Irish Fisheries Bulletin No. 26

GUTTED TO ROUND-WEIGHT CONVERSION FACTORS FOR ANGLERFISH (*LOPHIUS PISCATORIUS* AND *LOPHIUS BUDEGASSA*)

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ISSN:1649 5055

ABSTRACT

In response to a request from the Department of Communications Marine and Natural Resources and fishing industry, the conversion factors used to estimate round or live weights from gutted anglerfish were re-examined. A number of data sources was available from survey data, port sampling and observer trips. In some cases, the liver is left in place when the fish are gutted. For these landings a separate conversion factor is necessary. The conversion factors were found to be independent of fish size, however, some significant differences between the data sources were found. Significant differences between the conversion factors of the two species of anglerfish (*Lophius piscatorius* and *L. budegassa*) were also found. As commercial landings of anglerfish are not usually speciated, a generic conversion factor was estimated for *Lophius* spp. by combining the data for both species after weighting by the estimated proportions of the two species in the Irish landings. The resultant conversion factor for fully gutted fish is 1.23 and 1.17 when the liver is left in place; both estimates are lower than the current Irish factor of 1.28.

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INTRODUCTION

As most demersal fish are gutted before they are landed, conversion factors are routinely applied to estimate round or live weights. Inaccurate conversion factors can lead to biased estimates in the catch.

Estimates of gutted-to-round weight conversion factors can be sensitive to the stomach content, gonad development and condition of the sampled fish. Both the stomach contents and the gonads could make up a significant proportion of the weight of an anglerfish. As these parameters could vary by region, season and possibly gear type, it is important to obtain samples from various sources

The current conversion factors used for anglerfish landed in various presentation types in northeast Atlantic countries are given in Table 1. This shows considerable variation in the factors used for gutted to live weight from 1.15-1.30. There are also some variations in the conversion factors available for the other presentation methods in which anglerfish are landed. The current Irish conversion factor for gutted anglerfish, which is taken from a study by Bedford *et al.* (1986), is towards the higher end of factors used in Europe. Bedford *et al.* (1986) obtained round and gutted weights from 220 anglerfish (all *Lophius piscatorius*) on surveys over the period 1978-1982 (unknown locations/seasons). The current study examines data from various sources to evaluate the accuracy of Irish conversions factors for anglerfish.

Table 1. Current conversion factors used for anglerfish landed in various presentation types in northeast Atlantic countries.

		Presentation					
		Whole	Frozen		Tailed	Tailed	Filleted
Country	Species	Fresh	Gutted	Gutted	Fresh	Frozen	Skinned
Ireland[1,3]	*Lophius* spp	1.00		1.28	3.00		
Belgium[3]	*L. piscatorius*				3.00		
Belgium[3]	*Lophius* spp			1.18			
Denmark[2]	*Lophius* spp				2.72		
France[2]	*Lophius* spp	1.04		1.20	3.07		3.95
Germany[2]	*Lophius* spp			1.20	3.25	3.25	6.33
Netherlands[3]	*Lophius* spp	1.00		1.22	3.00		
Norway[3]	*L. piscatorius*	1.00		1.20	2.80		5.60
Portugal[2]	*Lophius* spp		1.2	1.16			
Portugal[3]	*Lophius* spp			1.15			
Spain[2]	*Lophius* spp			1.18			
Spain[2]	*L. budegassa*			1.18			
Spain[2]	*L. piscatorius*			1.20			
Sweden[3]	*L. piscatorius*			1.30	2.86		
UK E/W[1,3]	*Lophius* spp	1.00	1.28	1.28	3.00	3.00	
UK Scot[1]	*Lophius* spp			1.28			

Data sources: [1]Bedford *et al.* (1986); [2]DCR National Programs 2006 (available from http://datacollection.jrc.cec.eu.int/); [3]FAO (2000)

MATERIALS AND METHODS

Sampling

Data on anglerfish round and gutted weights were available from a number of sources:

Samples were available from two surveys carried out under EU Contract 98/096 (Anon. 2001). In March and April of 1999, a survey was carried out to the west and north of Scotland on RV Scotia (SC0599); 44 valid hauls were completed. Round and gutted weights were collected as well as information on maturity of anglerfish. During the Irish West Coast Groundfish Survey (WCGFS99), round and gutted weights were collected for anglerfish. This survey was carried out off the north and west coast of Ireland in October 1999 on a commercial vessel (MFV Marliona); 33 hauls were completed.

In July 2005, an observer trip was carried out from Ros a Mhil on a twin rigged prawn trawler (ROS05); 16 hauls were carried out on the prawn grounds to the west of the Aran Islands. The total round and gutted weights were obtained for *Lophius* spp., most samples were not further speciated and no individual fish weights were recorded.

In October 2005, landings of anglerfish in Castletownbere were sampled (CTB05), round and gutted weights were recorded as well as the weight of the stomach contents

During October and November of 2005, round, gutted and liver weights and maturity stages were obtained for 60 hauls of the Irish Groundfish Survey (IGFS05) in ICES areas VIIg and VIIj (the Celtic Sea and to the south-west of Ireland). The survey was carried out on RV Celtic Explorer.

Analysis

The conversion factor of individual fish can vary with size: the relative weight of the gonads might change with size or growth might be non-allometric. In order to test whether this is the case for anglerfish, the individual conversion factors were plotted against fish length and the slope of the regression line was tested for a significant difference from zero using analysis of variance (ANOVA) (Zar, 1999). Differences between the data sources were also evaluated using ANOVA. The ROS05 samples were not included in this analysis, as no individual fish weights were available.

If one can assume that the conversion factor is independent of fish size, there are three possible methods of estimating a conversion factor:

1. Estimating the slope of the regression of round to gutted weights of individual fish
2. Taking the mean of all conversion factors for individual fish.
3. Using the total round and gutted weights to estimate the conversion factor.

The first method will be strongly influenced by large fish, as these will have the highest leverage. The second method gives equal weight to each individual observation. The third method effectively weights the observations by the fish weights. This might be the most appropriate as the precision of the weight measurements would tend to increase with the weight of the fish.

As some anglerfish are landed gutted, but with the liver in place, a separate conversion factor was estimated for these landings. This conversion factor will be abbreviated as C_{liver}, the conversion factor from gutted weight without the liver to round weight will be abbreviated as C_{gutted}.

In addition to the conversion factors, the condition index of the fish was also estimated using fulton's K, (Lambert and Dutil 1997) which is given by:

$$K = 100\,W/L^3$$

where W is the round weight of the fish in grams and L is the total length of the fish in cm. Fulton's K can also be estimated for bulk samples if individual lengths are available but only the bulk weight by dividing the sample weight, W_S by the sum of the cubed lengths.

$$K = 100\,W_S/\sum L^3$$

RESULTS

For both species, a large range of sizes were represented in the samples (Figure 1) The largest number of *L. piscatorius* samples were collected on the Scotia in 1999 (SCO0599) while most of the *L. budegassa* samples were from the Irish Groundfish Survey 2005 (IGFS05) and port sampling from Castletownbere during the same year (CTB05; Table 2)

For *L. piscatorius*, the slope of the regression of the individual conversion factors onto the length of the fish was not significantly different from zero, indicating that the conversion factors were independent of fish length (ANOVA for C_{gutted} p=0.26; for C_{liver} p=0.14; Figure 1). There was no significant difference between the data sources for C_{gutted} (ANOVA; p=0.08) and there was a mildly significant effect of data source for C_{liver} (p=0.03). However the difference in the C_{liver} estimates was less than 2% (Table 2).

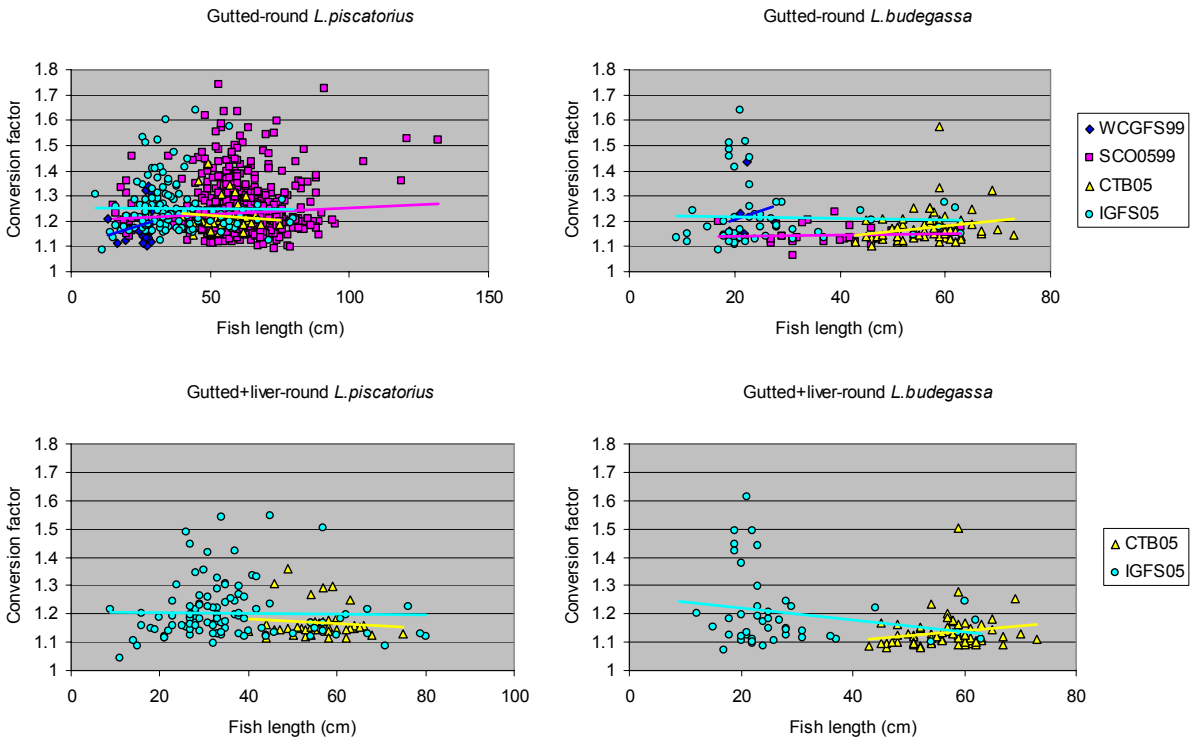

Figure 1. Conversion factors including and excluding the liver weight from a number of sources: WCGFS99 (West Coast GroundFish Survey 1999); SCO0599 (Scotia 1999); CTB05 (Castletownbere port sampling 2005) and IGFS05 (Irish GroundFish Survey 2005).

For *L budegassa*, the slope of the regression of the individual conversion factors onto length was not significantly different from zero for C_{gutted} (ANOVA; p=0.10). However, for C_{liver}, the slope was found to be highly significantly different from zero (ANOVA; p<0.001) but when the two data sources were tested separately, the slope was no longer different from zero (ANOVA IGFS05: p=0.17; CTB05 p=0.16). For C_{gutted} there was a mildly significant effect of data source (ANOVA; p<0.03). For C_{liver}, this effect was highly significant (ANOVA;

p<0.001). It appears that the apparent size trend for C_{liver} was driven by differences between the data sources (which had different length distributions) rather than by length alone.

Overall, there was a highly significant effect of species (ANOVA for C_{gutted} p<0.001; for C_{liver} p=0.008), with *L. piscatorius* having the higher conversion factors. For both species the difference between C_{gutted} and C_{liver} was highly significant (ANOVA; *L. piscatorius* p<0.001; *L. budegassa* p=0.007)

No individual weights were available from the observer trip from Ros a Mhill (ROS05), instead bulk weights of round and gutted weights were collected for each haul. The conversion factor of 1.36 from this data source is considerably higher than those of the others. For individual hauls, the C_{gutted} varied from 1.25 to 1.46, so the conversion factors were consistently higher for these samples. The mean condition index, K, for the Ros a Mhill samples was 1.65 with a standard deviation of 0.22, while the mean condition indices for the other data sources varied from 1.39 to 1.51. It therefore appears that the Ros a Mhill fish samples had a larger round weight-at-length than fish from the other samples. This appears to confirm that the higher conversion factor estimate from these fish is not an artefact. The most likely explanation is the observation that trawling on muddy ground with relatively small meshes, results in the gills of the anglerfish filling up with mud during trawling. The average tow duration was in the order of four hours, which is sufficient time for a significant amount of mud to build up. Anglerfish caught by prawn boats are gutted normally, but also cut under the jaw and the gill opening with the specific purpose to allow this mud to be washed out. Given that mud build on the gills cannot be considered part of the live fish weight it was appropriate to omit the Ros a Mhill data from the analysis.

Table 2. Conversion factors and sample sizes between brackets. Sample size for ROS05 refers to the number of hauls, otherwise the number of fish are indicated. Values in italics were omitted from the analysis.

	Gutted-round, C_{gutted}			Gutted+liver-round, C_{liver}		
Data source	*piscatorius*	*budegassa*[a]	*Lophius* spp	*piscatorius*	*budegassa*[a]	*Lophius* spp
CTB05[a]	1.22 (39)	1.18 (66)		1.17 (39)	1.14 (66)	
IGFS05[b]	1.24 (134)	1.21 (57)		1.19 (109)	1.17 (45)	
ROS05[c]	1.37 (3)	1.26 (3)	1.36 (16)			
SCO0599[d]	1.24 (811)	1.15 (26)				
WCGSF99[e]	1.19 (24)	1.22 (6)				
Total	1.24 (1008)	1.18 (155)	1.23 (1163)[f]	1.18 (148)	1.14 (111)	1.17 (259)[f]

a Port sampling in Castletownbere 2005; b Irish Groundfish Survey 2005; c Observer trip from Ros a Mhill 2005; d RV Scotia 1999; e West Coast Groundfish Survey 1999; f Weighted by abundance of *L. piscatorius* and *L. budegassa* in the Irish landings

The stomach content of anglerfish can potentially make up a large proportion of the weight of the guts. The weight of the stomach contents was available for 104 fish sampled in Castletownbere (CTB05). Of the fish that had full stomachs, the stomach contents made up around 31% of the total weight of the guts, however, more than two thirds of the fish had empty stomachs, so the mean weight that the stomach contents contributed to the weight of the guts, was only 11%.

Gonad weights were available for 817 fish from the Scotia survey (SCO0599); on average, the gonads made up 6% of the weight of the guts. In less than 1% of the cases the gonad weight did exceed 20% of the total weight of the guts.

DISCUSSION AND CONCLUSIONS

For *L. piscatorius*, the size of the fish appeared to be independent of C_{gutted} and C_{liver}. A small, but significant, difference was found between the two data sources for C_{liver}. For *L. budegassa* there the size of the fish was also independent of C_{gutted} and C_{liver}, once the different data sources were taken into account. It is therefore valid to estimate the conversion factors by simply using the total round and gutted weights. The maturity stages were recorded for more than 1000 fish and only one female (121cm) and three males were found in spawning condition. It is presently unclear where monkfish spawn, but fish with gonads in spawning condition are very rare in commercial and research catches (Anon. 2001; Hislop *et al.* 2001; Thangstad *et al.* 2003). This might explain why the condition index does not significantly increase with size. In Figure 1, one can see that only the largest (>100cm) monkfish appear to have a higher mean conversion factor than the smaller fish. These fish are very rare in the landings, so their influence on the conversion factor will be very limited.
Some significant differences were found between the data sources. These could be due to the fact that sampling took place in different seasons and areas. The condition, liver and gonad size and gut contents of the anglerfish might well vary over time and space. At present, the data do not merit anything more sophisticated than simply combining all data sources, as these various influences cannot be resolved with the information currently available.

As anglerfish can have a significant amount of fish in their stomach, some of it maybe ingested during trawling or hauling, it has been argued that this is not part of the fish's biomass and that conversion factors should take account of this. However the purpose of a conversion factor is to estimate the round weight from gutted fish. This round weight is the weight that would have been recorded had the fish not been gutted. As it is not normal practice to empty the stomach of fish before weighing, it is not appropriate to estimate a conversion factor for fish without their stomach contents. In this context the calculated conversion factors will still give a slightly biased estimate of anglerfish biomass in the catch.

Leaving the liver in place, when gutting the fish could cause an over-estimate of the round weight by 5% if C_{gutted} would be used. It is therefore advisable to have a separate conversion factor for fish that have the liver in place.

Commercial landings statistics of anglerfish do not usually distinguish between *L piscatorius* and *L. budegassa*. It is therefore necessary to estimate a generalised *Lophius* conversion factor that reflects the relative proportions of the two species in the Irish landings. This is particularly important, as there is a large and highly significant difference in the conversion factors of the two species. The estimate species composition based on 2004 commercial landings sampling suggests that 12% of the landed weight weigh comprised of *L. budegassa*. Therefore the overall estimates for the conversion factors (weighted by species prevalence in the landings) are 1.23 for gutted weights and 1.17 for gutted with liver in. These are significantly lower than the current conversion factor that is in use (1.28) therefore a change to these new values is recommended.

Acknowledgements
Thanks to the staff of the West Coast Groundfish survey 1999, the Scotia survey 0599 and the Irish Groundfish Survey 2005. Also thanks to the FATS and port samplers (Sean O'Connor, Turloch Smith and Stephen Comerford) for collecting commercial data. The commercial sample data obtained from Castletowenbere was obtained in co-operation with Mike Fitzpatrick of the Irish South and West fish producers' organisation.

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