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MANAGEMENT BRIEF

Fork Length–Total Length Conversions for Haddock and Pollock

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Abstract

Fork length–total length conversions for haddock *Melanogrammus aeglefinus* from Georges Bank and pollock *Pollachius virens* from the Gulf of Maine were developed by linear regression with data from fish caught during gear comparison studies. These conversions were developed to replace previous conversions that were inaccurate or insufficiently documented. Total lengths (TLs) and fork lengths (FLs) were obtained from 216 haddock ranging from 35 to 73 cm TL (median = 57 cm) and 220 pollock ranging from 43 to 107 cm TL (median = 75 cm). The conversion equation for haddock was FL = 0.95 × TL + 0.65. For pollock, it was FL = 0.94 × TL − 0.62. Reciprocal equations were also determined.

Haddock *Melanogrammus aeglefinus* and pollock *Pollachius virens* are commercially important species with combined catches exceeding 750,000 metric tons per year. As with nearly 50% of the species common in commercial catches off New England, the caudal fins of both species are forked (NEFOP 2010), and both fork length (FL) and total length (TL) may be used as metrics for measuring individuals. Fork length is commonly collected during fishery resource surveys, recreational and commercial catch sampling, and fishing gear selectivity studies, while TL is often used to define and enforce the minimum landing size (MLS) (for examples, see Marciano et al. 2006; He 2007; USOFR 2004). Conversion from one length measurement to another may be necessary when (1) the incorrect metric is collected, (2) caudal fins are damaged, (3) interpreting results from mesh-size selectivity studies in relation to MLS, (4) comparing historical data, or (5) for other reasons. To ensure correct data interpretation, equations to convert from one measure to another must be estimated with reasonable precision and accuracy (Booth and Isted 1997).

Two widely available FL-to-TL conversion equations for haddock and pollock each are derived from single data points: measurements from photographs in Cohen et al. (1990) (Froese and Pauly 2007; C. Binohlan, Fishbase, personal communication). A sample size of one is insufficient to establish a reliable conversion owing to natural variation in fish. Further, the equations are inaccurate based on our experience; for example, the average depth of the tail fork in haddock of the sizes we commonly observe is not typically 16.5% of the total fish length, as reported by Froese and Pauly (2007). For haddock, a second, less-available, poorly documented, and unreviewed relationship (Livingstone 1957) using data from 1930 is sometimes used. We sought to develop and distribute updated, reliable, accurate relationships for conversion between TL and FL for these two species (Lowe-McConnell 1978; Strauss and Bond 1990).

METHODS

We collected lengths opportunistically during two separate gear comparison studies. Haddock were caught during nine tows of a trawl-net comparison study (described in Chosid et al. 2008) conducted on Georges Bank between December 10 and 15, 2006, aboard the Western-rig commercial trawler FV *Mary Elena* using a standard flatfish demersal trawl net (152 mm diamond mesh opening, 3 mm diameter polyethylene throughout, with 165-cm black knotless square mesh in the cod end, 25 meshes wide on the top and bottom, and 50 meshes long, with chaffing gear) or an experimental "Ribas" trawl, similarly constructed, but with large mesh in the top of the trawl net.

Pollock were caught during 11 hauls of a gill-net comparison study (described in Eayrs and Salerno 2008) conducted in the

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Gulf of Maine in January 2007 and February 2008 aboard two gill-net vessels with either standard gill nets (165 or 178 mm mesh opening) or experimental norsel gill nets (178 mm mesh opening). Norsel gill nets are modified with lines leading from the bottom of the gill-net webbing sheet to the leadline to create open space between the webbing and the sea floor.

The entire catch of pollock or haddock, or a representative subsample from well-mixed, single-species assortments when catches were large, was measured. Total and fork lengths were measured once for each whole fish to the nearest whole centimeter within 1 h after deposition on deck for trawled fish and within 5 min or less after fish were brought onboard from gill nets. Lengths were straight-line measurements from the anterior end of the snout to the caudal fork (FL), and to the posterior tip of the caudal fin (TL).

Two simple, reciprocal linear regressions were used to obtain functional relationships between TL and FL for each species that would allow conversion from either length type to the other (Sokal and Rohlf 1995; R Development Core Team 2009; Sarkar 2009). Assumptions of linearity, normality, and heteroscedasticity were checked by means of residual and quantile plots (Sarkar 2009). Outlying data points were investigated and included as natural variation if no evidence of recording or measurement error was found. Prediction limits for converted MLS were calculated with the predict function in R (R Development Core Team 2009).

RESULTS

Haddock

Total and fork lengths were obtained from 216 haddock ranging in FL from 34 to 70 cm (median = 56 cm) and in TL from 35 to 73 cm (median = 57 cm). The linear relationship between the lengths was strong ($r^2 = 0.99$). Examination of the residuals and quantile–quantile plots revealed no unusual or unexplained patterns in the data. The functional relationship for predicting FL from TL was calculated to be

$$\mathrm{FL} = 0.95 \times \mathrm{TL} + 0.65. \quad (1)$$

Reversing the response and predictor yielded a relationship of

$$\mathrm{TL} = 1.05 \times \mathrm{FL} - 0.40. \quad (2)$$

The first relationship is depicted in Figure 1 along with length-frequency distributions for each metric; the length frequencies along the margins allow recreation of the data set (which is also available upon request). Standard errors for equation 1 were 0.004639 (slope) and 0.259868 (intercept); for equation (2), the standard errors were 0.005118 (slope) and 0.275596 for the intercept.

Equation (1) was used to convert current and previous MLS for haddock in the USA to FL along with 99% prediction limits (PL) based on the *t*-test (USOFR 2004; R Development Core Team 2009). The haddock MLS for commercial vessels in 2009, 48.3 cm TL, converts to 46.5 cm FL (99% PL: 46.4 and 46.7 cm) using equation (1). In 2011, the MLS for haddock was reduced to 45.7 cm TL, which converts to 44.0 cm FL (99% PL: 43.9 and 44.2 cm) (USOFR 2004).

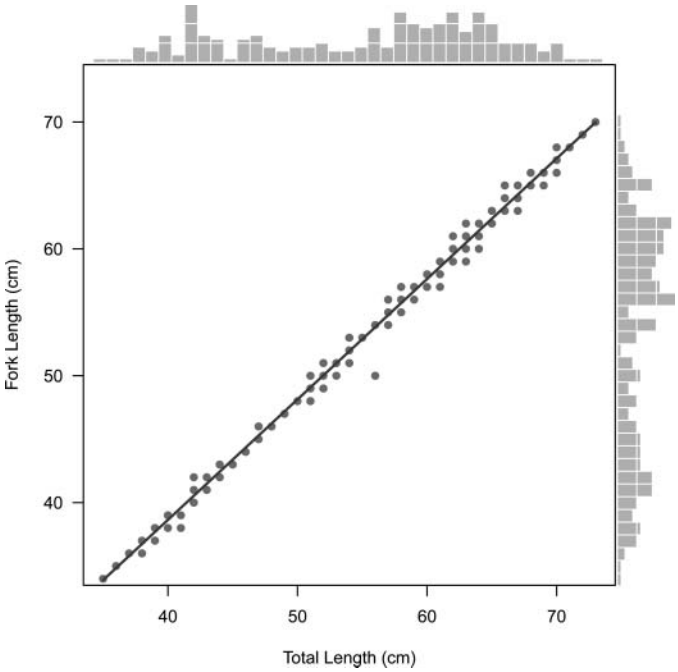

FIGURE 1. Estimated relationship between the total and fork lengths of haddock. Many points represent multiple observations. The length-frequency histograms of total length (top of graph) and fork length (right-hand side of graph) include white lines at every five observations.

Pollock

Total and fork lengths were obtained from 222 pollock ranging in FL from 40 to 99 cm (median = 69 cm) and TL from 43 to 107 cm (median = 75 cm). A strong, straight-line relationship between the lengths was once again found ($r^2 = 0.998$). Examination of the residuals and quantile–quantile plots revealed no unexplained patterns in the data. The functional relationship for predicting FL from TL was calculated to be

$$\mathrm{FL} = 0.94 \times \mathrm{TL} - 0.62. \quad (3)$$

Reversing the response and predictor yielded a relationship of

$$\mathrm{TL} = 1.07 \times \mathrm{FL} + 0.96. \quad (4)$$

Equation (3) is depicted in Figure 2 along with length-frequency distributions for each metric. Standard errors for equation (3) were 0.00408 (slope) and 0.3023 (intercept); for equation 4, the standard errors were 0.004647 (slope) and 0.319126 for the intercept.

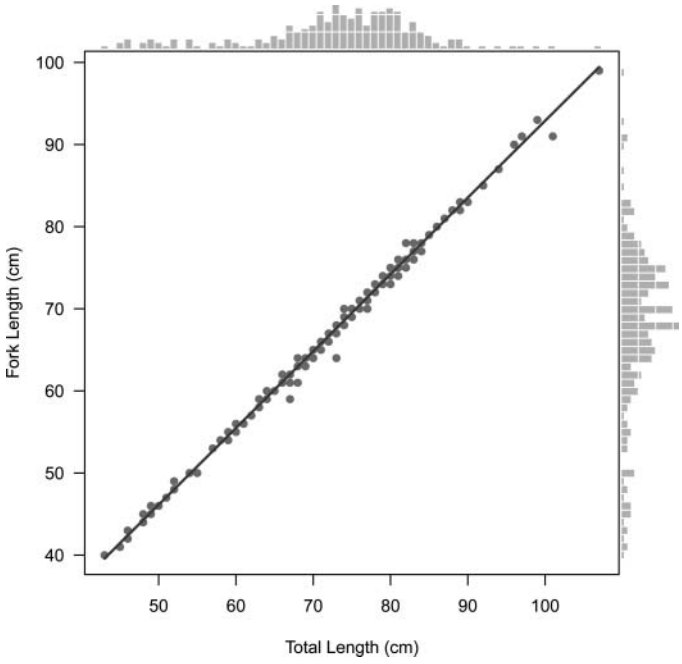

FIGURE 2. Estimated relationship between the total and fork lengths of pollock. See Figure 1 for additional details.

Equation (3) was used to convert the pollock MLS of 48.3 cm TL to a FL of 44.5 cm (99% PL: 44.3 and 44.8 cm) (USOFR 2004).

DISCUSSION

These relationships allow for accurate, updated conversions between fork and total lengths in haddock and pollock. Our main interest is to improve interpretation of results from mesh selectivity research on haddock (e.g., He 2007) or pollock (e.g., Marciano et al. 2006), measured in FL, in relationship to past, current, and proposed minimum landing sizes. Additionally, stock assessment biologists can now accurately convert scientific measurements to recruitment sizes. Potentially, these results could also be used by law enforcement personnel; however, we refrain from providing direct guidance as evidentiary standards may differ across jurisdictions.

The conversions are highly precise, as evidenced by the narrow 99% prediction limits for the MLS—within 3 mm for a 48.3-cm-TL haddock. These relationships are only reliable for the range of sizes for which they were developed; extrapolations for lengths greater or less than our sampled fish are not recommended. In ideal situations, and particularly for smaller fish, more precise measurements at the millimeter scale are desirable to develop conversions, but in our experience this scale is impractical owing to lack of rigidity in fresh, live fish and difficult sampling conditions at sea. Conversion of length frequencies or large data sets with these equations may require special techniques to avoid distortions of the distributional shape (Booth and Isted 1997).

Haddock results from Livingstone (1957), also from Georges Bank from 81 years previous, were reported as FL = 0.944 × TL + 0.58, with an additional reported Grand Banks conversion for haddock of FL = 0.965 × TL; neither relationship includes the individual data points or any variability parameters. For comparison, these relationships yield converted 19 in (48.3 cm TL) MLS values of 46.18 (Georges Bank) and 46.61 (Grand Banks) cm FL. The Grand Banks results are within our prediction limits, and in both cases the difference is less than 4 mm. However, the older data lack full documentation, peer review, and any description of the variability of the original data.

Equation (1) defines the typical depth of the fork in a haddock's caudal fin as approximately 5% of the overall length. The conversion reported by Froese and Pauly (2007), FL = 0.865 × TL, suggests a fork depth of over 14% of the TL. Equation (2) approximates a slightly deeper caudal fork for pollock (6%); the conversion reported by Froese and Pauly (2007), FL = 0.879 × TL, results in a fork depth of approximately 12%. Our results agree more closely with our experience of caudal tail morphology and further confirm the inadequacy of Froese and Pauly's (2007) conversions in our size ranges.

The results described in this paper should supplant both the results of Livingstone (1957) and Froese and Pauly (2007) based on greater accuracy, rigor, and documentation. In the absence of other more specific data, our conversions may be broadly applied across the range of these species.

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