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Brief Report

Length–Weight Relationships of Commercial Species in the Eastern Australian Sea Cucumber Fishery

Kristen L. McSpadden [1,2,*], Vincent Raoult [2,3], Matthew Koopman [4], Ian A. Knuckey [4] and Jane E. Williamson [2]

1 School of Environmental and Life Sciences, University of Newcastle, Ourimbah, NSW 2258, Australia
2 School of Natural Sciences, Wallumattagal Campus, Macquarie University, Sydney, NSW 2109, Australia; v.raoult@griffith.edu.au (V.R.); jane.williamson@mq.edu.au (J.E.W.)
3 School of Environment and Science, Griffith University, Gold Coast, QLD 4222, Australia
4 Fishwell Pty Ltd., Queenscliff, VIC 3225, Australia; matt@fishwell.com.au (M.K.); ian@fishwell.com.au (I.A.K.)
* Correspondence: kristen.mcspadden@gmail.com or kristen.mcspadden@uon.edu.au

Abstract: Biological data, such as length–weight relationships, are essential for the management and stewardship of harvested individuals. Sea cucumbers are a lucrative industry globally but many of the associated fisheries lack species-level biological data, which reduces the effectiveness of any management strategy. The Queensland Sea Cucumber Fishery (QSCF) on the Great Barrier Reef is managed through various controls: primarily catch limits, effort limits, zoning, and size restrictions. Over 20 species may be harvested but there is a lack of comprehensive biological data for many of these species, particularly important life history characteristics. This study addresses this knowledge gap by assessing 2621 individual length–weight relationships of key-target sea cucumber species associated with the fishery across the range of the distribution of the species and covering a variety of habitats, depths, sampling times, and management zones. Linear models with log transformations were used to analyse the relationships between length and weight. Results revealed significant positive relationships for all assessed species, with *Holothuria atra* having the clearest relationship between length and weight ($R^2 = 0.45$). Only negative allometric relationships were observed, as is the case for many species of holothurians. Despite challenges associated with measuring and weighing these soft and elastic animals, results will be useful for understanding length–weight dynamics across species. This research underscores the importance of robust biological data for the effective management of sea cucumber fisheries and ultimately reef health.

Keywords: bêche-de-mer; echinoderm; holothurian; Queensland; Great Barrier Reef; morphometrics; body condition; length and growth equations

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1. Introduction

Globally, at least 70 species of sea cucumber (Bêche-de-mer) are harvested annually in a billion-dollar industry [1,2]. While some of these fisheries such as the Western Australian Sea Cucumber Fishery are certified as sustainable [3], a lack of biological data at a species level coupled with unmanaged overharvesting and illegal trade in some countries has led to the overexploitation of many species. The rapid onset of fishing often outpaces science and management, with the high value of species and ease of capture leading to declining populations [4]. Sea cucumbers are at an elevated risk of depletion due to biological characteristics such as a density-dependent reproductive success, low mobility, and longevity [5]. Over 80% of species harvested have experienced declining population levels, leading to unanticipated collapses of fisheries and ecological extinctions of species in areas [6,7]. This is apparent in the Galapagos fishery, with local extinctions of *Isostichopus fuscus* leading to a five-year total fishing ban to attempt population recovery, despite evidence of management measures failing to prevent the overexploitation of this species [8]. In response to global population declines, six sea cucumbers have been listed by the Convention of International Trade of Endangered Species, including *Holothuria fuscogilva*, *H. whitmaei*, *H. nobilis*, *Thelenota ananas*, *T. anax*, and *Isostichopus fuscus*. Biological data, such as length–weight relationships, age and growth, mortality, and stock structure, are used to formulate optimal harvesting rates, catch quotas, rotational closures and the time needed for stock recovery [5,9,10]. In the absence of these data, assumptions are made, heightening the uncertainty of management strategies and stock assessments [11].

Length–weight relationships reflect the growth of species and are often used as a key biological input into fishery stock assessments [10]. Such information is often unavailable for sea cucumbers [1]. Obtaining robust length–weight relationships relies on capturing the full range of the species sizes and a representative sample size throughout the geographic distribution of a species [12]. Most biological data used to assess fishery stocks, however, originate from the fisheries themselves, which can be problematic for obtaining data from individuals across their full size and distribution ranges, particularly across management zones. Independent fishery data are thus key to obtaining broader size distribution data, but generally lack the extensive spatial and temporal coverage of fishery-dependent sources. Since such data do not exist for many species of commercially harvested sea cucumbers, assessments to determine stock depletion levels in a fishery are difficult, as is determining possible fishing impacts on different size classes.

The Queensland Sea Cucumber Fishery (east coast) (QSCF) covers the entirety of Australia's Great Barrier Reef (GBR) management zone, extending from Cape York to the southern limit of Tin Can Bay; however, over a third of the park is closed to the fishery [13]. The QSCF was divided into 158 rotational harvest zones (RHZs) in 2004, which can be fished for a maximum of 18 days every 3 years [13]. This applies to all harvested species except for burrowing blackfish, *Actinopyga spinea*, which contributes a large portion of annual catch and is mostly harvested from the three exclusion zones which are excluded from the triannual rotational approach: Bunkers Group, Gould Reef, and Lizard/Waining Reef [14]. As a restricted-entry, hand-harvest fishery managed primarily through catch limits, it is highly selective towards target species [14]. It also has several input controls that include rotational harvest strategies, special zones, and minimum size limits [14]. It is a relatively small sea cucumber fishery with a limited number of licenses and a total annual quota of 391 t, with 53 t allocated to white teatfish, *H. fuscogilva*; 30 t for black teatfish, *H. whitmaei*; and 308 t for 'other sea cucumbers' [13,14]. The fishery is divided into Tier 1 priority species that are preferentially targeted—including white teatfish, *H. fuscogilva*; black teatfish, *H. whitmaei*; and burrowing blackfish, *A. spinea*—then a further 18 Tier 2 species that are fished to a lesser extent [14]. The species composition of the catch has varied over time and is dependent on changing market values, species depletions, and changes in processing technology [4]. The fishery itself is recognised for independently initiating stock management techniques, such as rotational harvests [15].

As with many sea cucumber fisheries globally, detailed and current information on the stock structure, population biology, and ecology of the species associated with this fishery is limited. Most information is based on fishery catch and effort logbook data available in annual reports by the State Government, but more recently a series of fishery-independent surveys has provided much-needed biological data that can be used to estimate length–weight relationships for sea cucumber species across the GBR. This research combines fishery-dependent and -independent data to assess live length–weight relationships for six key species associated with the fishery. We aimed to (1) collect essential length–weight data for key commercial species across a broad spatio-temporal gradient, (2) improve the availability of biological data in this fishery, and (3) provide managers and stakeholders with robust length–weight relationships to inform future stock assessments. This information fills a knowledge gap of biological data required to improve our understanding of the population dynamics of these species and how we may better manage fishing effort and other anthropogenic impacts on these animals on the GBR.

2. Materials and Methods

Sampling occurred across the Great Barrier Reef Marine Park Area between September 2015 and March 2024, with animals collected from various management zones including General Use, Habitat Protection, Marine Park, and Conservation Park zones. Fishery-independent data were collected in February, March, July, and October 2023, and March 2024. Sea cucumbers were collected by experienced free divers from depths of 1 to 12 m on snorkel, in shallow reef, rubble, and sand habitats, at 18 reefs extending from Neville Coleman Reef in the south (−20°57′58″ S, 151°24′12″ E) to Lizard Island (−14°40′2″ S, 145°27′37″ E) in the northern GBR (Table 1, Figure 1). Roving surveys were conducted to locate individuals inhabiting shallow water. Upon locating each animal, the sea cucumbers were hand collected and were immediately brought to a small vessel, where the animals were measured to ±0.5 cm. Each animal was weighed in a small bucket after a two-minute draining period to the nearest 10 g using a Berkely digital spring sea scale. Similar methodologies have been employed for obtaining length–weight data for sea cucumbers for the last two decades, and this method is commonly used in this fishery [5,16–20].

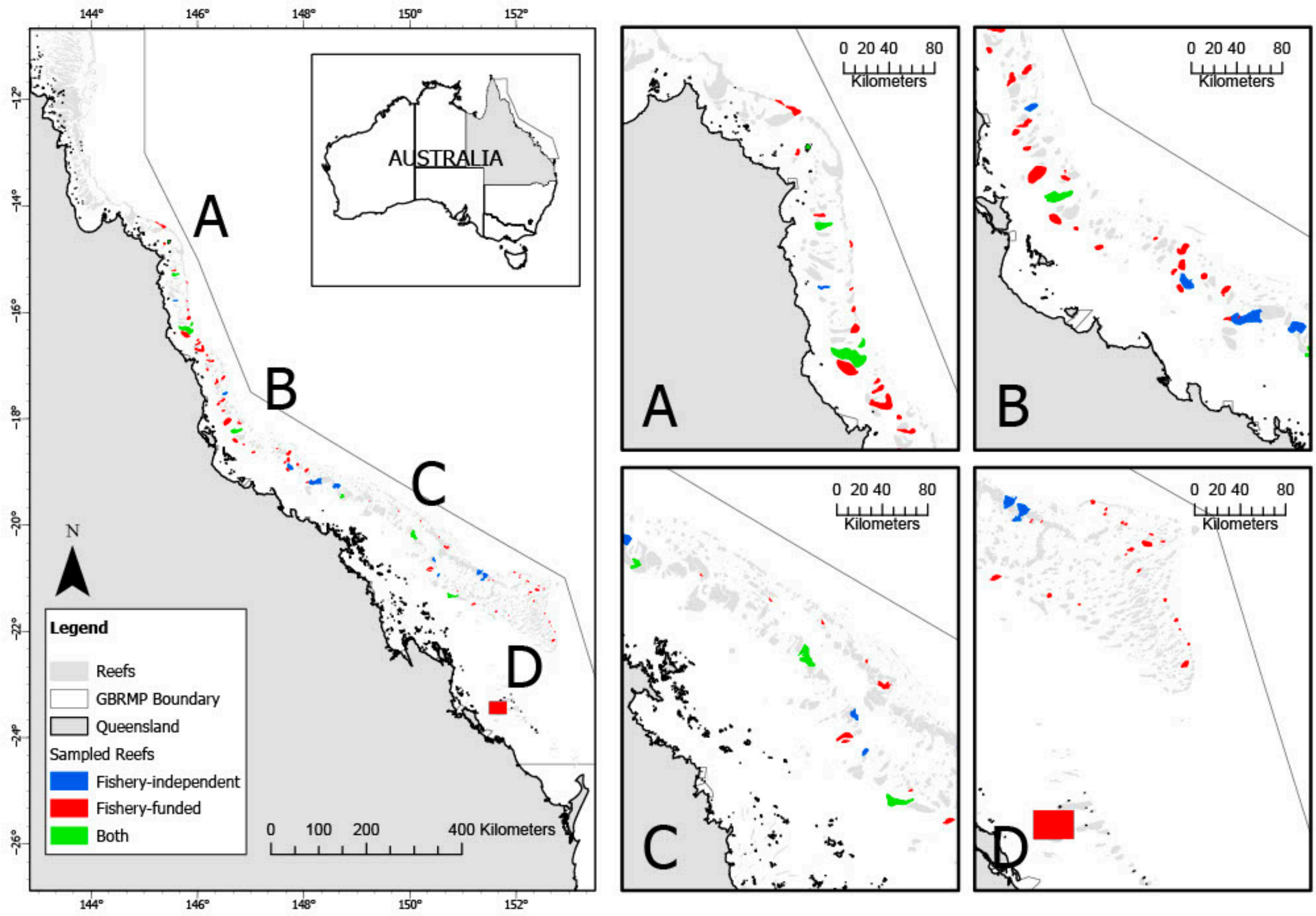

Figure 1. A map of the Great Barrier Reef Marine Park Area, in Queensland, Australia, depicting the reefs sampled throughout this study. The map highlights reefs sampled by fishery-independent researchers (blue), fishery-funded researchers (red), and reefs that both groups sampled (green). The small-scale map on the left is divided into four large-scale maps on the right, denoted as sections A, B, C, and D, from the north to the south.

Table 1. Summary spatio-temporal information of the locations in this study where sea cucumbers were briefly collected and sampled for their lengths and weights. A summary of the species and total count of sea cucumbers sampled per reef is included.

Reef	Species	No. Samples	Year
(Big) Broadhurst Reef (No. 1) (18-100a)	*Holothuria atra*, *Holothuria whitmaei*, *Stichopus herrmanni*, *Thelenota ananas*	77	2023
(Little) Broadhurst Reef (18-106)	*Holothuria whitmaei*	9	2015
Adelaide Reef (17-042)	*Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	22	2023
Agincourt Reefs (No. 4) (15-096)	*Holothuria whitmaei*	12	2015
Andersen Reef (15-090)	*Holothuria whitmaei*	8	2015
Arlington Reef (16-064)	*Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	20	2023
Batt Reef (16-029)	*Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	15	2023
Beaver Reef (17-051)	*Holothuria whitmaei*	1	2015
Blu-Lion Reef (21-566)	*Holothuria whitmaei*	5	2021
Bramble Reef (18-029)	*Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	10	2023
Britomart Reef (18-024)	*Holothuria whitmaei*, *Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	50	2023
Bunker Group	*Actinopyga spinea*	369	2023
Chauvel Reefs (North) (20-307)	*Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	6	2023
Chauvel Reefs (South) (20-308)	*Stichopus herrmanni*	3	2023
Chicken Reef (18-086)	*Holothuria whitmaei*	10	2015
Conder Reef (19-219)	*Holothuria whitmaei*	5	2021
Darley Reef (19-043)	*Holothuria whitmaei*, *Stichopus herrmanni*, *Thelenota ananas*	27	2023
Davies Reef (18-096)	*Holothuria whitmaei*	7	2015, 2021
Dingo Reef (No. 1) (19-038a)	*Stichopus herrmanni*, *Thelenota ananas*	8	2023
Dingo Reef (No. 3) (19-038c)	*Holothuria whitmaei*, *Stichopus herrmanni*	10	2023
Duncan Reef (18-020)	*Stichopus herrmanni*, *Thelenota ananas*	18	2023
Elford Reef (16-073)	*Stichopus herrmanni*, *Thelenota ananas*	5	2023
Ellison Reef (17-044)	*Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	18	2023
Endeavour Reef (15-089)	*Holothuria whitmaei*, *Thelenota ananas*	30	2023
Eyrie Reef (14-118)	*Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	22	2023
Gater Reef (22-130)	*Stichopus herrmanni*, *Thelenota ananas*	6	2023
Gibson Reef (17-017)	*Stichopus herrmanni*, *Thelenota ananas*	15	2023
Gould Reef (No. 2) (19-072b)	*Actinopyga spinea*, *Holothuria whitmaei*, *Stichopus herrmanni*, *Thelenota ananas*	405	2019, 2023
Half Moon Reef (22-103)	*Stichopus herrmanni*, *Thelenota ananas*	10	2023
Hastings Reef (16-057)	*Holothuria whitmaei*	6	2015
Heart Reef (21-575)	*Holothuria whitmaei*	5	2021
Hedley Reef (17-014)	*Holothuria whitmaei*	3	2015
Henderson Reefs (20-129)	*Stichopus herrmanni*	16	2023
Howse Reef (19-179)	*Holothuria whitmaei*	2	2021
Jewell Reef (14-079)	*Holothuria whitmaei*	11	2015
John Brewer Reef (18-075)	*Holothuria whitmaei*	38	2015
Kangaroo Reef (East) (19-063a)	*Holothuria whitmaei*, *Stichopus herrmanni*, *Thelenota ananas*	45	2023
Lark Reef (15-033)	*Holothuria whitmaei*, *Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	36	2023
Lizard Island (14-116a)	*Actinopyga spinea*, *Holothuria atra*	655	2022, 2024
Lynchs Reef (18-091)	*Holothuria whitmaei*	6	2015
Michaelmas Reef (16-060)	*Stichopus herrmanni*, *Thelenota ananas*	7	2023
Nathan Reef (17-035)	*Holothuria whitmaei*, *Thelenota ananas*	31	2023
Neville Coleman Reef (20-389)	*Stichopus herrmanni*	9	2023
Opal Reef (16-025)	*Holothuria whitmaei*, *Thelenota ananas*	47	2015, 2023
Otter Reef (18-018)	*Holothuria whitmaei*	1	2015
Paul Reef (21-086)	*Stichopus herrmanni*	21	2023
Pompey Reef (No. 1) (20-351a)	*Stichopus herrmanni*	12	2023
Reg Ward Reef (18-017)	*Stichopus herrmanni*, *Thelenota ananas*	30	2023
Rib Reef (18-032)	*Holothuria whitmaei*	1	2015

Table 1. *Cont.*

Reef	Species	No. Samples	Year
Ribbon No. 5 Reef (15-038)	*Holothuria whitmaei*	10	2015
Saville-Kent Reef (18-099)	*Holothuria whitmaei*	4	2015
Scott Reef (17-004)	*Holothuria whitmaei*	5	2015
Shrimp Reef (18-118)	*Stichopus herrmanni*, *Thelenota ananas*	7	2023
Southampton Reef (20-299c)	*Stichopus herrmanni*	15	2023
St Crispin Reef (16-019)	*Holothuria whitmaei*	9	2015
Startle Reefs (15-028)	*Stichopus herrmanni*, *Thelenota ananas*	23	2023
Thetford Reef (16-068)	*Holothuria whitmaei*	9	2015
Tongue Reef (16-026)	*Holothuria atra*, *Holothuria whitmaei*, *Stichopus herrmanni*, *Stichopus vastus*, *Thelenota ananas*	84	2023
U/N Reef (14-077a)	*Holothuria whitmaei*	12	2015
U/N Reef (14-139)	*Holothuria whitmaei*	4	2015
U/N Reef (14-140)	*Holothuria whitmaei*	5	2015
U/N Reef (17-065)	*Holothuria whitmaei*	4	2015
U/N Reef (18-022)	*Holothuria whitmaei*	10	2015
U/N Reef (19-041)	*Stichopus herrmanni*, *Thelenota ananas*	14	2023
U/N Reef (19-042)	*Stichopus herrmanni*, *Thelenota ananas*	8	2023
U/N Reef (19-302)	*Holothuria whitmaei*	4	2021
U/N Reef (20-166)	*Holothuria whitmaei*	17	2021
U/N Reef (20-194a)	*Holothuria whitmaei*	6	2021
U/N Reef (20-382)	*Stichopus herrmanni*, *Thelenota ananas*	17	2023
U/N Reef (20-392)	*Holothuria whitmaei*	5	2021
U/N Reef (20-394)	*Thelenota ananas*	3	2023
U/N Reef (20-398)	*Holothuria whitmaei*	6	2021
U/N Reef (21-082)	*Stichopus herrmanni*	16	2023
U/N Reef (21-097)	*Holothuria whitmaei*	1	2021
U/N Reef (21-141)	*Stichopus herrmanni*	26	2023
U/N Reef (21-143)	*Holothuria whitmaei*	21	2021
U/N Reef (21-198)	*Holothuria whitmaei*	5	2021
U/N Reef (21-200)	*Holothuria whitmaei*	6	2021
U/N Reef (21-221)	*Holothuria whitmaei*	4	2021
U/N Reef (21-236)	*Stichopus herrmanni*	13	2023
U/N Reef (21-239)	*Holothuria whitmaei*	7	2021
U/N Reef (21-242a)	*Holothuria whitmaei*	3	2021
U/N Reef (21-265)	*Stichopus herrmanni*, *Thelenota ananas*	10	2023
U/N Reef (21-290)	*Stichopus herrmanni*, *Thelenota ananas*	11	2023
U/N Reef (21-450)	*Stichopus herrmanni*, *Thelenota ananas*	16	2023
U/N Reef (21-461)	*Stichopus herrmanni*, *Thelenota ananas*	12	2023
U/N Reef (21-560)	*Holothuria whitmaei*	1	2021
Yankee Reef (18-074)	*Holothuria whitmaei*	3	2015

Fishery-funded surveys collected length–weight measurements for all species excluding *Holothuria atra,* with individuals inhabiting shallow waters collected on snorkel or hookah systems, and animals located in deeper waters collected by commercial divers using hookah systems. For fishery-funded surveys, the methods for obtaining length–weight data are the same as described above. Burrowing blackfish, *A. spinea*, were collected by experienced commercial divers on hookah systems in low-complexity, open-sand and algal-mat-dominated habitats, at depths of 10 to 35 m. Data were collected in 2019 at Gould Reef, at Lizard Island in February 2022 and March 2024, and at the Bunkers Group in January 2023 (Table 1, Figure 1). Data for prickly redfish, *T. ananas*, and curryfish, *Stichopus herrmanni* and *S. vastus*, were collected in the central region of the GBR from 19 reefs, from Chicken Reef to Startle Reef in the north, and 15 reefs in the Swains region, from Half Moon Reef in the south to Henderson Reef in the northern Swains, in September and October 2023 (Table 1, Figure 1). Black teatfish were collected in September 2015 from 25 reefs in the central GBR region and from 18 reefs in the Southern GBR in April 2021. For these species, individuals were collected at depths of 2 to 30 m (Table 1, Figure 1).

As sea cucumbers can elongate and contract their bodies, handling the animals can alter the in situ length of an animal [18,21]. Fishery-funded surveys also initially collected in situ measurements of collected sea cucumbers in an undisturbed state on the benthos and assessed the relationship between these data and the length measurements obtained once the animal was brought to the nearby vessel. No significant relationship was found between in situ length data and length data obtained on the boat compared to measurements in the water [22]; thus, to improve efficiency and reduce bottom time for divers, all measurements were collected on board the vessel. To assess whether in situ or on-vessel measurements are more accurate, the goodness-of-fit for finalized models in this study (R^2) will be compared to those obtained from other studies, with the assumption that the method that results in a lower residual variation is more reliable.

Data on commercially harvested individuals were combined with those collected during fishery-independent surveys to increase the size range of individuals available for estimating the length–weight relationships. Data were analysed using linear models with log base 10 transformations for both length and weight measurements. This method follows the equations that were proficient at describing length–weight relationships in other studies on sea cucumbers [19,23]. These linear models are direct log base 10 transformations of the typical power relationship that describes length and growth relationships in many marine species, including sea cucumbers ($W = aL^b$). Analysing and visualising these relationships with transformed linear models allows more effective interpretation of residual distributions and identification of outliers. The response variable was set as weight (kg), with length (cm) as the determinant. All analyses were conducted in R V. 4.3.1 [24]. To enable these relationships to be interpreted as part of the broad literature, we present the corresponding back-transformed models in the more traditional power equation format.

3. Results

A total of 2621 samples were used to estimate length–weight relationships across six key species (Table 2). All species had significant ($p < 0.001$) positive linear relationships between logged weight and size. *Holothuria atra* had the strongest linear relationship, with an R^2 of 0.45, while *H. whitmaei* had a much broader residual distribution ($R^2 = 0.19$; Figure 2). All species had negative allometric relationships with exponent values < 3, while *H. whitmaei* had the lowest exponent value of 0.46, suggesting that larger individuals of the species increase in length but not in weight.

Table 2. Summary data on lengths and weights of live sea cucumbers measured in this study, with exponential equations derived from linear models above.

Species and Common Name	*n*	Mean Length ± SD (cm)	Smallest and Largest (cm)	Mean Weight ± SD (kg)	Range (kg)	Length–Weight Relationship (W = kg, L = cm)
Actinopyga spinea Burrowing Blackfish	1344	22.99 ± 4.95	3.6–43.5	0.72 ± 0.34	0.01–2.15	$W = 0.0022 \times L^{1.81}$
Holothuria atra Lollyfish	78	17.48 ± 4.30	8.0–29.0	0.15 ± 0.07	0.03–0.33	$W = 0.0038 \times L^{1.26}$
Holothuria whitmaei Black Teatfish	464	27.38 ± 6.72	14.0–50.0	1.82 ± 0.43	0.50–3.57	$W = 0.3908 \times L^{0.46}$
Stichopus herrmanni Curryfish herrmanni	383	38.56 ± 7.74	15.0–73.0	2.85 ± 1.06	0.48–7.29	$W = 0.0457 \times L^{1.12}$
Stichopus vastus Curryfish vastus	50	33.33 ± 5.46	21.0–44.0	2.73 ± 0.59	1.21–3.94	$W = 0.1250 \times L^{0.87}$
Thelenota ananas Prickly Redfish	302	48.17 ± 9.67	24.0–89.0	4.21 ± 1.34	1.34–8.24	$W = 0.1483 \times L^{0.85}$

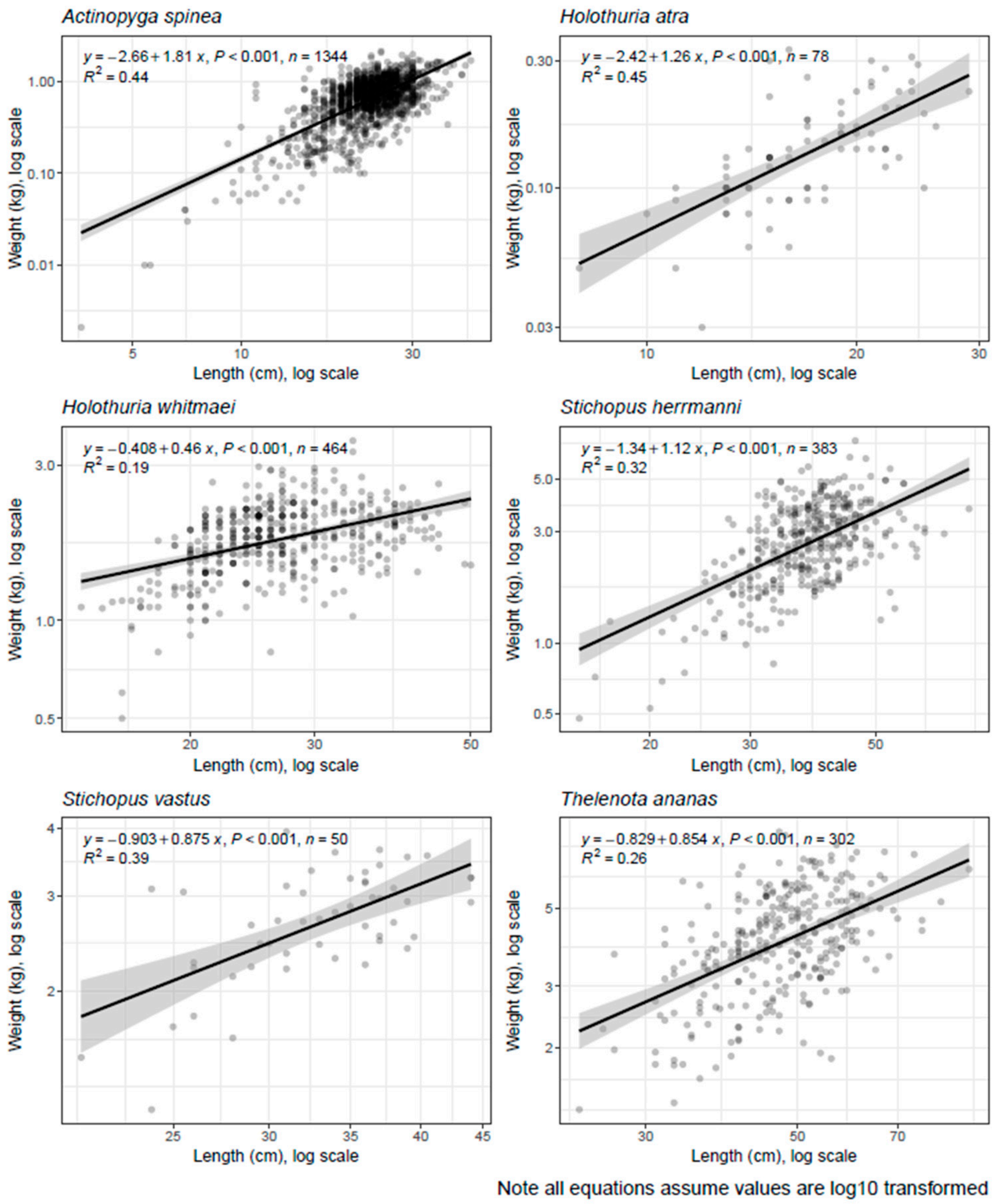

Figure 2. The length–weight scatterplots for sea cucumber species sampled across the Great Barrier Reef. The equations provided assume that both length and weight variables have been log10 transformed, noting the log10 distributions for both the length and weight axes. The black lines represent linear regression, with the shaded areas representing the 95% CI. Note: all data points are translucent grey; however, some appear black if several individuals have the same values.

4. Discussion

To date, most length–weight relationships for species found on the GBR have been derived from studies conducted over two decades ago, extrapolated from other areas within their distributions, had restricted sample sizes, and/or had an over-reliance on fishery-derived samples. This research gives the most robust estimates of length–weight relationships for the assessed species on the GBR. Such data provide a better understanding of the population biology of these species, but also improve the biological inputs into stock assessment models. Data for the species sampled here span many years and numerous localities over the ranges of each species on the GBR so that any local or temporal within-species differences that might be present are pooled into one relationship, increasing the ubiquity of application across the GBR. Our datasets are an order of magnitude greater than other previously available datasets for this region. To our knowledge, we record the first comprehensive length–weight data for *A. spinea*, *H. atra* and *S. vastus*. Our data also indicate a larger maximum size of 89 cm for *T. ananas* on the GBR, which was previously recorded at 67 cm [25], and a larger maximum size of 43.5 cm for *A. spinea*, previously recorded at 38 cm [2]. The presence of several *T. ananas* in our dataset larger than the previously recorded maximum length highlights the importance of augmenting fishery data with non-fishery data for such biological relationships.

Not surprisingly given the plasticity of sea cucumber bodies, substantial variations in length–weight relationships existed for all species assessed. Model goodness-of-fit (R^2) was similar to that of other species measured in situ (e.g., Hammond and Purcell 2024, 0.23–0.52; Setyastuti et al., 2024, 0.2–0.75), confirming that in situ and ex situ length–weight relationships are relatively similar in estimating length–weight relationships [5,26]. Size relationships for sea cucumbers are notoriously inconsistent relative to fishes largely due to the ability of sea cucumbers to increase and decrease fluid in large amounts through body contractibility and to their vascular systems that can hold variable amounts of water [18]. Such inconsistency can be dampened with the inclusion of large numbers of individuals, as we have in our datasets. Species-specific differences in length–weight relationships exist, and uncertainty increases around those relationships in our datasets for species with a lower sample size (e.g., *S. vastus*), a diversity of maturity statuses (unknown), or those with an increased ability to internally regulate fluid (e.g., *H. whitmaei*). Such variability has also been noted in these and other species on the GBR [17,27] and in species from other regions such as the Timor Sea [18]. Hammond and Purcell, 2023, found substantial variability in weights of the sea cucumber *Personothuria graeffei*, with small animals (<700 g) tending to gain weight, whereas large animals (>700 g) had lost weight on recapture over a two-year period. As sea cucumber lengths and weights are highly variable within-species, due to several factors including their ability to retain large quantities of sea water, stomach contents (i.e., if the animal has a full or empty stomach), reproductive stage (weight contribution of fecund gonads), and ability to eviscerate internal organs under duress [18,28], it is important to sample across the full size range, habitat extent, depth gradients, and seasons. For clarity, sea cucumbers possess a unique defensive strategy, known as evisceration, where they can eject their internal organs (all or part of their intestine) through their anus or mouth, as a response to a stressor, with the ability to regenerate these organs over time [29,30]. It is also worth noting that fishing may influence length–weight relationships if fishing pressures also alter natural growth and maturation rates; however, this phenomenon is less studied in invertebrate fisheries [31,32]. This reiterates the importance of sampling many individuals across fished and unfished management zones. Nevertheless, sample size is not always a good indicator of relationship fit (e.g., *H. atra*), and the length–weight relationship on a dataset of any size is still the most commonly used metric feeding into fishery' stock assessments due to the ease of data collection.

Choosing the appropriate model to describe growth patterns is an important part of accurately describing length and growth relationships [12]. Most sea cucumbers have exponential length–weight relationships [23], which is why this model was chosen for these species. These models are useful for comparing species and populations from different regions, as sea cucumbers can accumulate more weight per length as they grow, or the inverse whereby they lengthen faster than they get heavier [16]. In our research, all species demonstrated negative allometric relationships with exponent values < 3 where individuals grow longer but their relative weight at longer lengths was less than expected. Interestingly, the relationship for *A. spinea* was closest to isometric (b = 1.81), growing more consistently in weight with length, while that of *H. whitmeai* was near asymptotic (b = 0.46). Our data demonstrate the importance of evaluating length–growth relationships at a species level and highlight different growth patterns for different species of sea cucumber.

Whilst this study is a significant step forward for the management of sea cucumbers in the Queensland Sea Cucumber Fishery, we also note the potential biases and limitations within. Notably, samples were collected by commercial fishers throughout fishery-funded surveys and whilst this is unlikely to affect length–weight relations, commercial fishers could access greater depths on hookah systems, which may have induced additional stressors to sea cucumbers due to longer handling times. Additionally, this study was geographically limited to the Great Barrier Reef Marine Park Area. Whilst this study covered an ecologically significant spatio-temporal gradient for this region, these data are most applicable to the Queensland Sea Cucumber Fishery and its management. To bolster the applicability of these data for use across multiple sea cucumber fisheries, future work should include data collected in various countries and across all seasons. Considering the high densities of some sea cucumbers on the GBR and beyond [1,7,33], along with their potential contribution to reef health [34,35], understanding biological data at a species level transcends further than fisheries applications. Informed decision-making based on species-level data for sea cucumbers may be crucial for the effective management and sustainability of sea cucumber fisheries and coral reef ecosystems.

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