SOUTH AFRICA'S CONVERSION FACTOR OF SOUTHERN BLUEFIN TUNA FROM PROCESSED WEIGHT TO WHOLE WEIGHT

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CCSBT Members or Cooperating Non-Members may advise the Executive Secretary of the product states and conversion factors they are using, and in the absence of which default conversion factors are used. The default conversion factors applied to South Africa's Catch Document Scheme (CDS) data (1.15 for GG (Gilled and Gutted)/GGO (Gilled and Gutted, Tail On)/GGT (Gilled and Gutted, Tail Off) and 1.8 for DR (Dressed: headed, gilled and gutted)/DRO (Dressed, Tail On) /DRT (Dressed, Tail Off) have contributed towards discrepancies, of between 25% and 30%, appearing regularly in the reconciliation reports produced by the CCSBT Secretariat. Weight measurements, particularly GGO and DRO, were collected at the quayside and in the processing establishment for 6 216 SBT from 2019 to 2024. The DRO conversion factor, calculated using the 1.15 GGO default conversion factor, showed a mean value of 1.28 (SD = 0.028, CV = 2.23%), for SBT caught in the region of South Africa's EEZ. The length-weight relationship of SBT sampled for weight and fork length (n = 2932, range 102-217cm FL) in this study from 2023 to 2024 is described by the equation $W = 0.021\ L^{2.57}$ (R^2 = 0.786), weight being GGO weight (kg) and fork length (cm). The slope of the length–weight relationship differed significantly among months, however, there is no clear pattern in the growth that can be attributed to periods of reproductive activity or environmental conditions influencing body condition, and more data over an extended period of time is required to discern a pattern. The weight measurement taken in the processing establishment is significantly smaller and considered more accurate than the weight measurement taken at the quayside, likely due to plastic or cloth dressing and ice packed in the body cavity that can falsely inflate weights, and the exposed and unstable environment at a quayside that can impact the operation of the scale.

Introduction

The CCSBT *Resolution on the Implementation of a CCSBT Catch Documentation Scheme* requests that each Member or Cooperating Non-Member advise the Executive Secretary of the product states and conversion factors they are using (CCSBT, 2021). In the absence of Member-/ Cooperating Non-Member (CNM) -specific conversion factors, the Executive Secretary uses default conversion factors to convert to whole weights. South Africa has not provided any information on conversion factors to date. Consequently, the default conversion factors of 1.15 for GG/GGO/GGT* and 1.8 for DR/DRO/DRT* are used by the Secretariat (CCSBT, 2024).

Within South Africa's fleet of approximately 28 active longline vessels (20-35m LOA), 15 (53%) of the vessels have an ice hold (below deck) for chilling fish, and the remainder have a refrigerated hold for freezing fish. However, the vessels that catch 75-80% of SBT are ice vessels, landing and exporting their catch fresh and chilled. Over the last five years, a majority of fresh/chilled SBT (~80%) caught by South African vessels have been exported to the USA, and ~18% to Japan (SARS, 2025). In the past vessels would either land their SBT Gilled, Gutted, Tail off (GGT) or Dressed, Tail off (DRT). To achieve higher meat quality during handling and refrigeration, through minimising the amount of exposed flesh and through packing the body cavity with ice, all vessels land their

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SBT Gilled, Gutted, Tail on (GGO). After processing the SBT are exported fresh as Dressed, Tail on (DRO).

The Resolution on the Implementation of a CCSBT Catch Documentation Scheme (CDS) requires that a Catch Tagging Form (CTF) is filled in as soon as practicable after the time of kill and shall include the weight measurement (and its processed state) before the SBT is frozen. The Catch Monitoring Form (CMF) accompanies the export of SBT and includes the SBT weight measurement and its processed state. Generally, South Africa's CTF has SBT recorded in GGO processed state and the 1.15 default conversion factor is applied, whereas the CMF has SBT recorded in DRO processed state and the 1.8 default conversion factor is applied.

The CCSBT Secretariat conducts regular verification exercises to identify and reconcile discrepancies in the flow of CDS information. In particular, the weights of SBT on the CTF and CMF are converted to Round (RD) weight, where applicable, and the weights compared. The reconciliation report of CDS information consistently finds a discrepancy between the CTF and CMF weights after these conversion factors are applied. The CTF weights (GGO converted to RD) have been shown to be between 25 and 30% lower than the CMF weights (DRO converted to RD). The CDS tracks the flow of product entering the market and is a tool designed to combat illegal, unreported and unregulated (IUU) fishing activities. Although not unique to South African fisheries, the discrepancy between CTF and CMF weights raises questions about the accuracy of South Africa's CDS data and this needs to be further explored. Conversion factors are applied to retrospectively estimate live weight. Differences in processing gear and technique (FAO, 2000, iuuwatch, 2021) can lead to variations in the estimation of live weight depending on who has processed the fish. It is therefore necessary to either develop conversion factors by fleet for the same stock (Hareide et al., 2007) or to develop conversion factors that are representative through broad spatial, temporal, size range and fishing gear coverage (Rodriguez-Marin et al., 2015).

The conversion factor on record for Members and CNM for GG/GGO/GGT is 1.15, except for Australia that uses "1.12 x processed weight + 1kg per fish" and 1.176. On the other hand, the conversion factor on record for Members and CNM for DR/DRO/DRT has a broad range between 1.2 and 1.8. The default conversion factor applied by the CCSBT Secretariat is 1.8 and Australia requested the conversion factors of 1.2 (DR) and 1.27 (DRT) be applied to their SBT. Based on the widespread occurrence of the discrepancy irrespective of vessel or processing establishments, the conversion factors need to be reviewed and updated where necessary.

Looking at the discrepancy between the CTF and CMF data and the conversion factors provided by Australia for DR/DRT, the conversion factor for DR/DRO/DRT for South African SBT is likely to be smaller than 1.8. This was echoed in the CCSBT's Quality Assurance Review (QAR) of South Africa in 2018, where South Africa's Fisheries Department (called DAFF at the time) noted that it would seek a reduction in the current conversion factor (1.8) for DR/DRO/DRT (CCSBT, 2018).

The weight measurements from a processing establishment, collected during the implementation of CDS, will be used to propose a revised conversion factor for DR/DRO/DRT for South Africa. These data will also be used to test the difference between weights taken with scales at the quayside compared to weights taken on scales in the processing establishment.

*GG = Gilled and Gutted. GGO = Gilled and Gutted, Tail On. GGT = Gilled and Gutted, Tail Off. DR = Dressed (headed, gilled and gutted). DRO = Dressed, Tail On. DRT = Dressed, Tail Off. RD = whole round

Materials and Methods

A processing establishment (Processor A) conducts the processing of up to 70% of South Africa's SBT. From 2019 to 2024 Processor A collected the weight measurements of individual SBT, at the quayside during offloading of the vessel (generally GGO state) and in the processing establishment (GGO and DRO states), and the fork length measurement to the nearest 1 centimetre. Electronic scales with a resolution of 0.01kg were used to collect all weights. Preliminary examination of the processing establishment weights (GGO and DRO states) and length measurements saw 526 outliers being removed, likely from SBT measured after the head was removed or human error in the capturing of the measurements, and these were excluded from the conversion and length-weight calculations. These included, 55 records where GGO weight was the same as DRO weight, 3 records where GGO weight was greater than DRO weight, 111 records of inconceivably low/high GGO or DRO weights, and 357 records of fork length-processing establishment GGO weight identified using Cook's Distance where values exceeding the common threshold of 4/n (where n is the sample size) were considered potentially influential (Cook and Weisberg, 1982).

The following calculation was used to estimate the DRO conversion factor. Individual fish were converted to RD weight by using the conversion factor of 1.15 for the GG/GGO/GRT processing state with the weight collected at the processing establishment. The RD weight was divided by the DR/DRO/DRT weight to derive the conversion factor. This method is reflected in Australia's Southern Bluefin Tuna Management Advisory Committee meeting minutes (SBTMAC, 2019).

A Generalized Linear Model (GLM) was used to test for significant differences in the length–weight relationship among months. Month was treated as a categorical factor. A full model (both intercepts and slopes to vary by month), an additive model (only intercepts to vary) and a null model (no month effect) were used. Model comparisons were made using analysis of variance (ANOVA) with F-tests to determine whether including interaction or additive terms significantly improved model fit. All analyses were conducted in R (version 4.4.3), using the glm() function for model fitting and anova() for model comparison.

The quality of meat is increasingly compromised the longer the guts and gills remain in the SBT after capture and killing. An exercise with few available SBT was run to determine the GG/GGO/GRT and DR/DRO/DRT conversion factors from SBT that were landed in a RD state, to compare with the default conversion factors provided by CCSBT and the DRO conversion factor estimated in this study.

Each SBT was weighed at the quayside during offloading and re-weighed at Processor A, in the same processing state (e.g. GGO weight during offload and GGO weight in the processing establishment), in a fresh (unfrozen) condition. These weights were compared to test for significant differences.

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Results and Discussion

A total of 6 216 SBT caught within South Africa's EEZ were sampled for weight measurements from 26 vessels between 2019 to 2024, a majority of which were caught during the peak fishing season from June to October (Figure 1). Of those, 2 932 were sampled for length and weight measurements, from 2023 to 2024. SBT sampled were a combination of smaller and larger fish (FL from 102 to 217cm), with a mean of 165cm FL (SD = 14.9cm) (Figure 2).

All SBT were landed in the GGO processing state, which is gills and guts removed, and tail is attached. While some vessels choose to remove the gill plates and others do not, this detail of processing for GGO was not used in the conversion calculations.

The DRO to RD conversion factor showed a mean value of 1.28 (SD = 0.028, CV = 2.23%). This suggests that the DRO to RD conversion factor is fairly consistent for SBT over a wide length frequency range, with a low degree of variability. The DRO to RD conversion factor per vessel ranged between 1.23 and 1.32, with 19 of the 26 vessels between 1.27 and 1.29.

In 2024, four (4) vessels landed seven (7) SBT in a RD state, to enable a full complement of weight measurements to be collected on land (Figure 3). Since GGO and DRO are the main processing states used in the CDS in South Africa, these weights along with an accurate RD weight were taken for these SBT (Table 1). The GGO to RD and DRO to RD conversion factors averaged at 1.12 and 1.25, respectively, for SBT from 165 to 181cm FL. Considering the small sample size, these conversion factors are within an acceptable range from the 1.15 default used by CCSBT and the 1.28 calculated in this study.

The length-weight relationship of SBT sampled in this study, using data from 2023-2024, is described by the equation $W = 0.021\ L^{2.57}$ ($R^2 = 0.786$), weight being GGO weight (kg) (from the processing establishment) and fork length (cm). The full GLM, which allowed both the intercept and slope of the length–weight relationship to vary by month, provided a significantly better fit to the data compared to the additive model (ANOVA: $F = 9.99$, $p<0.05$). This indicates that both the scaling constant a and the growth exponent b differed significantly among months. Additionally, the additive model significantly outperformed the null model (ANOVA: $F=3.81$, $p<0.05$), confirming that even when assuming a constant slope, the intercepts varied significantly by month. These results demonstrate that the allometric growth patterns of the fish vary temporally, with both the relative condition (intercept) and growth rates (slope) differing across months. Figure 4 shows the length-weight relationship of SBT, separated by month. However, the values of the slope for June to October (β = 2.7, 2.6, 2.4, 2.8, 2.5, respectively) do not indicate a clear pattern in the growth that can be attributed to periods of reproductive activity or environmental conditions influencing body condition, and requires more data over an extended period of time to discern a pattern.

The weight recorded on the CTF is obtained at the quayside when the vessel offloads, and the CMF weight is obtained from the processing establishment. To assess the difference between the weight measurement at the quayside during offloading with the weight measurement for the same fish in the same processing state (i.e. GGO weight during offload and GGO weight in the

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processing establishment), at Processor A, a paired-samples t-test was performed. The test revealed a significant difference between GGO weights (kilogram) ($t(2928) = 27.203$, $p < 0.05$, 95% CI (2.09kg, 2.42kg)), suggesting that the GGO weight measurement in the processing establishment is significantly less than the GGO weight taken at the quayside. The number of outliers in Figure 5 suggests that there are more instances of weight measurement errors at the quayside compared to in the processing establishment. Considering that the weight of SBT on the quayside may be falsely inflated with plastic or cloth dressing, ice packed in the body cavity, excess seawater, incorrect calibration or tarring, and considering that the exposed and unstable environment at a quayside that can impact the operation of the scale, the weight measurement from the processing establishment is more accurate for recording on the Catch Tagging Form. These factors may lead to the weight on the CTF to be overestimated and create additional issues of weight discrepancies during reconciliation calculations. The scales in the processing establishment are setup permanently in a controlled environment and, because the weight measurements obtained from these scales are used for calculation of market sales and shipment cost, there is a greater chance that these scales are calibrated correctly and that the SBT is weighed without excess ice or packaging. This measurement would fulfil the requirement in the CDS for the weight measurement to be recorded on the CTF as soon as practicable after the time of kill and before the SBT is frozen.

Acknowledgements

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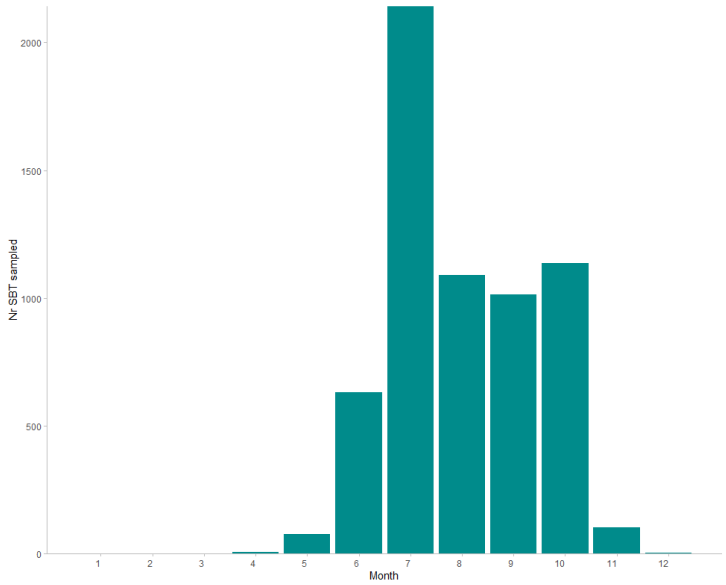

Figure 1. Number of SBT sampled per month over the period 2019-2024.

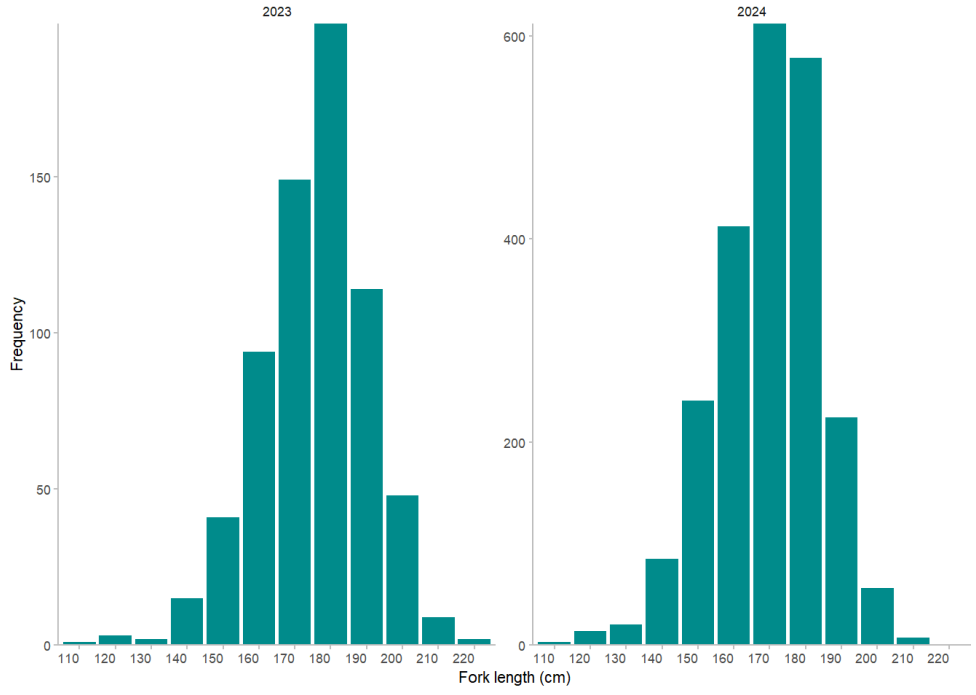

Figure 2. Length frequency distribution per year, 2023-2024

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Table 1. Length and weight measurements of SBT landed RD, with all measurements conducted on land.

Offload date	Tag nr	Fork length (cm)	RD weight (kg)	GGO weight (kg)	DRO weight (kg)	RD-GGO difference (%) (Gill and guts weight)	GGO to RD	GGO-DRO difference (%) (Head weight)	DRO to RD	RD-DRO difference (%) (Gill, guts and head weight)
29-Jun-24	ZA24000172	167	73.2	65.8	59.2	10.1	1.11	10.0	1.24	19.1
29-Jun-24	ZA24000173	165	81.8	71.8	63.4	12.2	1.14	11.7	1.29	22.5
29-Jun-24	ZA24000485	177	103.1	98.7	88.1	4.3	1.04	10.7	1.17	14.5
29-Jun-24	ZA24000491	167	90.1	82.6	74.7	8.3	1.09	9.6	1.21	17.1
01-Jul-24	ZA24005430	181	94.5	80.6	74.6	14.7	1.17	7.4	1.27	21.1
01-Jul-24	ZA24006666	176	87.2	76.6	67.8	12.2	1.14	11.5	1.29	22.2
01-Jul-24	ZA24006665	168	86	74.7	67.4	13.1	1.15	9.8	1.28	21.6
					Average:	10.70	1.12	10.11	1.25	19.74

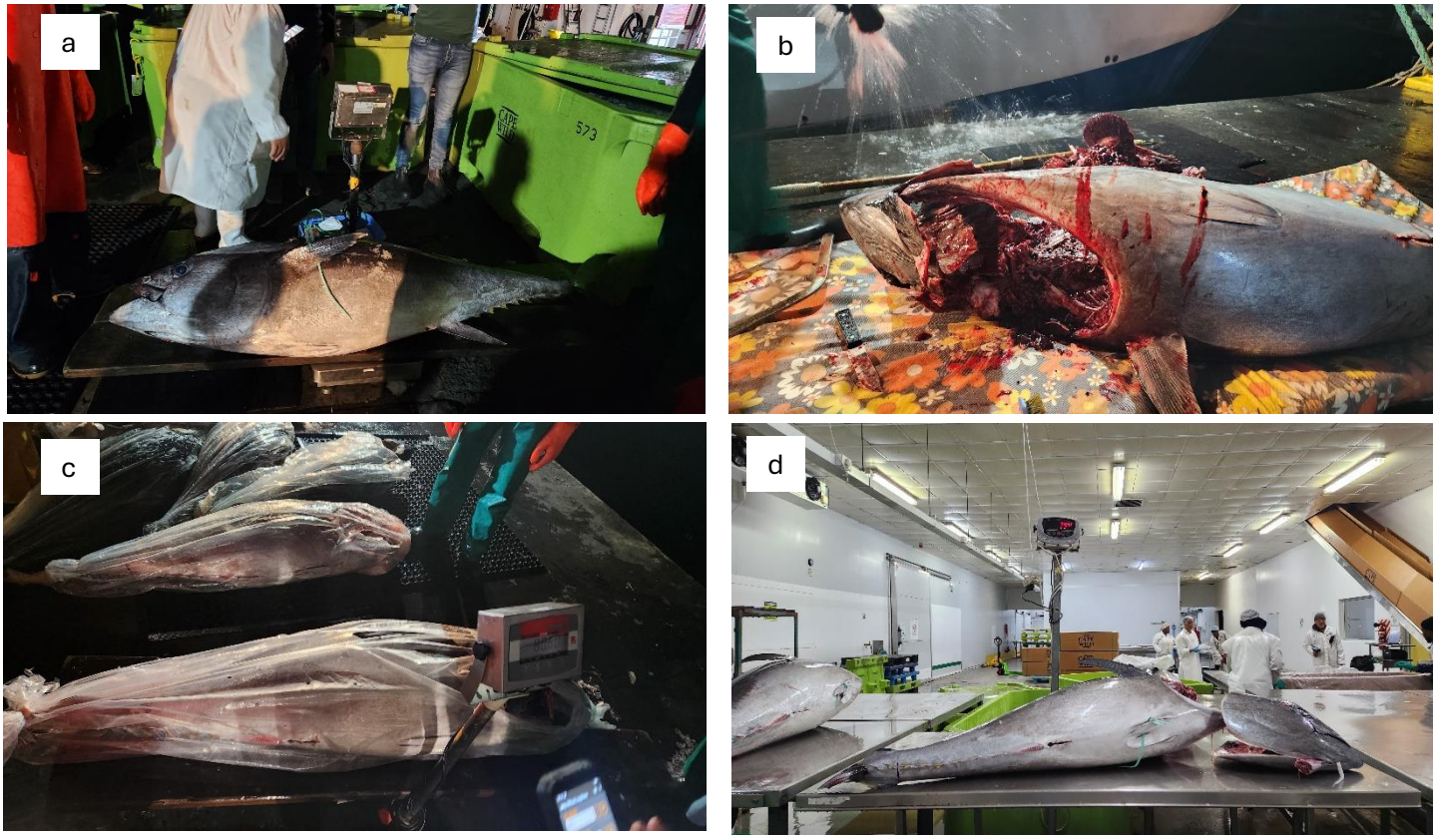

Figure 3. (a) RD weight measurement taken at the quayside after SBT has been offloaded from the vessel, (b) SBT dressed in GGO processing state at the quayside (gill plates removed, in this example), (c) GGO weight measured on a scale at the quayside with SBT wrapped in plastic, and (d) GGO weight measurement on a scale in the processing establishment (gill plates not removed, in this example).

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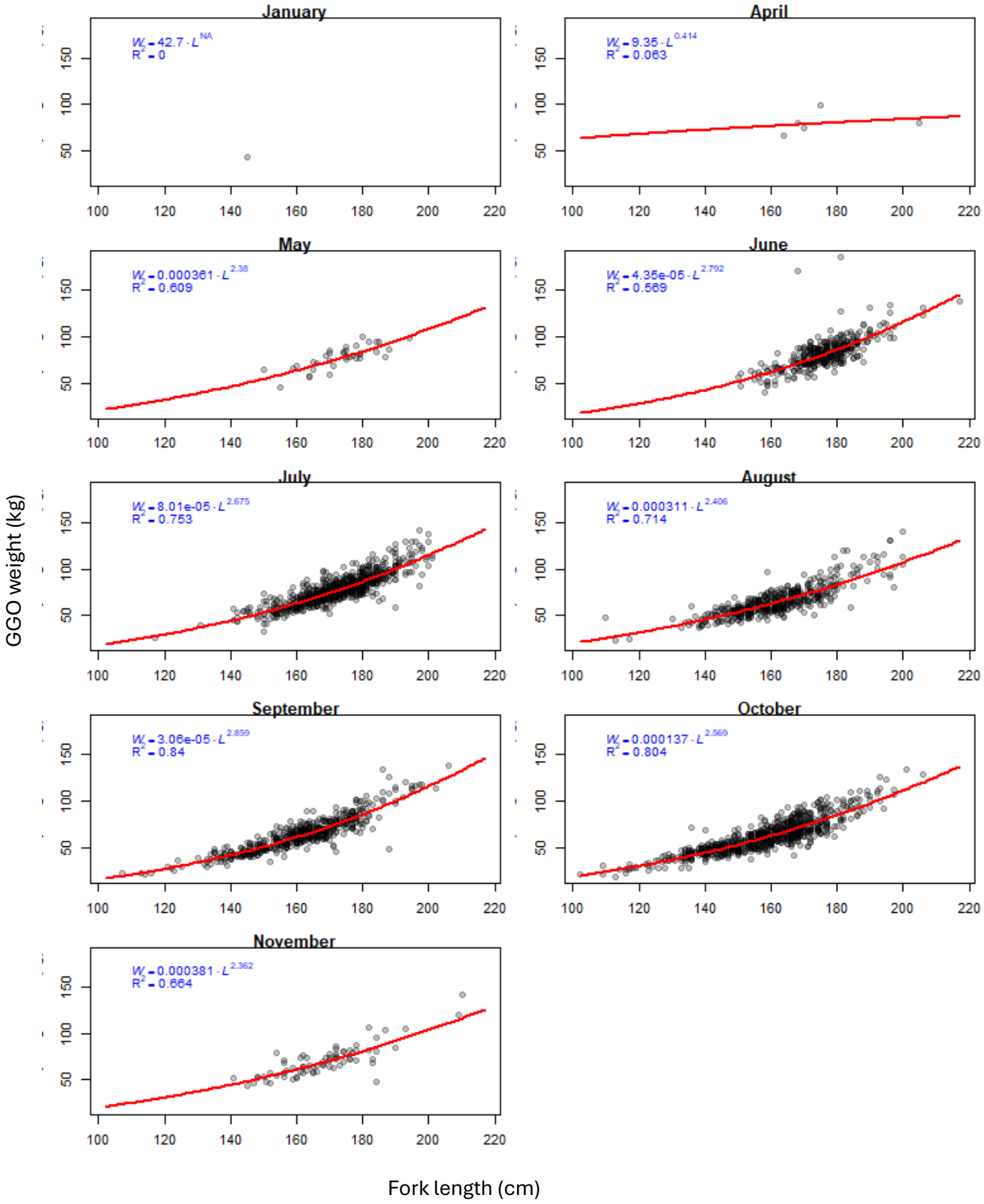

Figure 4. Length (fork length, cm) and weight (processing establishment GGO) relationship of SBT caught by month, 2023-2024, in South Africa's EEZ.

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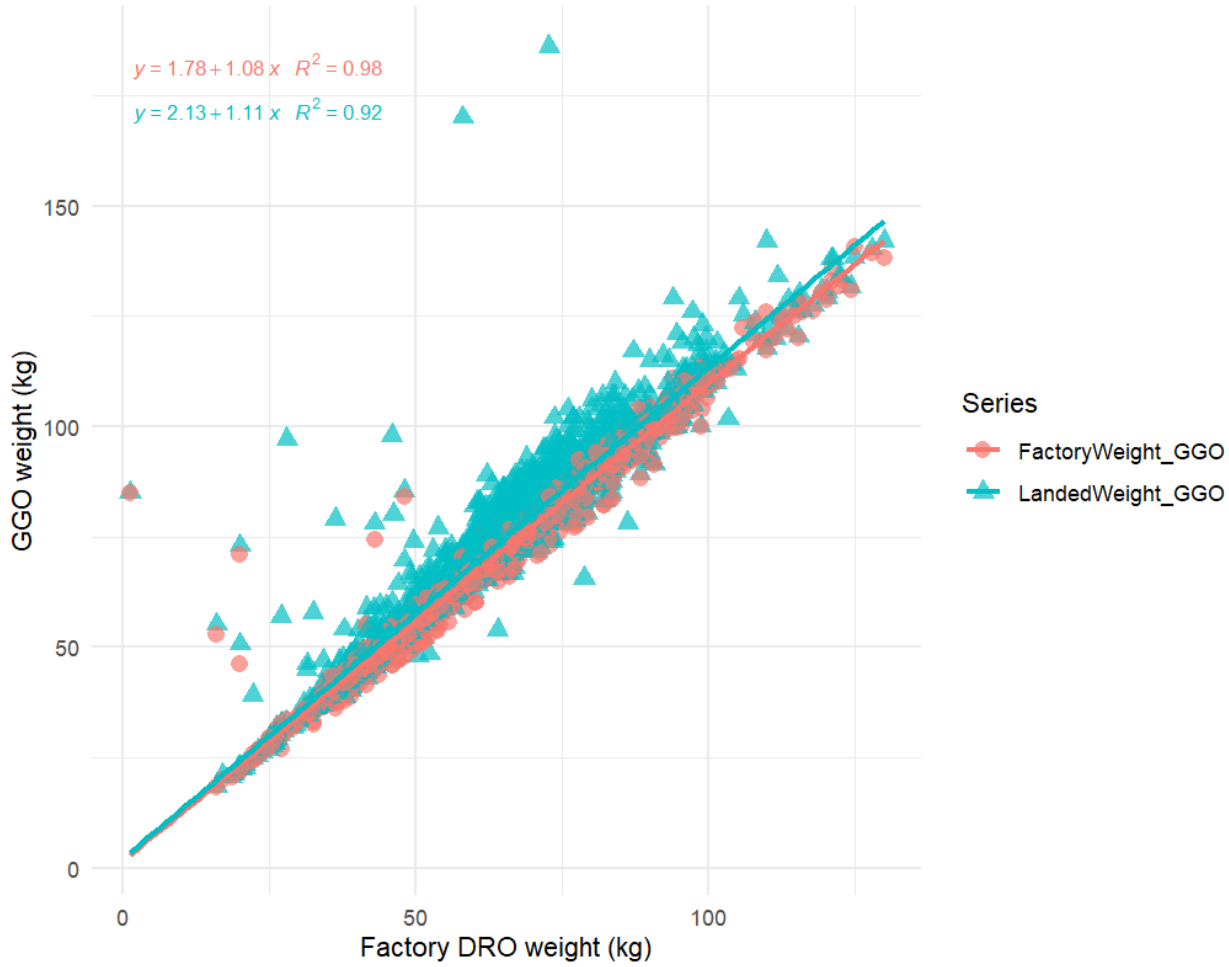

Figure 5. GGO weight measured at the quayside (LandedWeight_GGO) and GGO weight measured at the processing establishment (FactoryWeight_GGO), for the period 2023-2024.

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