Length-weight relationship of four demersal species from the San Matías Gulf, Patagonia, Argentina

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Abstract. This study provides the length-weight relationship (LWR) for the main fish of fishery importance in northern Patagonia, Argentina. The LWR for *Genypterus brasiliensis* and *Acanthistius patachonicus* was not available for the Argentine Continental Shelf, so these results contribute to our knowledge of these species.

Key words: fisheries resources, northern Patagonia, trawl fishery.

Resumen: Relación largo-peso de cuatro especies demersales del Golfo San Matías, Patagonia, Argentina. Este estudio provee la relación largo peso (RLP) de los recursos pesqueros más importantes de la Patagonia norte, Argentina. Las RLP para *Genypterus brasiliensis* y *Acanthistius patachonicus* no estaban disponibles para la Plataforma Continental Argentina, por lo que estos resultados contribuyen al conocimiento de estas especies.

Palabras clave: recursos pesqueros, Patagonia norte, pesquerías de arrastre.

The length-weight relationship (LWR) indicates the average weight at a given size, usually based on the use of a potential equation that shows a relationship between both variables. LWR of fishes is of utmost importance in fishery sciences and management and has been studied since the late 19th century (Froese 1998, Garcia-Ayala *et al.* 2014). It is useful for estimating the biomass of fish stocks when only length data is known, and for understanding the life cycle of fishes since it is related to growth, energy budget, reproductive patterns, and feeding conditions of individuals (Froese 2006). Estimates of mean weight by length class are required for stock assessment models such as virtual population analysis and similar approaches (Pauly 1993). In the San Matías Gulf (SMG), a trawl demersal fishery has been developed since 1971 which focuses on the Argentine hake *Merluccius hubbsi* Marini, 1933 (Romero *et al.* 2013). Other demersal species such as the pink cusk-eel *Genypterus brasiliensis* Regan, 1903, the Argentine seabass *Acanthistius patachonicus* (Jenyns, 1842), and the Brazilian flathead *Percophis brasiliensis* Quoy and Gaimard, 1825 are also important commercial resources. The Fishery Statistics for the last decade show that these species represent more than 50% of the total catches of trawl fishery that operates in the SMG (Millán 2017). In addition to their economic importance, these species are preyed upon by the system's most conspicuous predators, such as the South American sea lion *Otaria flavescens* (Romero *et al.* 2011), the common

dolphin *Delphinus delphis* and the dusky dolphin *Lagenorhynchus oscurus* (Romero *et al.* 2012), as well as by cartilaginous fish, such as the La Plata skate *Atlantoraja platana* (Coller 2012) and the smallnose fanskate *Symterygia bonaparti* (Estalles *et al.* 2016). Previous studies determined the LWR for these species in other sites of their geographic distribution (Haimovici & Velasco 2000, Frota *et al.* 2004, Vianna *et al.* 2004, Macchi *et al.* 2006, Vaz-Dos-Santos *et al.* 2009, Portela *et al.* 2012, Rico *et al.* 2018) and some of them were made some years ago in the SMG (Rubinich & González 2001, Ocampo Reinaldo 2010). However, knowing this relationship for individuals present in the SMG, would provide basic information to understand growth patterns that could later contribute to the differentiation, assessment and management of fish stocks. In particular, the *M. hubbsi* stock in the SMG constitutes an independent demographic unit (Sardella & Timi 2004, González *et al*. 2007, Machado Schiaffino *et al*. 2011) from the other stocks described in the Argentine Exclusive Economic Zone. Therefore, the aim of this study is to determine the LWR of *M. hubbsi*, *G. brasiliensis*, *A. patachonicus* and *P. brasiliensis* sampled in the SMG. Accurately estimating the growth condition of these species will determine if somatic growth is isometric (b=3) or allometric (b≠3), providing basic knowledge of the intrinsic characteristics of the populations analyzed.

Fish samples were obtained from two sources (Table I): a) the CIMAS (Centro de Investigación

Aplicada y Transferencia Tecnológica en Recursos Marinos "Almirante Storni", San Antonio Oeste, Río Negro, Argentina) fish database; b) a research survey in 2016. Specimens were first sexed and the total length (TL) was measured to the nearest 1 cm with an ichthyometer, and wet weights (W) were determined to the nearest 0.01 g using an electronic scale. Error distribution (multiplicative or additive) was evaluated for each species' data set using likelihood analysis in order to decide which model (linear regression with logarithmically transformed data or non-linear regression with raw data) was appropriate for estimating the parameters of the relationship (Xiao *et al.* 2011). As the assumption of multiplicative log-normal error was better supported, the parameters of the length-weight relationship (W= a LT^b, where W: total weight in grams, LT: total length in cm) were estimated by fitting linear regressions to the log-transformed data (log [W]= log [a]+ log [TL]). In addition, differences between sexes for each species were compared using ANCOVA. In order to verify if calculated *b* was significantly different from 3, the Student's t-test was employed. All analyses were carried out using R software (R Core Team 2018).

A total of 3008 specimens belonging to four species were used to estimate the length-weight relationships. There were no differences in LWR between sexes for *M. hubbsi*, *A. patachonicus* and

Table I. Origin and size of the sample.

Species	Family	Origin of the sample	N
Merluccius hubbsi	**Merlucciidae**	Research survey	1812
Acanthistius patachonicus	**Serranidae**	CIMAS database	762
Genypterus brasiliensis	**Ophidiidae**	Research survey	150
Percophis brasiliensis	**Percophidae**	Research survey	294

Table II. Descriptive statistics and estimated length-weight relationship parameters for four fish species from the San Matías Gulf. ***** b is significantly different from 3 (P < 0.05).

Species	Total length range (cm)	Total weight range (g)	Regression parameters (CI 95%$_{inf}$ – CI 95%$_{sup}$) a	b	R^2	*P*-value ANCOVA
Merluccius hubbsi	19 - 81	41 – 3.485	0.0095 (0.0090 – 0.0100)	2.919***** (2.905 – 2.934)	0.99	0.19
Acanthistius patachonicus	21 - 55	200 – 2.696	0.0438 (0.0387 – 0.0496)	2.723***** (2.689 – 2.757)	0.97	0.17
Genypterus brasiliensis	30 - 62	106 - 1.616	0.0018 (0.0012 – 0.0028)	3.229 (3.122 – 3.336)	0.96	0.10
Percophis brasiliensis	32 - 71	121 – 1.579	0.0034 (0.0024- 0.0046)	3.067 (2.986 – 3.147)	0.95	0.004

G. brasiliensis, so results from pooled individuals are presented for each species in Table II. Although the LWR for *P. brasiliensis* showed significant differences between sexes ($P < 0.05$), a model using pooled individuals is also presented (Table II) for comparison purposes. Based on the results of the t-test, the growth exponent of *G. brasiliensis* and *P. brasiliensis* were not significantly different ($P > 0.05$) from 3, while *M. hubbsi* and *A. patachonicus* were significantly different ($P < 0.05$) from 3.

In this study we provide the length-weight relationship of the main commercial species landed by trawl demersal fisheries in the San Matías Gulf. All species showed an allometric coefficient of around 3, which is the expected value for most fish species (Froese 2006). *M. hubbsi* and *A. patachonicus* present allometric growth. *Acanthistius patachonicus* had the lowest coefficient *b* value, with slightly negative allometry. Although this result is similar to that obtained by Rubinich & González (2001) ($b = 2.7$) using samples from the SMG, this study provides the proportionality parameter *a* and the range of sizes in which the determined LWR could be used. There are no previous studies that report the complete LWR of *A. patachonicus* for its distribution, so this is the first record. On the other hand, the value of the coefficient *b* for *M. hubbsi* indicates negative allometry growth. When individuals collected in 2016 were incorporated in the analysis, similar results were obtained to those of Ocampo Reinaldo (2010) for individuals from SMG ($b = 3.00$). The available information on the allometric coefficient of the LWR for *M. hubbsi* populations located in Argentina ($b = 2.85$ Macchi *et al.* 2006), Uruguay ($b \sim 2.7$ Portela *et al.* 2012) and Brazil ($b = 2.87$ Haimovici & Velasco 2000, $b = 2.93$ Frota *et al.* 2004) suggests that this species shows growth in length faster than in weight. Nevertheless, Dias *et al.* (2014) when analyzing individuals from Brazil, reported positive asymmetry ($b = 3.503$) for that population, although this could be influenced by the low number of individuals used ($n = 52$) to calculate the LWR.

The LWR calculated for *G. brasiliensis* in the present study represents the first report for the Argentine sea. *G. brasiliensis* present isometric growth and compared with published data, the coefficient *b* estimated here is higher than that obtained for the same species from the central Brazilian coast ($b = 2.76$ Frota *et al.* 2004). This difference could be linked to sample size, since Frota *et al.* (2004) analyzed fewer individuals (n=

41). The growth pattern of *P. brasiliensis* was found to be isometric which indicates that an increment in length and weight occurs at equivalent rate. The value of the allometric coefficient *b* estimated for pooled sexes of *P. brasiliensis* is lower than those previously determined for the southwest Atlantic coastal waters (San Román 1974, Rico *et al.* 2018) and the southern coast of Brazil (Vianna *et al.* 2004). This variation could be explained by exogenous factors, such as fish habitat, sample size, and length of specimens examined; and various endogenous factors, such as sex of individuals, stage of sex maturity, and the amount of food contained in the stomach (Froese 2006). Significant differences were found between sexes of *P. brasiliensis* have already been reported for individuals from the Buenos Aires coast (Rico *et al.* 2018). Our results provide essential information for more complex analyses of stock status and the condition of fishes. This study updates the length-weight parameters for some of the main fishery resources in northern Patagonia, and reports for the first time LWR data for Argentine populations of *Genypterus brasiliensis* and *Acanthistius patachonicus.*

Acknowledgments

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