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Length–weight relations of underutilized nine fish species (Actinopterygii) from set-net fishery, Mie, Japan

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Abstract

Bycatch, the unintentional capture of non-target species, poses a significant challenge in fisheries management worldwide. Underutilized bycatch species often lack biological information, hindering the assessment of their stock status and the implementation of appropriate management strategies. This study investigated the length–weight relations (LWRs) of 9 of 14 underutilized bycatch fish species collected from set-net fisheries in Nishiki, Mie Prefecture, Japan, during the 2018–2020 fishing seasons. The following fish species were studied: *Hyperoglyphe japonica* (Döderlein, 1884); *Labracoglossa argenteiventris* Peters, 1866; *Macroramphosus sagifue* Jordan et Starks, 1902; *Microcanthus strigatus* (Cuvier, 1831); *Ostorhinchus semilineatus* (Temminck et Schlegel, 1843); *Parapriacanthus ransonneti* Steindachner, 1870; *Rexea prometheoides* (Bleeker, 1856); *Siganus fuscescens* (Houttuyn, 1782); *Upeneus japonicus* (Houttuyn, 1782). A total of 251 fishing operations were conducted, and the collected fish specimens were measured for length (fork length) and wet weight. Simple regression analysis was performed on the logarithm of length and weight data to estimate the LWR parameters (a, b, and R^2) for each species. The estimated values of the relative growth coefficient (b) ranged from 2.862 to 3.311, and the coefficients of determination (R^2) were above 0.8 for all species, indicating robust LWR estimations. Notably, five species were not previously listed or credibly described in FishBase, and four were new records for the Japanese coast. This study provides new biological information on LWRs for underutilized bycatch fish species, contributing to our understanding of their population dynamics and supporting future management efforts for sustainable fisheries and biodiversity conservation.

Keywords

biodiversity conservation, bycatch, fisheries management, length–weight relation, population dynamics, set-net fishery, stock assessment, underutilized fish species

Introduction

The waters surrounding Japan boast exceptionally high species diversity, even on a global scale (Fujikura et al. 2010). Various fishing methods have been employed along Japan's coast since ancient times. These methods, including set nets, seine nets, trawl nets, and gillnets, capture a diverse array of fish species. In coastal fisheries, the primary target species for catch are those with high commercial value and large landings. However, due to the wide variety of species targeted for catch, unintentional bycatch of other species is common.

Bycatch refers to catches that are not specifically targeted, utilized, or managed catches. It is reported to constitute 40.4% of the global ocean catch (Hall 1996; Davies et al. 2009). This unintentional bycatch threatens the stock status of the affected fish species. The lack of information for stock assessment poses a significant challenge (Hall 1996). Accumulating detailed information on biological characteristics, in addition to species, size, and weight, is essential to consider appropriate bycatch management.

However, studies on bycatch of non-target fish species (i.e., often underutilized), excluding sea turtles, marine mammals, and seabirds, usually provide broad, country-specific, or fishery-specific examples (Alverson et al. 1994; Kelleher 2005; Finkbeiner et al. 2011; Oliver et al. 2015). These studies lack biological data (Kindong et al. 2020; Armelloni et al. 2021; Heimann et al. 2023). Information on underutilized fish is seldom recorded during fish surveys (Stohs and Harmon 2022), hindering assessments of their distribution, abundance, and population structure. Fish surveys often record bycatch of non-fish vertebrates and large crustaceans, which can result in undesirable mortality of both target and non-target species.

Length–weight relations (LWR) are crucial ecological data for understanding underutilized fish species. LWR provides valuable insights into fish population dynamics, aiding in stock assessments, size limit determinations, and fishing quota settings (Rodríguez-García et al. 2023). Understanding the LWR of each fish species enables tracking changes in body mass index and length composition, estimating growth patterns, and body condition of sampled fish specimens (Shubhadeep et al. 2022). Establishing LWRs for newly recorded fish species is vital for estimating biological weights and observing changes over time (Kodeeswaran et al. 2020). Thus, summarizing LWRs of bycatch species is crucial for enhancing our comprehension of fish populations and providing valuable insights for future research and management endeavors.

The set-net fishery is one of Japan's primary fisheries, contributing approximately 40% of the total production in Japan's coastal fisheries (Akiyama 2007; Anonymous 2024). It represents a passive fishing method, leading to the capture of various species due to low selectivity yet raising concerns about bycatch (Cheng and Chen 1997; Akiyama 2007). This study aimed to estimate the length–weight relations (LWR) of underutilized bycatch fish species collected from set nets in Nishiki, Oki-cho, Mie Prefecture, facing the Pacific Ocean.

Materials and methods

The study was conducted on large set nets operating in the northern coastal area of the Kumano-nada Sea. This set net was positioned off the coast of Nishiki, Taiki-cho, Watarai-gun, Mie Prefecture (34°11′38″N, 136°24′31″E) (Fig. 1) and comprised a total length of 230 m with an installed depth of 50 m. The set net consisted of two final chambers with the top covered. Surveys were conducted 26 times during the 2018 fishing season (28 Nov. 2018–17 Jun. 2019), 94 times during the 2019 fishing season (2 Dec. 2019–21 Jul. 2020), and 131 times during the 2020 fishing season (2 Dec. 2020–18 Jun. 2021), totaling 251 operations.

During the study, researchers boarded a set-net fishing boat to collect underutilized bycatch species that the fishermen sorted after the catch was hauled on board. The remainder of the catch was landed at Nishiki Port (34°12′54″N, 136°23′40″E). The landed catch was further sorted on a sorting table, and underutilized fish species that were discarded in the process were also collected. The collected

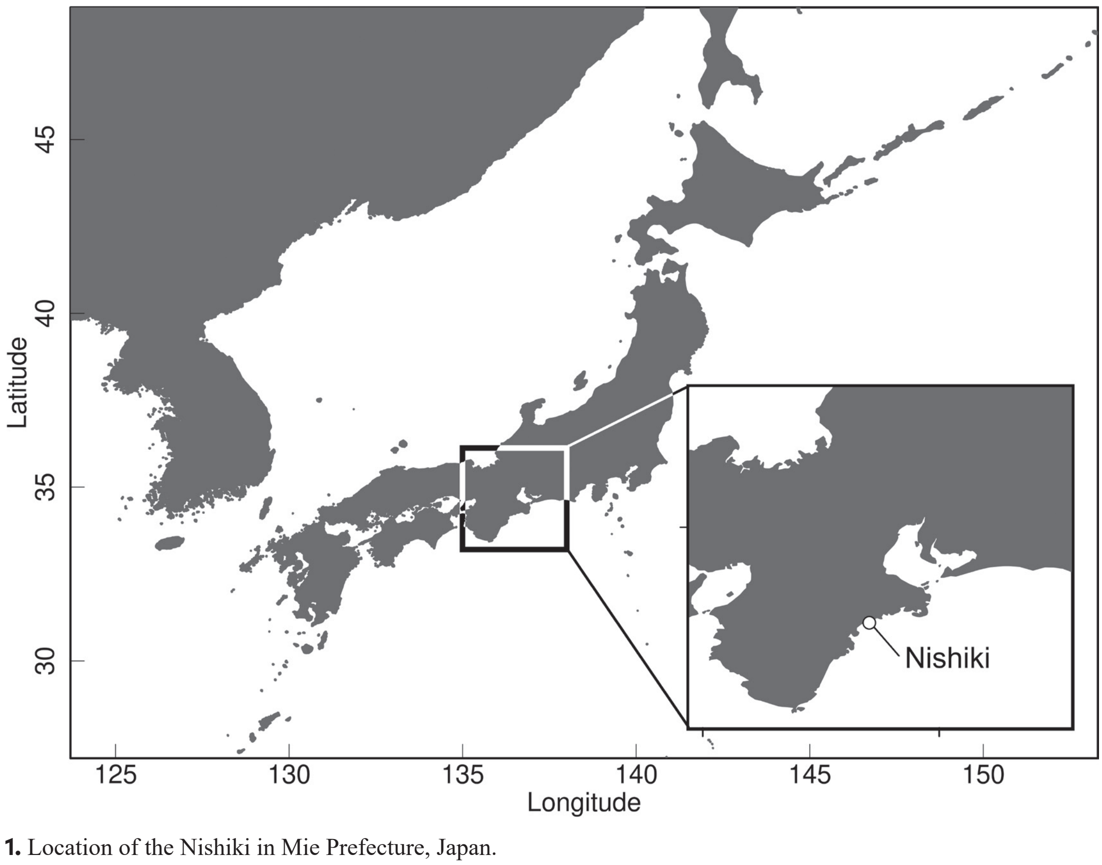

Figure 1. Location of the Nishiki in Mie Prefecture, Japan.

unutilized bycatch species were measured for length (fork length) and wet weight. Fork length was measured in 1 cm increments, weight less than 1 kg in 1 g increments, and weight greater than 1 kg in 10 g increments. Species identification was based on standard literature (Nakabo 2013).

In the analysis, simple regression analysis was performed on the logarithm of fork length (L) and weight (W) (log L, log W) for the bony fish species that could be discriminated to species. The calculated Cook's distance was rounded to the second decimal place, and values greater than 1 were excluded as outliers (Cook and Weisberg 1982). After outliers were excluded, species with ten or more observations were considered for analysis. For each analyzed fish species, the relation between L and W was applied to the allometric equation

$$W = aL^b$$

to calculate the initial growth coefficient a, relative growth coefficient b, and determination coefficient R^2. The statistical analyses were performed with R 4.2.2 (R Core Team 2022).

A large-scale language models, Claude 3 (https://www.anthropic.com/claude), were used for the English review of this manuscript.

Results

The survey revealed that a total of 679.4 tonnes of total catch weight was landed during 251 operations during the 2018–2020 fishing season. A total of 208 species with a total weight of 5.9 tonnes of underutilized bycatch species were recovered, representing 1% of the total catch weight landed. Bony fish species comprised 152 species and 1227 kg, or 31% of the total. The analyzed bony fishes encompassed 14 species from 13 orders and 14 families. Five of these species were removed from the final results because three species of them had either significantly low R^2 values such as *Abudefduf vaigiensis* (Quoy et Gaimard, 1825); *Lagocephalus sceleratus* (Gmelin, 1789); and *Pempheris schwenkii* Bleeker, 1855 or were deviated significantly from the a or b values of existing reports in FishBase (Froese and Pauly 2024), such as *Pterocaesio trilineata* Carpenter, 1987, and *Spratelloides gracilis* (Temminck et Schlegel, 1846). Commonly exploited species like *Engraulis japonicus* Temminck et Schlegel, 1846 and *Sardinops melanosticta* (Temminck et Schlegel, 1846) were also caught as bycatch at the study site but were excluded from the analysis in this study. The presently reported study focused on a total of 909 fish individuals representing the following nine fish species: *Hyperoglyphe japonica* (Döderlein, 1884); *Labracoglossa argenteiventris* Peters, 1866; *Macroramphosus sagifue* Jordan et Starks, 1902; *Microcanthus strigatus* (Cuvier, 1831); *Ostorhinchus semilineatus* (Temminck et Schlegel, 1843); *Parapriacanthus ransonneti* Steindachner, 1870; *Rexea prometheoides* (Bleeker, 1856); *Siganus fuscescens* (Houttuyn, 1782); *Upeneus japonicus* (Houttuyn, 1782). Those fishes belonged to eight orders and nine families (Table 1).

The relation between weight (W) and fork length (L) was plotted for 9 species (Fig. 2), revealing distinct patterns for each fish species. The number of samples, along with length, weight, and estimated values of a, b, and R^2 for each fish species, are presented in Table 1. The a values ranged from 0.003 (*Rexea prometheoides*) to 0.019 (*Parapriacanthus ransonneti*; *Upeneus japonicus*), while the b values ranged from 2.862 (*Macroramphosus sagifue*) to 3.311 (*Hyperoglyphe japonica*). High coefficients of determination (R^2 values) ranging from 0.806 (*Parapriacanthus ransonneti*) to 0.994 (*Hyperoglyphe japonica*) were obtained for all species.

Table 1. Length–weight relation (LWR) parameters of 9 underutilized fish species sampled in Nishiki, Japan.

Species	n	Fork length [cm]		Weight [g]		Regression parameters				
[FAMILY]		Range	Mean ± SD	Range	Mean ± SD	a	95% CI of a	b	95 CI of b	R^2
Hyperoglyphe japonica [CENTROLOPHIDAE]	13	11.2–24.9	20.15 ± 3.91	25–400	162.46 ± 104.20	0.012	0.010–0.015	3.311	3.225–3.397	0.994
Labracoglossa argenteiventris [KYPHOSIDAE]	155	4.6–16.7	8.35 ± 2.27	1–72	9.89 ± 13.64	0.007	0.006–0.009	3.272	3.170–3.373	0.963
Macroramphosus sagifue [CENTRISCIDAE]	53	4.4–9.6	7.31 ± 1.23	1–7	2.70 ± 1.37	0.008	0.005–0.015	2.862	2.569–3.154	0.881
Microcanthus strigatus [KYPHOSIDAE]	37	3.7–16.2	10.33 ± 5.02	1–135	50.24 ± 45.29	0.012	0.002–0.064	3.125	2.559–3.691	0.924
Ostorhinchus semilineatus [APOGONIDAE]	397	4.7–11.5	7.33 ± 1.43	1–25	6.69 ± 4.51	0.014	0.012–0.017	3.034	2.945–3.124	0.919
Parapriacanthus ransonneti [PEMPHERIDAE]	97	4.9–7.8	6.20 ± 0.62	2–9	4.35 ± 1.38	0.019	0.011–0.032	2.971	2.676–3.265	0.806
Rexea prometheoides [GEMPYLIDAE]	19	18.3–22.2	20.30 ± 0.96	43–90	62.26 ± 10.50	0.003	0.0004–0.020	3.307	2.662–3.952	0.866
Siganus fuscescens [SIGANIDAE]	119	13.3–38.6	29.99 ± 5.28	33–1160	531.24 ± 232.70	0.008	0.005–0.012	3.239	3.114–3.363	0.957
Upeneus japonicus [MULLIDAE]	22	8.8–17.0	13.84 ± 2.08	9–77	41.05 ± 16.63)	0.011	0.005–0.025	3.091	2.794–3.388	0.957

a is the intercept and b is the slope of the linear LWR regression; CI is the confidence interval.

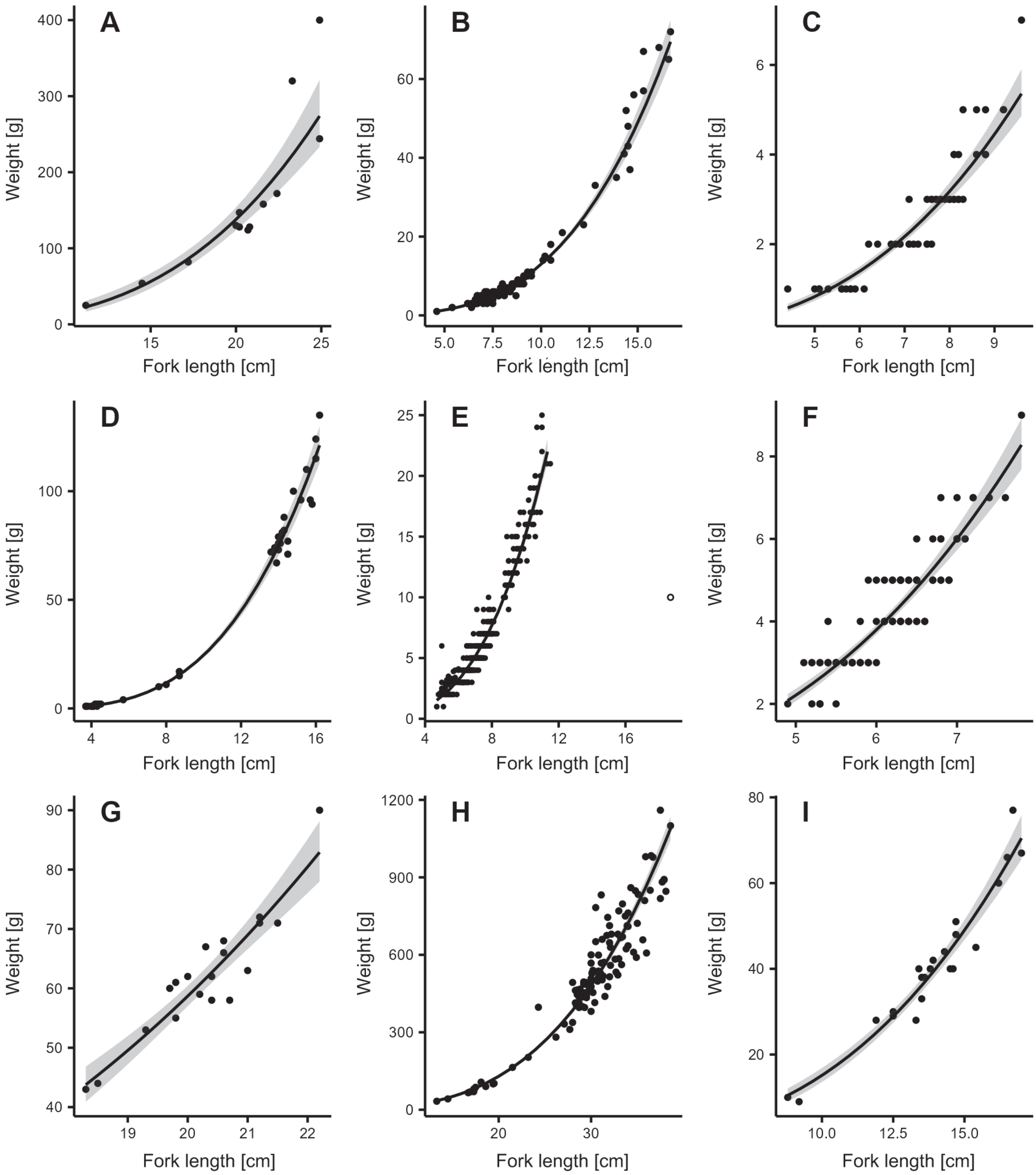

Figure 2. Length–weight relations (LWR) of 9 underutilized fish species. Black dots indicate observations used in the analysis, white dots indicate observations excluded from the analysis, and solid black lines indicate estimated curves and shaded areas indicate confidence intervals. (**A**) *Hyperoglyphe japonica*; (**B**) *Labracoglossa argenteiventris*; (**C**) *Macroramphosus sagifue*; (**D**) *Microcanthus strigatus*; (**E**) *Ostorhinchus semilineatus*; (**F**) *Parapriacanthus ransonneti*; (**G**) *Rexea prometheoides*; (**H**) *Siganus fuscescens*; (**I**) *Upeneus japonicus*.

Discussion

The survey results indicated that underutilized fish accounted for only 1% of the total catch weight, a significantly low value compared to other regions (Akiyama 2007). Among the estimated length–weight relations (LWR) of fish species reported in this study, five species (*Hyperoglyphe japonica*, *Labracoglossa argenteiventris*, *Microcanthus strigatus*, *Parapriacanthus ransonneti*, and *Rexea prometheoides*) were not listed or credibly described in FishBase (Froese and Pauly 2024). Additionally, four novel species (*Macroramphosus sagifue*, *Ostorhinchus semilineatus*, *Siganus fuscescens*, and *Upeneus japonicus*) for which no credible LWRs had been reported for the Japanese coast were newly reported. Therefore, this study's major significance lies in providing new biological information on these fish species.

Nine of the estimated LWR equations demonstrated high accuracy, with coefficient of determination (R^2) greater than 0.8 and b values within a realistic range of 2.8623.311 (Froese 2006). On the other hand, all specimens used for *Hyperoglyphe japonica* considered to be juveniles (Kawano and Shigenaga 2011) and further information is required. Therefore, improving the accuracy of these parameters requires ensuring sufficient populations over a broader size range (Froese et al. 2011).

Alverson et al. (1994) classified discard problems in the northwest Atlantic were classified into four groups:

- Marketable species too small or otherwise prohibited from landings.
- Species for which no current market exists but are caught along with commercial or recreational species.
- Species-specific fleet sectors discarding another fisheries target species.
- Non-fishery bycatch species, including marine mammals, turtles, and birds.

Regulatory approaches and management actions to address these problems are also discussed. In Japanese coastal fisheries, juvenile individuals of the target fish, belonging to category 1 in the Alverson et al. (1994) classification, are often caught as bycatch, but biological information is limited if the species themselves are not commercially utilized. None of the 9 species discussed in this study were utilized along the Mie Prefecture coast, and no biological information was available for any of them. Therefore, identifying LWR in this study provides fundamental and important information for assessing these fish species' stock status and future stock management. However, for many underutilized fish species in coastal waters, the actual bycatch and even the existence of biological data are unknown (Alverson et al. 1994). Considering that enhancing such primary data is essential for proper resource management and biodiversity conservation (Pauly et al. 2013), bycatch assessments in various fishing modes in different regions should be pursued, along with the comprehensive collection and accumulation of biological information on underutilized fish species in the future (Zeller et al. 2017).

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References

Akiyama S (2007) [Discards in large-scale set net in Tateyama Bay.] Nippon Suisan Gakkaishi 73(6): 1103–1108. [In Japanese with English abstract] https://doi.org/10.2331/suisan.73.1103

Alverson DL, Freeberg MH, Pope JG, Murawski SA (1994) A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper. No. 339. Rome, FAO, 233 pp.

Anonymous (2024) [2022 Fishery and Aquaculture Production Statistics.] Ministry of Agriculture, Forestry and Fisheries. [In Japanese] https://www.maff.go.jp/j/tokei/kouhyou/kaimen_gyosei/index.html

Armelloni EN, Scanu M, Masnadi F, Coro G, Angelini S, Scarcella G (2021) Data poor approach for the assessment of the main target species of rapido trawl fishery in Adriatic Sea. Frontiers in Marine Science 8: e552076. https://doi.org/10.3389/fmars.2021.552076

Cheng IJ, Chen TH (1997) The incidental capture of five species of sea turtles by coastal setnet fisheries in the eastern waters of Taiwan. Biological Conservation 82(2): 235–239. https://doi.org/10.1016/S0006-3207(97)00027-X

Cook RD, Weisberg S (1982) Residuals and Influence in Regression. Chapman and Hall, New York.

Davies RWD, Cripps SJ, Nickson A, Porter G (2009) Defining and estimating global marine fisheries bycatch. Marine Policy 33(4): 661–672. https://doi.org/10.1016/j.marpol.2009.01.003

Finkbeiner EM, Wallace BP, Moore JE, Lewison RL, Crowder LB, Read AJ (2011) Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. Biological Conservation 144(11): 2719–2727. https://doi.org/10.1016/j.biocon.2011.07.033

Froese R (2006) Cube law, condition factor and weight–length relationships: History, meta-analysis and recommendations. Journal of Applied Ichthyology 22(4): 241–253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Froese R, Pauly D (Eds.) (2024) FishBase. [version 02/2024] https://www.fishbase.org

Froese R, Tsikliras AC, Stergiou KI (2011) Editorial note on weight–length relations of fishes. Acta Ichthyologica et Piscatoria 41(4): 261–263. https://doi.org/10.3750/AIP2011.41.4.01

Fujikura K, Lindsay D, Kitazato H, Nishida S, Shirayama Y (2010) Marine biodiversity in Japanese waters. PLoS ONE 5(8): e11836. https://doi.org/10.1371/journal.pone.0011836

Hall MA (1996) On bycatches. Reviews in Fish Biology and Fisheries 6(3): 319–352. https://doi.org/10.1007/BF00122585

Heimann T, Verkamp H, McNamee J, Bethoney ND (2023) Mobilizing the fishing industry to address data gaps created by shifting species distribution. Frontiers in Marine Science 10: e1043676. https://doi.org/10.3389/fmars.2023.1043676

Kawano M, Shigenaga Y (2011) [Maturation and spawning of *Hyperoglyphe japonica* in the southwestern Japan Sea off Yamaguchi Prefecture.] Bulletin of Yamaguchi Prefectural Fisheries Research Center No 9: 99–103. [In Japanese with English abstract]

Kelleher K (2005) Discards in the World's marine fisheries. An update. FAO Fisheries Technical Paper 470. FAO, Rome, 134 pp.

Kindong R, Gao C, Pandong NA, Ma Q, Tian S, Wu F, Sarr O (2020) Stock status assessments of five small pelagic species in the Atlantic and Pacific oceans using the length-based Bayesian estimation (LBB) method. Frontiers in Marine Science 7: e592082. https://doi.org/10.3389/fmars.2020.592082

Kodeeswaran P, Jayakumar N, SriHari M, Durairaja R, Praveenraj J, Abarna KM, Moulitharan N (2020) Length–weight relationship of seven bycatch fish species caught along the Chennai coast, Bay of Bengal, Eastern Indian Ocean. Journal of Applied Ichthyology 36(2): 246–248. https://doi.org/10.1111/jai.14008

Nakabo T (Ed.) (2013) [Fishes of Japan with pictorial keys to the species Third edition.] Tokai University Press, Hadano, Japan, 2428 pp. [In Japanese]

Oliver S, Braccini M, Newman SJ, Harvey ES (2015) Global patterns in the bycatch of sharks and rays. Marine Policy 54: 86–97. https://doi.org/10.1016/j.marpol.2014.12.017

Pauly D, Hilborn R, Branch TA (2013) Fisheries: Does catch reflect abundance? Nature 494(7437): 303–306. https://doi.org/10.1038/494303a

R Core Team (2022) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Rodríguez-García C, Castro-Gutiérrez J, Domínguez-Bustos ÁR, García-González A, Cabrera-Castro R (2023) Every fish counts: Challenging length–weight relationship bias in discards. Fishes 8(5): e222. https://doi.org/10.3390/fishes8050222

Shubhadeep G, Loveson E, Muktha M, Indira D, Behera PR, Jasmin F, Manas HM, Phalguni P, Madhumita D, Gourisankar R, Satishkumar M, Dineshbabu AP, Gopalakrishnan A (2022) Length–weight relations for finfish species landed as trawl by-catch from north-western Bay of Bengal. Journal of Applied Ichthyology 38(6): 621–623. https://doi.org/10.1111/jai.14357

Stohs SM, Harmon KM (2022) Bayesian prediction of fishery biological impacts from limited data: A deep-set buoy gear case study. Fisheries Research 249: e106228. https://doi.org/10.1016/j.fishres.2022.106228

Zeller D, Cashion T, Palomares M, Pauly D (2017) Global marine fisheries discards: A synthesis of reconstructed data. Fish and Fisheries 19(1): 30–39. https://doi.org/10.1111/faf.12233