajangdara and Watanabe, 2005).

Variation in egg colouration indicates the population is reproducing with a range of reproductive stages, ensuring a continuous influx of juveniles into the population (Ikhwanuddin et al., 2015), which is a positive sign for population stability and resilience. However, egg colouration on its own is not the most reliable indicator of reproductive dynamics, as the success of fertilisation remains uncertain.

Additionally, the small sample size of females with eggs, along with the limited spatial and temporal coverage is inconclusive in understanding the reproductive behaviour of spanner crabs. As spawning is the basis of recruitment (Annala and Eayrs 2010; De Croos et al., 2011), further research on gonad development using histological analysis is needed to understand the reproductive biology of spanner crab in Seychelles. To predict future recruitment, seasonality, location, spawning duration, size at maturity and fecundity, a comprehensive understanding of reproductive biology and other population parameters is necessary. Parameters such as the size at maturity and fecundity are important inputs to analytical stock assessments, which help determine stock status (Slipke et al., 2002; Caddy, 2004). Subsequently, stock status can be incorporated within a formal harvest strategy, prompting appropriate management responses. Associated management measures may include quotas, gear alteration, and zone closures in areas with high abundance of oviparous females.

### 5.4.2. REPRODUCTIVE PERIODICITY

The reproductive period of spanner crab varies spatially depending on location (Baylon and Tito, 2012). According to Baylon and Tito (2012), in Japan and Hawaii, the spawning season peaks between May to August, while in the Philippines and Australia between November to February. Boullé (1995) stated that spanner crab reproductive period in Seychelles coincides with that of the Philippines and Australia from November to February. However, a small percentage of oviparous females were sampled in January during the survey leg 2 (Southern part of Plateau, Constant Bank). Therefore, this study failed to capture the reproductive periodicity to make a conclusive statement. Spanner crab fishers have occasionally reported sightings of oviparous females from October to March, which merits further investigation (fisher's personal observation).

## 5.5. SEX RATIO

Sex ratio provides a basic indication of the ability to reproduce effectively (Vicetini and Araujo, 2003). An overall 1:1 sex ratio was observed from the survey, indicative of a balanced distribution between male and female crabs in the population. The sex ratio observed showed spatial heterogeneity, where survey legs 3 and 4 were female-dominated compared to survey legs 2 and 5. Differences in sex ratio can be related to different factors such as size-selective harvesting (Dwivedi and Mayank, 2017) or other environmental factors (eg; temperature; Stauffer and De Costa, 2023). Moreover, such differences could also be due to an artefact of the small sample size. As spanner crabs congregate to spawn, their susceptibility to size-selective harvesting can disproportionately impact males. Such impacts can be observed in the catch data, whereby more males are caught compared to females (SFA, 2022). However, the sex ratio observed in this study does not show evidence of adverse fishing impact.

## 5.6. HABITAT AND DEPTH RAGE

Sandy habitat yielded the highest catches in both numbers and weight. The majority of crab species, including spanner crab, exhibit burrowing behaviour for refuge. Morphological adaptations in spanner crabs, such as semi-shovel-like pereiopods, facilitate their digging abilities (Matondo and Demayo, 2015). Due to the smooth texture of sand, spanner crabs can easily dig in and out using a bilateral synchrony motion as they descend into the sand, which may not be possible in other types of habitats (Faulkes, 2006).

Crabs were more dominant in the depth range of 31-55 metres, possibly due to a variety of factors such as water temperature, availability of food, and competition with other species. Crabs may have adapted to this specific depth range to take advantage of the resources available in this environment. No relationships were observed between depth, habitat type and crab catch, which may imply other factors not explored in this study hold more weight in influencing catch rates. Spencer et al., (2019) highlighted that oceanographic indices were spatially heterogeneous, impacting the variation in spanner crab catch rates across southern Queensland. This underscores the need for further research incorporating additional variables to comprehensively understand the dynamics influencing spanner crab distribution in the region. It is important to note that these are assumptions, and further research is needed to understand the reasons behind the dominance of crabs in this depth range and habitat type.

## 5.7. STUDY LIMITATIONS

There were several limitations to this study, and this included logistical constraints and delays. One major constraint was the small sample size collected to assess the state of the stock. Additionally, the long period between surveys, combined with sample collection across different years which extended over two different monsoon seasons, introduces variability and uncertainty to the survey results. Not all sections of the Mahé Plateau were sampled due to time constraints, and the survey did not begin as scheduled. Weather conditions were also a major impediment to the survey, particularly rough seas and strong currents, which caused certain difficulties in undertaking the habitat survey.

Additionally, there was limited participation of fishers in the survey, despite there being some level of engagement with the stakeholders (mainly boat owners, skippers and a few fishermen) during the study. Involvement was limited to the theoretical aspects of implementing the survey, with no practical engagement. This was not possible despite efforts to involve local fishers in practical engagement.

Habitat sampling was constrained by strong currents, limiting depth and equipment use. Uncertainties persisted with the sediment grabber, often retrieved without sediments due to difficulties in closing lids caused by the strong current.

The sample size of oviparous females collected was relatively small and limited to one survey area, which is insufficient for examining temporal trends in reproductive parameters. Additionally, relying solely on egg colour as a measure of embryonic development may not provide precise results.

# 6. CONCLUSION

The research provides a snapshot of the distribution, relative spatial abundance (as estimated by CPUE and WPUE), size variation and potential impacts of fishing pressure on spanner crabs within the surveyed area of the Mahé Plateau. The survey had certain limitations, including a small sample size and a limited habitat survey. The study highlights spatial variations in relative crab abundance (as estimated by CPUE/WPUE), with survey leg 4 emerging as potentially the most productive area. Fishing pressure may impact the population dynamics, with areas subjected to more pressure exhibiting smaller average crab sizes and, in this case, in survey leg 3. Survey leg 3 also showed the second highest relative CPUE/WPUE and smaller mean size males. In terms of comparison between the 1995 and 2022/23 surveys, a decline in overall crab size and weight was observed, potentially due to increased fishing pressure. It is important to exercise caution while interpreting the insight mentioned above. This is because the survey location, although not specified in detail for 1995, was not the same for both instances.

Additionally, there were slight modifications in the fishing gear, using square frames rather than circular frame tangle nets. Moreover, the survey duration and time may also vary between survey years. Overall, the findings underscore the importance of considering multiple factors in understanding and managing spanner crab populations for long-term sustainability and the need for further research. It is crucial to acknowledge that although this survey provides an overview of the spanner crab's status, it has limitations regarding sample size and survey duration. A time series analysis of catch and effort data from the fishery would be useful in gaining a better understanding of the spanner crab's status over time.

# 7. RECOMMENDATIONS

Based on the insights of this study and gaps identified, several research and management recommendations are being proposed:

- Implement a robust data collection programme for the spanner crab fishery to collect catch and effort data. This will facilitate a thorough assessment of the fishery's dynamics over time, enabling a comprehensive evaluation of stock status.
- Implement a long-term biological sampling program to track changes in population size, sex ratios, and size distribution.
- Investigate the use of rotational closures of specific zones of the Mahé Plateau (in consultation with stakeholders) as an option to alleviate fishing pressure and support recovery of spanner crab stocks.
- Depending on the reliability of fisheries-dependent assessments, conduct a fisheries-independent survey every 3-5 years to get an updated snapshot of the status of the spanner crab resource on the Plateau.
- Undertake genetic studies to investigate the stock structure of spanner crab resources on the Mahe Plateau.
- Future assessments and surveys should investigate the effects of environmental variables on the ecology, spatial distribution and habitat preferences of spanner crabs.
- Stakeholder engagements should be undertaken regularly to foster collaboration between scientists, fisheries managers, fishers and other stakeholders to highlight the importance of data collection, knowledge sharing and to develop effective management strategies.

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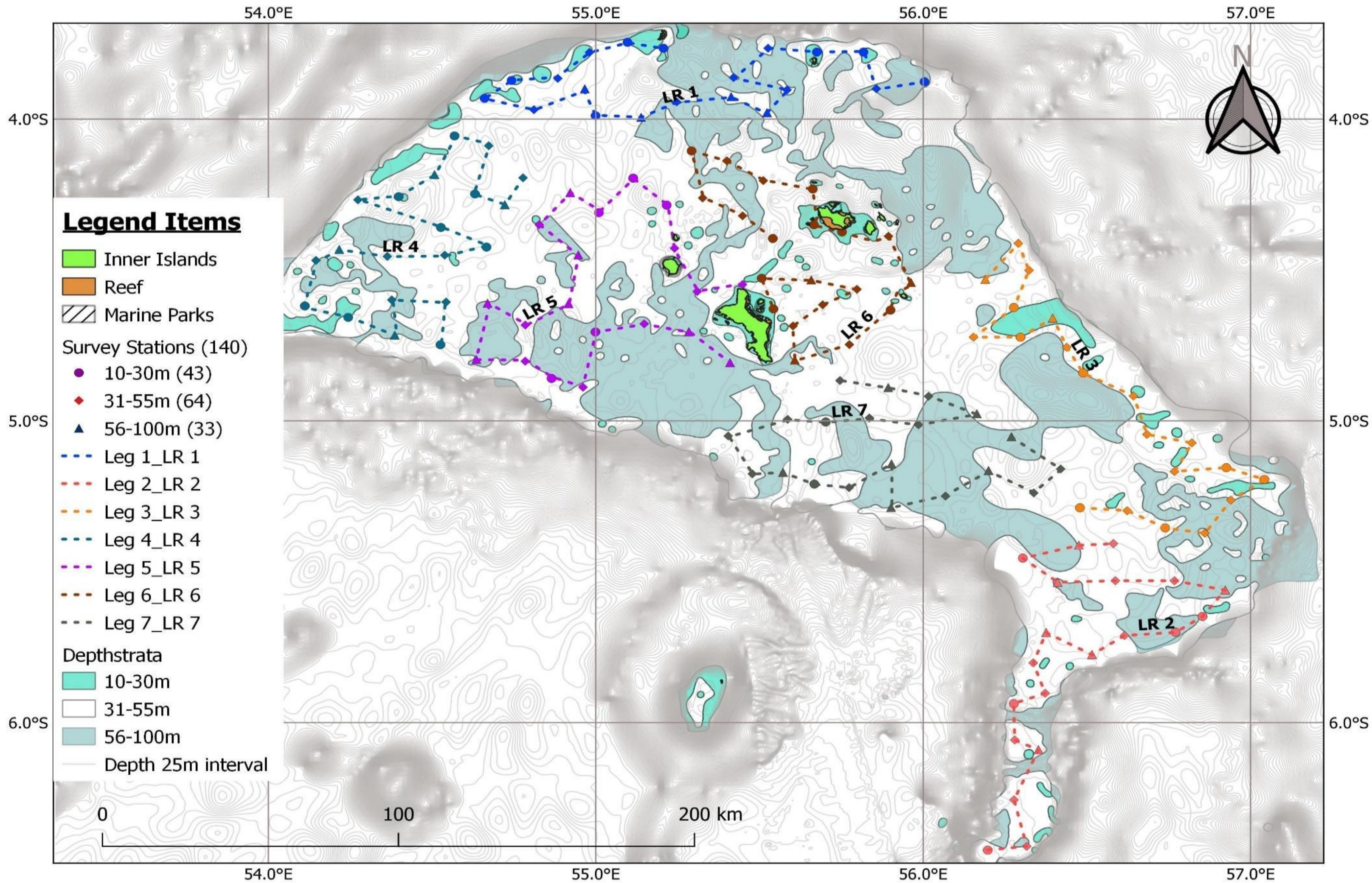
## APPENDIX 1

Cruise ship route for the 2022-2025 Fisheries Independent Survey.



## APPENDIX 2

Catch per station number by leg.

| Survey leg | Stations number | Total catch (No) | Total catch |
|---|---|---|---|
| **2** | 2 | 1 | 97 |
| | 4 | 3 | |
| | 5 | 1 | |
| | 6 | 8 | |
| | 7 | 6 | |
| | 10 | 2 | |
| | 15 | 2 | |
| | 16 | 39 | |
| | 18 | 2 | |
| | 20 | 33 | |
| 3 | 21 | 31 | 138 |
| | 22 | 1 | |
| | 25 | 44 | |
| | 26 | 4 | |
| | 30 | 20 | |
| | 31 | 27 | |
| | 34 | 2 | |
| | 38 | 9 | |
| 4 | 68 | 1 | 245 |
| | 73 | 196 | |
| | 104 | 48 | |
| 5 | 74 | 2 | 12 |
| | 112 | 10 | |

## APPENDIX 3

Statistical Summary: Pairwise comparisons of CPUE and WPUE.

**Table 6:** Dunn's test post hoc pairwise comparisons of **female CPUE (numbers/net lift ) per survey legs.** P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 2.859e-06 | P <.05 |
| 2 | Survey Leg 2 - 4 | 1.987e-08 | P <.05 |
| 3 | Survey Leg 3 - 4 | 1.000e+00 | ns |
| 4 | Survey Leg 2 - 5 | 2.360e-02 | P <.05 |
| 5 | Survey Leg 3 - 5 | 1.000e+00 | ns |
| 6 | Survey Leg 4 - 5 | 1.000e+00 | ns |

Significance level at 0.05. ns; nonsignificant difference.

**Table 7:** Dunn's test post hoc pairwise comparisons of **female WPUE (kg/net lift) per survey**. P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 3.589e-02 | P <.05 |
| 2 | Survey Leg 2 - 4 | 1.598e-03 | P <.05 |
| 3 | Survey Leg 3 - 4 | 9.788e-01 | ns |
| 4 | Survey Leg 2 - 5 | 1.000e+00 | ns |
| 5 | Survey Leg 3 - 5 | 1.000e+00 | ns |
| 6 | Survey Leg 4 - 5 | 1.000e+00 | ns |

Significance level at 0.05. ns; nonsignificant difference.

**Table 8:** Dunn's test post hoc pairwise comparisons of **male CPUE (numbers/net lift) per survey.** P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 5.344e-14 | P <.05 |
| 2 | Survey Leg 2 - 4 | 4.164e-13 | P <.05 |
| 3 | Survey Leg 3 - 4 | 8.995e-01 | ns |
| 4 | Survey Leg 2 - 5 | 3.968e-02 | P <.05 |
| 5 | Survey Leg 3 - 5 | 8.323e-01 | ns |
| 6 | Survey Leg 4 - 5 | 1.000e+00 | ns |

Significance level at 0.05. ns; nonsignificant difference.

**Table 9:** Dunn's test post hoc pairwise comparisons of **male WPUE (kg/net lift) per survey**. P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 5.754e-07 | P <.05 |
| 2 | Survey Leg 2 - 4 | 6.927e-05 | P <.05 |
| 3 | Survey Leg 3 - 4 | 3.977e-01 | ns |
| 4 | Survey Leg 2 - 5 | 1.000e+00 | ns |
| 5 | Survey Leg 3 - 5 | 1.105e-01 | ns |
| 6 | Survey Leg 4 - 5 | 4.130e-01 | ns |

Significance level at 0.05. ns; nonsignificant difference.

## APPENDIX 4

Statistical Summary: Pairwise comparisons of mean carapace length (cm).

**Table 10:** Dunn's test post hoc pairwise comparisons **of all spanner crab's mean carapace length (cm) per survey leg.** P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 5.096e-11 | P <.05 |
| 2 | Survey Leg 2 - 4 | 1.944e-19 | P <.05 |
| 3 | Survey Leg 3 - 4 | 3.577e-01 | ns |
| 4 | Survey Leg 2 - 5 | 1.000e+00 | ns |
| 5 | Survey Leg 3 - 5 | 4.557e-01 | ns |
| 6 | Survey Leg 4 - 5 | 7.777e-02 | ns |

Significance level at 0.05. ns; nonsignificant difference.

**Table 11:** Dunn's test post hoc pairwise comparisons of **male spanner crab's mean carapace length (cm) per survey leg**. P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 2.990e-09 | P <.05 |
| 2 | Survey Leg 2 - 4 | 9.422e-07 | P <.05 |
| 3 | Survey Leg 3 - 4 | 6.667e-01 | ns |
| 4 | Survey Leg 2 - 5 | 1.000e+00 | ns |
| 5 | Survey Leg 3 - 5 | 5.147e-01 | ns |
| 6 | Survey Leg 4 - 5 | 1.000e+00 | ns |

Significance level at 0.05. ns; nonsignificant difference.

**Table 12:** Dunn's test post hoc pairwise comparisons of **female spanner crab's mean carapace length (cm) per survey leg.** P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 1.872e-02 | P <.05 |
| 2 | Survey Leg 2 - 4 | 1.152e-10 | P <.05 |
| 3 | Survey Leg 3 - 4 | 1.510e-05 | P <.05 |
| 4 | Survey Leg 2 - 5 | 1.000e+00 | ns |
| 5 | Survey Leg 3 - 5 | 1.000e+00 | ns |
| 6 | Survey Leg 4 - 5 | 1.000e+00 | ns |

Significance level at 0.05. ns; nonsignificant difference.

## APPENDIX 5

Statistical Summary: Pairwise comparisons of mean body weight (kg).

**Table 13:** Dunn's test post hoc pairwise comparisons of **female spanner crab's mean body weight (kg) per survey leg.** P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 1.589e-01 | ns |
| 2 | Survey Leg 2 - 4 | 1.180e-02 | P <.05 |
| 3 | Survey Leg 3 - 4 | 1.000e+00 | ns |
| 4 | Survey Leg 2 - 5 | 1.000e+00 | ns |
| 5 | Survey Leg 3 - 5 | 1.000e+00 | ns |
| 6 | Survey Leg 4 - 5 | 1.000e+00 | ns |

Significance level at 0.05. ns; nonsignificant difference.

**Table 14:** Dunn's test post hoc pairwise comparisons of **male spanner crab's mean body weight (kg) per survey leg.** P values were adjusted with the Bonferroni method.

| № | Comparison Groups | Carapace Length (cm) | |
|---|---|---|---|
| | | Adjusted P value | Significance level |
| 1 | Survey Leg 2 - 3 | 6.982e-06 | P <.05 |
| 2 | Survey Leg 2 - 4 | 8.035e-04 | P <.05 |
| 3 | Survey Leg 3 - 4 | 7.439e-01 | ns |
| 4 | Survey Leg 2 - 5 | 1.000e+00 | ns |
| 5 | Survey Leg 3 - 5 | 2.243e-01 | ns |
| 6 | Survey Leg 4 - 5 | 8.598e-01 | ns |

Significance level at 0.05. ns; nonsignificant difference.