Length-weight relationship and condition factor of ethanol-preserved contemporary and museum *Spratelloides delicatulus*

# Introduction

The purpose of this study is to report the length-weight relationship and condition factor of Philippines *Spratelloides delicatulus* (blue sprat; Spratelloididae) from ethanol-preserved museum and contemporary specimens. Additionally, the effect of ethanol preservation on contemporary samples is investigated to establish a correction factor for length-weight relationship and condition factor between fresh and after 1 month of ethanol preservation.

Body condition is a key indicator of health at the individual or population level, since it is closely related to important fitness variables, such as growth, reproduction, behavior, and survival.

# Methods

## Museum (USS Albatross) Collection (n = 124)

Specimens were collected by the USS Albatross during the Albatross Philippine Expedition from 1907 to 1910. Specimens were fixed and preserved in ethanol, without formalin. Specimens were collected from four locations:

Mapun Island, Tawi-Tawi, Philippines (USNM 138978). (n = 38). Date: January 8, 1909. Collection Method: 130-ft seine. Depth 1 m. Daily Surface Water Temp Range: 80-82 F

Jamelo Cove, Batangas, Philippines (USNM 138979). (n = 28). Date: July 13, 1908. Collection Method: 150-ft seine. Depth ?. Daily Surface Water Temp Range: 82-87 F

Sacol Island, Zamboanga, Philippines (USNM 150772). (n = 26). Date: September 8, 1909. Collection Method: Dip net, electric light. Depth ?, but probably surface. Daily Surface Water Temp Range: 80-84 F

Mansalay, Oriental Mindoro, Philippines (USNM 138969). (n = 32). Date: June 4, 1908. Collection Method: 150-ft seine. Depth 2-3 m. Daily Surface Water Temp Range: 81-85 F

Collection Method:

Mansalay & Jamelo were collected with a 150' seine. Cagayan de Jolo with a 130' seine. Sacol with an electric light and dip net. This makes sense with the size of the specimens from Sacol, which might need to be removed from the dataset.

SST:

Surface water temperature can be identified from the logbooks. SST measurements are taken every hour for 24 hours a day. It's difficult to identify the time of capture so I'm using the daily temperature range on the date of capture.

Cagayan de Jolo (1/8/1909): 80-82 F

Jamelo (7/13/1908): 82-87 F

Mansalay 6/4/1908): 81-85 F

Sacol (9/8/1909): 80-84 F

Fulton's Condition Factor (cf) is calculated from the observed standard length and weight: cf=100(W/SL^3).

A cf of 1 indicates a "normal" fish, >1 is relatively more fit, <1 is relatively less fit.

Le Cren's Relative Condition Factor (Kn) first requires the calculation of the constants a & b from the length-weight relationship equation.

This uses the observed standard length and weight data in the equation: W=aL^b. The constants from the observed data are used in Le Cren's equation: Kn=W/aL^b. The denominator in this equation is the expected fish weight at a given length. So, this is the ratio of the observed to the theoretically expected weight for a given length. Values are similar to Fulton's cf.

Individual specimens were taken out of the ethanol preservation solution. The mouth and gill cavities were drained, then the specimens were dried using Kimtech wipes. Individuals who had their abdominal cavities cut were drained and gently squeezed to remove excess ethanol. The standard and total lengths (mm) were measured using calipers. The mass (g) was measured using an analytical balance. This process was kept consistently within 1-3 minutes, during which time additional ethanol also evaporated.

## Contemporary Collection (n = 124)

Samples were collected from Olympia Island, North Bais Bay, Negros Oriental, Philippines (n = 124). Fish were purchased from local fisherman between June 2-12, 2023. Fresh measurements were taken by John Paul Sullera and Rabbi Montegrejo (Negros Oriental State University). Specimens were fixed and preserved in 70% ethanol. Measurements were taken again 1 month after fresh measurements.

## Data Analysis

Length-weight Relationship, where W is the expected weight based on the actual standard length (L).

Equation 1. W=aL^b.

Fulton's Condition Factor, for comparison to an ideal weight

Equation 2. K=100(W/SL^3).

Le Cren's Relative Condition Factor, for comparison to the average weight. Where W is weight, L is standard length.

K\_n = W/aL^n.

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Figure #. (S\_delicatulus\_Albatross\_Locations.png)

# Results

## Museum (USS Albatross) Collection

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Figure #. (S\_delicatulus\_LWR\_SL.png). The length-weight relationship of museum *Spratelloides delicatulus* specimens collected in 1908 and 1909 from Mapun Island, Hamilo Cove, Sacol Island, and Mansalay (n = 124). Standard length is reported in cm and mass in g.

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Figure #. (S\_delicatulus\_log10a\_b). The log10*a* and *b* values from the length-weight relationship of *Spratelloides delicatulus* calculated from three different locations.

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Figure #. (S\_delicatulus\_lm.png). A linear regression of the log 10 mass and standard length of museum *Spratelloides delicatulus* (n = 124).

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Figure #. (S\_delicatulus\_kn.png). The relative condition factor and standard length of museum *Spratelloides delicatulus*.

## Fulton’s Condition Factor from Museum Collection

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Figure #. (S\_delicatulus\_cfvSL\_byLocality\_95CI.png) S delicatulus linear regression of condition factor by site.

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Figure #. (S\_delicatulus\_boxplot\_cf\_byLocality.png) S. delicatulus condition factor by site.

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| --- | --- | --- | --- | --- |
| Table #. Kruskal-Wallis with Dunn Test and Bonferroni for Fulton's Condition Factor (cf). | | | | |
| Comparison | Z-value | Unadjusted p-value | Adjusted p-value | Significance |
| Cagayan\_de\_Jolo - Jamelo\_Cove\_Luzon | -6.6224 | < 0.0001 | < 0.0001 | \*\*\* |
| Cagayan\_de\_Jolo - Mansalay\_Mindoro | -4.626 | < 0.0001 | < 0.0001 | \*\*\* |
| Jamelo\_Cove\_Luzon - Mansalay\_Mindoro | 2.0847 | 0.0185 | 0.1113 |  |
| Cagayan\_de\_Jolo - Sacol\_Island\_Zamboanga | 2.7417 | 0.0031 | 0.0183 | \* |
| Jamelo\_Cove\_Luzon - Sacol\_Island\_Zamboanga | 8.6182 | < 0.0001 | < 0.0001 | \*\*\* |
| Mansalay\_Mindoro - Sacol\_Island\_Zamboanga | 6.8466 | < 0.0001 | < 0.0001 | \*\*\* |

## Le Cren’s Relative Condition Factor from Museum Collection

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Figure #. (S\_delicatulus\_KnvSL\_byLocality\_95CI.png) S delicatulus linear regression of relative condition factor by site.

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Figure #. (S\_delicatulus\_boxplot\_Kn\_byLocality.png) S. delicatulus relative condition factor by site.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table #. Kruskal-Wallis with Dunn Test and Bonferroni for Le Cren's Relative Condition Factor (Kn) | | | | |
| Comparison | Z-value | Unadjusted p-value | Adjusted p-value | Significance |
| Cagayan\_de\_Jolo - Jamelo\_Cove\_Luzon | -7.7356 | < 0.0001 | < 0.0001 | \*\*\* |
| Cagayan\_de\_Jolo - Mansalay\_Mindoro | -5.3399 | < 0.0001 | < 0.0001 | \*\*\* |
| Jamelo\_Cove\_Luzon - Mansalay\_Mindoro | 2.4942 | 0.0063 | 0.0379 |  |
| Cagayan\_de\_Jolo - Sacol\_Island\_Zamboanga | 0.3114 | 0.3778 | 1 |  |
| Jamelo\_Cove\_Luzon - Sacol\_Island\_Zamboanga | 7.365 | < 0.0001 | < 0.0001 | \*\*\* |
| Mansalay\_Mindoro - Sacol\_Island\_Zamboanga | 5.1526 | < 0.0001 | < 0.0001 | \*\*\* |

## Contemporary - Figures

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Figure #. (S\_delicatulus\_LWR\_SL\_2\_fresh.png). The length-weight relationship of freshly caught contemporary *Spratelloides delicatulus* specimens collected in 2023 from Bais Bay (n = 124). Standard length is reported in cm and mass in g.

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Figure #. (S\_delicatulus\_log10a\_b\_fresh.png). The log10*a* and *b* values from the length-weight relationship of freshly caught contemporary *Spratelloides delicatulus* and those from three other studies.

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Figure #. (S\_delicatulus\_lm\_fresh.png). A linear regression of the log 10 mass and standard length of freshly caught contemporary *Spratelloides delicatulus* from Bais Bay, Philippines (n = 124).

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Figure #. (S\_delicatulus\_kn\_fresh.png). The relative condition factor and standard length of freshly caught, contemporary *Spratelloides delicatulus*.

## Matching – Figures

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Figure #. (S\_delicatulus\_shrink.png). The length-weight relationship of freshly caught contemporary (n = 124), 1 month preserved contemporary (n = 124), and 115 year old museum (n = 124) *Spratelloides delicatulus* specimens. Standard length is reported in cm and mass in g.

The objective was to identify a historical baseline for multiple species (n=14) represented from Albatross collections at ODU. This is the "preserved" historical baseline. Then compare this baseline to contemporary collections for four species (Sde, Sgr, Sfu, Goy) upon collection (fresh) and after 1 month in ethanol. The contemporary collections would allow for the identification of an ethanol preservation correction factor, which could be applied to the Albatross collection to better estimate the "fresh" historical baseline. The average change in weight after 1 month of preservation is species specific: Sde -13.5%, Sgr -26.9%, Sfu -19.6%, Goy -24.3%. The correction factor for weight seems to remain constant across the range of standard length for Sde and Goy, however the correction factor slightly increases as standard length increases for Sgr and Sfu. If the preserved Albatross (orange) and preserved contemporary (red) are similar (Sde), then there doesn't seem to be a change over time. However, there are site-specific differences in condition factor for Albatross Sde, so I'll have to evaluate LWR by site. Furthermore, the contemporary site is different than all four historical sites. If the preserved Albatross weight is greater than the preserved contemporary weight (Sgr, Goy), then weight and thus condition factor have decreased over time.

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Figure #. (S\_delicatulus\_LWR\_SL\_matching.png).

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Figure #. (S\_delicatulus\_LWR\_SL\_2\_matching.png).

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Figure #. (S\_delicatulus\_log10a\_b\_matching.png).

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Figure #. (S\_delicatulus\_log10a\_b\_comparison.png). The log10*a* and *b* values from the length-weight relationship of freshly caught contemporary (n = 124), 1 month preserved contemporary (n = 124), and 115 year old museum (n = 124), and those from other studies as reported by fishbase (fb-world).

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Figure #. (S\_delicatulus\_lm\_matching.png).

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Figure #. (S\_delicatulus\_kn\_matching.png).

## One Month – Figures

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Figure #. (S\_delicatulus\_LWR\_SL\_month.png).

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Figure #. (S\_delicatulus\_LWR\_SL\_2\_month.png).

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Figure #. (S\_delicatulus\_log10a\_b\_month.png).

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Figure #. (S\_delicatulus\_lm\_month.png).

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Figure #. (S\_delicatulus\_kn\_month.png).

# Discussion

Latitudinal effect on condition factor

"Temperature and Growth in Fish" - Reviews in Fish Biology and Fisheries

"Seasonal and Latitudinal Variations in Fish Condition" - Journal of Fish Biology

"Genetic and Environmental Influences on Fish Condition Factor" - Marine Ecology Progress Series

Counterintuitive effect of fishing pressure on condition factor