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NOAA Administrative Report H-24-03

October, 2024

U.S. Department of Commerce
Gina Raimondo, Secretary

National Oceanic and Atmospheric Administration
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Recommended citation

Matthews T., Schemmel E., Cruz, E. (2024). Updating length-weight relationships for 22 reef and bottomfish species from Guam. Department of Commerce. NOAA Administrative Report. H-24-03. doi: 10.25923/7pgs-1c15

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Executive Summary

Length-weight relationships are a valuable resource when working with survey data, and a necessary input for many stock assessment models. Data from the Guam Commercial Fisheries Biosampling Program were used to generate length-weight relationships for 13 bottomfish management unit species and 9 coral reef ecosystem component species. These represent considerable improvements over previously available values, with much greater sample sizes and expanded size ranges.

Introduction

Length and weight are two fundamental metrics used in studying fishes and almost any other living organism. The allometric growth equation ($Weight = a * Length^b$) is typically used to define the relationship between increases in fish length and weight. Once developed, this formula can be used to estimate weight from length, or vice versa.

In Guam, creel surveys conducted by the Department of Agriculture, Division of Aquatic and Wildlife Resources are a major source of fishery information (Ma et al. 2022). To limit the time requested of participating fishers, surveyors will often only measure the length of fish from the catch. Length-weight coefficients are then used to estimate the weight of the measured fish, allowing the total catch weight to be calculated. Length-weight coefficients are also used in other surveys (e.g. diver surveys (Ayotte et al. 2015)) and in stock assessments (Bohaboy and Matthews 2024). The availability of Guam-specific length-weight coefficients can improve the reliability of estimates across these applications.

The 2023 Mariana Archipelago Stock Assessment and Fishery Evaluation report identifies species of particular interest to managers (WPRFMC 2024). These include 13 bottomfish management unit species and 9 priority coral reef ecosystem component species, which are the subject of this report. Guam-specific length-weight coefficients are available for all but one of these species (Kamikawa et al. 2015). However, over a decade worth of new length and weight data are available, presenting a timely opportunity to update the existing length-weight coefficients.

Materials and Methods

Data source

Data collected in Guam through the Pacific Islands Fisheries Science Center Commercial Fisheries Biosampling Program (Sundberg et al. 2015) were retrieved from a database maintained by the Western Pacific Fishery Information Network. The data were collected from August 2009 through July 2024. Over this period, 3644 fishing trips were sampled. In most cases, the entire catch from these trips was identified to species and fork-length measurements in centimeters were obtained for every fish, while weight in grams was recorded for most specimens. Generally, weights of individual fish were not collected once a sufficient number of paired length-weight data were collected. Only paired length-weight measurements for fish identified to species were included in the present analysis.

Length-weight data for three species were filtered to account for potential species misidentifications. First, *Etelis carbunculus* is visually similar to a recently identified cryptic species, *E. boweni*, except that the newly identified species reaches much greater size (Andrews et al. 2021). A maximum length filter of 55 cm was applied to the *E. carbunculus* data to remove probable *E. boweni*. While this would retain smaller *E. boweni*, Dahl et al. (2024) demonstrated that *E. boweni* represent only about 8% of previously identified *E. carbunculus* samples from the Guam biosampling program and are disproportionately present in the larger size classes. Thus, very few *E. boweni* likely remain after the filtering.

Maximum length filters were also applied for *Pristipomoides flavipinnis* and *P. sieboldii* due to misidentification with *P. filamentosus*, which reaches greater size. Fishers have reported difficulty distinguishing *P. filamentosus* from large *P. flavipinnis* and all *P. sieboldii* (Iwane et al. 2023). A maximum length filter of 50 cm was applied to *P. flavipinnis* and 44 cm for *P. sieboldii*, representing values 20% greater than local estimates of their asymptotic length.

Data manipulation

Paired length-weight measurements were analyzed by species using the statistical language R (R Core Team, 2022). Code used in a similar analysis of Guam biosampling data (Kamikawa et al. 2015) to automatically remove apparent outliers and produce parameters of the length-weight regressions was replicated for the present Guam biosampling data. The general methodology is described below.

For each species, paired length-weight measurements were fit to the model:

$$W = a * L^b$$

where W is the weight (g), L is the fork length (cm), and a and b are model parameters. To estimate the parameters via linear regression, a natural log transformation was applied, yielding:

$$\ln(W) = \ln(a) + b * \ln(L)$$

Linear regression of the logged weight onto the logged length measurements produced estimates of $\ln(a)$ and b.

After running the initial regression for each species, outliers were identified in ln-ln space as those points farther than four residual standard error measurements away from the regression line. Outliers were removed and the model was re-fit to the remaining paired length-weight measurements.

Although the code produced length-weight regression parameters for all species, only species deemed to have sufficient data for a reliable regression are reported. This was determined based on two criteria, as previously adopted when deriving length-weight relationships from CNMI biosampling data (Matthews et al. 2019):

- There must be a minimum of 100 paired length-weight measurements.
- The coefficient of determination (r^2) of the linear regression must be greater than or equal to 0.9.

Results

All 22 species had sufficient paired data to produce reliable length-weight regressions (Table 1). This represents all of the bottomfish management unit species and coral reef ecosystem component species.

Table 1. Length-weight relationships for 22 bottomfish management unit species and coral reef ecosystem component species from Guam. Sample size (n), minimum and maximum fork lengths (L_{min}, L_{max}), minimum and maximum weights (W_{min}, W_{max}), allometric growth parameters (a, b), 95% confidence intervals for the growth parameters ([$a_{0.025}$, $a_{0.975}$] and [$b_{0.025}$, $b_{0.975}$]), and the coefficient of determination (r^2) are given.

Scientific Name	**n**	**L_{min} (cm)**	**L_{max} (cm)**	**W_{min} (g)**	**W_{max} (g)**	**a**	**b**	**$a_{0.025}$**	**$a_{0.975}$**	**$b_{0.025}$**	**$b_{0.975}$**	**r^2**
Bottomfish species												
Aphareus rutilans	526	15.8	97.6	64	12200	0.0248	2.85	0.0233	0.0264	2.83	2.87	1.00
Caranx ignobilis	503	14.5	120.4	71	32205	0.0246	2.96	0.0236	0.0257	2.95	2.97	1.00
Caranx lugubris	467	10.6	80.8	190	10659	0.0313	2.88	0.0282	0.0349	2.85	2.91	0.99
Etelis carbunculus	1790	12.0	52.1	28	2370	0.0160	3.03	0.0154	0.0166	3.02	3.04	0.99
Etelis coruscans	910	15.4	95.0	394	13471	0.0379	2.78	0.0341	0.0421	2.75	2.80	0.98
Lethrinus rubrioperculatus	3375	15.4	57.4	67	2569	0.0266	2.89	0.0254	0.0279	2.88	2.91	0.98
Lutjanus kasmira	2121	6.5	30.3	12	502	0.0143	3.08	0.0131	0.0155	3.06	3.11	0.96
Pristipomoides auricilla	10224	10.7	39.0	20	1208	0.0119	3.15	0.0116	0.0122	3.14	3.15	0.98
Pristipomoides filamentosus	367	16.6	67.4	73	4937	0.0262	2.89	0.0240	0.0285	2.86	2.91	0.99
Pristipomoides flavipinnis	1031	13.2	48.2	40	1941	0.0158	3.04	0.0149	0.0169	3.02	3.05	0.99
Pristipomoides sieboldii	527	17.2	41.5	92	1258	0.0205	2.96	0.0176	0.0238	2.91	3.00	0.97
Pristipomoides zonatus	1872	11.5	44.5	28	1404	0.0155	3.09	0.0149	0.0162	3.07	3.10	0.99
Variola louti	1103	20.3	49.7	122	2084	0.0141	3.07	0.0125	0.0160	3.03	3.10	0.96
Coral reef species												
Caranx melampygus	1408	12.5	75.6	38	8580	0.0237	2.93	0.0228	0.0247	2.92	2.95	0.99
Chlorurus frontalis	516	18.2	48.5	121	2714	0.0169	3.09	0.0153	0.0186	3.06	3.12	0.99
Epinephelus fasciatus	2422	14.0	35.9	38	508	0.0134	3.05	0.0120	0.0149	3.01	3.08	0.93
Lethrinus harak	600	13.3	35.5	53	912	0.0258	2.92	0.0224	0.0297	2.88	2.97	0.96
Lethrinus olivaceus	681	20.2	72.2	135	6638	0.0189	2.94	0.0177	0.0201	2.92	2.96	0.99
Lutjanus fulvus	410	16.6	34.4	89	700	0.0164	3.06	0.0128	0.0210	2.98	3.14	0.93
Naso unicornis	8447	17.9	57.2	138	3993	0.0280	2.91	0.0274	0.0287	2.90	2.92	0.99

Scientific Name	n	L_{min} (cm)	L_{max} (cm)	W_{min} (g)	W_{max} (g)	a	b	$a_{0.025}$	$a_{0.975}$	$b_{0.025}$	$b_{0.975}$	r^2
Scarus rubroviolaceus	2236	18.2	47.8	129	2848	0.0116	3.18	0.0110	0.0122	3.16	3.19	0.99
Siganus spinus	1563	9.1	27.0	14	447	0.0297	2.85	0.0272	0.0325	2.82	2.88	0.95

Discussion

These 22 length-weight relationships represent notable improvements for 21 of the species and an entirely new set of estimates for *Caranx ignobilis*. Considerably greater sample sizes were available than during the previous assessment by Kamikawa et al. (2015), particularly for the bottomfish management unit species. Increased availability of small and large specimens expanded the size range over which the regression coefficients should be applied. However, caution should be exercised for *Siganus spinus*, which exhibits differential growth across its size range. Its regression coefficients should only be applied to lengths between 13 and 24 cm.

Acknowledgments

We acknowledge and thank the participation of Guam's local fishing community and the Guam Fishermen's Cooperative Association in the Pacific Islands Fisheries Science Center Commercial Fisheries Biosampling Program. Contracting partners and on the ground biosampling staff from Arc Environmental, Lynker, Ocean Associates, and Freestone Environmental Services. Collaborations with the Western Pacific Regional Fisheries Management Council, Guam Department of Agriculture Division of Aquatic and Wildlife Resources, and other local partners.

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