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Age and Growth of the lemon sole (*Microstomus kitt*) in the Celtic Sea and the North Sea

MAHÉ Kélig[1*] , ELLEBOODE Romain [1] , PERSOHN Cécile [2] , DUFOUR Jean Louis [1]

1)- IFREMER, Laboratoire Ressources Halieutiques, 150 quai Gambetta, BP699, 62321 Boulogne-sur-Mer, France.
2)- IFREMER, Laboratoire Ecologie et Modèles pour l'Halieutique, rue de l'Ile d'Yeu, B.P. 21105, 44311 Nantes Cedex 03, France.

(*) Corresponding author: (K. Mahé)
E-mail address: Kelig.Mahe@ifremer.fr

ABSTRACT: Age and growth of lemon sole (*Microstomus kitt*) were determined from 115 specimens collected in the Celtic Sea and in the North Sea in 2006 and 2007. Total length is ranged from 11 to 44 cm, while total weight varied between 12 and 1040 g. Age estimation was based on otoliths readings. The oldest male and female were estimated to be 9 years old.

The length–weight relationships parameters for lemon sole in the Celtic Sea and in the North Sea were $W=0.0043*TL^{3.2860}$ and $W=0.0062*TL^{3.1505}$ respectively. Weight including both sexes increased with positive allometric growth.

The von Bertalanffy growth equation in the North Sea was fitted on the basis of mean length-at-age data resulting in parameters values of TL_∞ = 36.44 cm (S.E. = 0.484), K = 0.187 /y (S.E. = 0.069), t_0 = -1.371 (S.E. = 0.701). Females appeared to grow more rapidely than males.

KEY WORDS: lemon sole, Growth, von Bertalanffy, Celtic Sea, North Sea.

ACRONYMS
EVHOE: EValuation Halieutique Ouest Européen
ICES: International Commission for the Exploration of the Sea
ANCOVA: Covariance analysis

Introduction

Lemon sole is a benthic fish belonging to the Pleuronectidae family. It is widely distributed in Eastern Atlantic from the White Sea and Iceland (Albert *et al.*, 1998) to the Bay of Biscay. It lives in waters from 0 to 200 m in depth (Rae, 1965 ; Jennings *et al.*, 1993). Very little is known about this species biology and ecology. Jennings et al (1999) calculated its growth in the waters of Scotland from the data of Rae (1965).

In 2007, the Working Group on Assessment of New MoU Species (ICES, 2007) made a first overview of the available knowledge of all 12 species, among which lemon sole :

sea bass (*Dicentrarchus labrax*);
striped red mullet (*Mullus surmuletus*);

red gurnard (*Aspitrigla cuculus*);
tub gurnard (*Trigla lucerna*);
grey gurnard (*Eutrigla gurnardus*);
John dory (*Zeus faber*);
dab (*Limanda limanda*);
flounder (*Platichthys flesus*);
witch flounder (*Glyptocephalus cynoglossus*);
lemon sole (*Microstomus kitt*) ,
turbot (*Psetta maxima*);
brill (*Scophthalmus rhombus*),
and tried to provide information on their general biology.

The aim of the present work was to provide information on age, growth and length-weight relationships of lemon sole in the Celtic Sea and in the North Sea for stock assessment studies.

Materials and methods:

A total of 115 lemon sole were caught with the research vessel "Thalassa" in the Celtic Sea (ICES Division VIIh, j, and g) in November 2006 during the EVHOE Groundfish Survey (n=37) and in the North Sea (ICES Division IVb and c) in February 2007 during the International Bottom Trawl Survey (n=78). All lemon sole caught were measured (total length, TL to the nearest centimetre), sexed and weighed (total weight, W to the nearest gram) on board. Otoliths (sagittae) pairs were extracted, cleaned and stored in paper envelopes. Age estimation was based on otoliths readings. Age readings were performed twice by two readers using a stereomicroscope with transmitted light at a magnification of x16.

Total Length (TL)/Total Weight (W) regressions were calculated according to the formula:

$$W=a.TL^{b}$$

where a, b are the regression's constants. Growth type (isometric and allometric) was determined by Student's t-test ($P<0.05$).

Growth rates and asymptotic lengths were described as K and TL_{∞} from the von Bertalanffy growth equation:

$$TL= TL_{\infty}\ (1 - e^{-k(t-to)})$$

where TL is length at age t and t_0 is the age at which length would theoretically be equal to zero. Differences of the slopes of the length-weight regressions between sexes were investigated using ANCOVA.

Results and discussion

Parameters of the length–weight relationships for lemon sole in the Celtic Sea and in the North Sea are given in Table 1. Males in the North Sea showed an isometric growth (b=3.004, t-test $P>0.05$). Otherwise, slopes were significantly different from 3 indicating positive allometric growth (t-test, $P<0.05$).

Table 1 : Regression's parameters ($W=aTL^{b}$) between total length (TL, cm) and total weight (W, g) for females, males and combined sexes of lemon sole in the Celtic Sea and in the North Sea.

		N	TL		W		a	b	r^2
			min	max	min	max			
Celtic Sea	All fish	37	19	44	67	1040	0,0043	3,2860	0,9845
	Females	15	23	44	137	1040	0,0073	3,1401	0,9898
	Males	22	19	37	67	533	0,0046	3,2579	0,9724
North Sea	All fish	78	11	40	12	759	0,0062	3,1505	0,9736
	Females	46	11	40	12	759	0,0058	3,1903	0,9828
	Males	39	14	33	28	369	0,0092	3,0041	0,9748

Most of the collected data from the Celtic Sea appear to follow the growth curve from Rae (1965) for Scotland waters (Fig 1, A) although several data points are low. The data for the South North Sea show a slower growth than in Celtic sea and Scotland waters (Fig. 1, B). Most of the growth occurred in the first year of life and continued at a relatively low and constant rate.

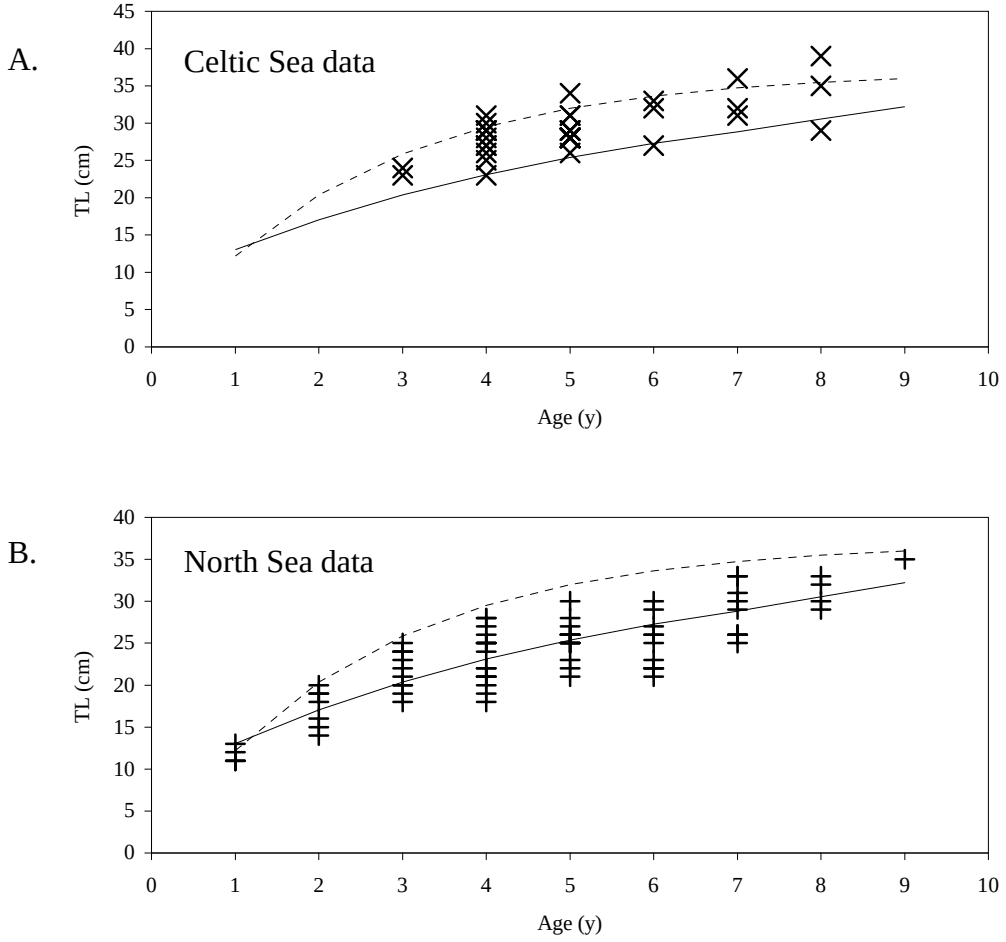

Figure 1 : Von Bertalanffy growth curves for the North Sea (solid line, our data) and the Waters of Scotland lemon sole (Rae, 1965 ; broken line).

A : data from the Celtic Sea (ICES Division VIIh, j, and g),

B : data from the North Sea (ICES Division IVb and c).

Table 2 : Parameters of lemon sole growth (L_∞, K, t_0). SE is standard error.

		L_∞		K		t_0	
		Estimate	SE	Estimate	SE	Estimate	SE
North Sea (ICES Division IV b and c)	All fish	36,440	4,837	0,187	0,069	-1,371	0,701
	Females	37,940	6,625	0,177	0,089	-1,756	0,111
	Males	36,700	7,900	0,173	0,091	-1,143	0,824
Waters of Scotland (Rae, 1965)	All fish	37,000		0,420		0,000	

Figure 2 shows growth curves for male and females. Growth coefficient (K) and asymptotic length (TL_∞) (Table 2) were higher for females (K= 0.177 ; TL_∞=37.94 cm) than males (K= 0.173 ; TL_∞=36.70 cm). There was significant differences between the two sexes (ANCOVA, $P<0.05$). Rae (1965) had already observed that female fishes appear to grow more quickly than the males with differences in the average size at each age.

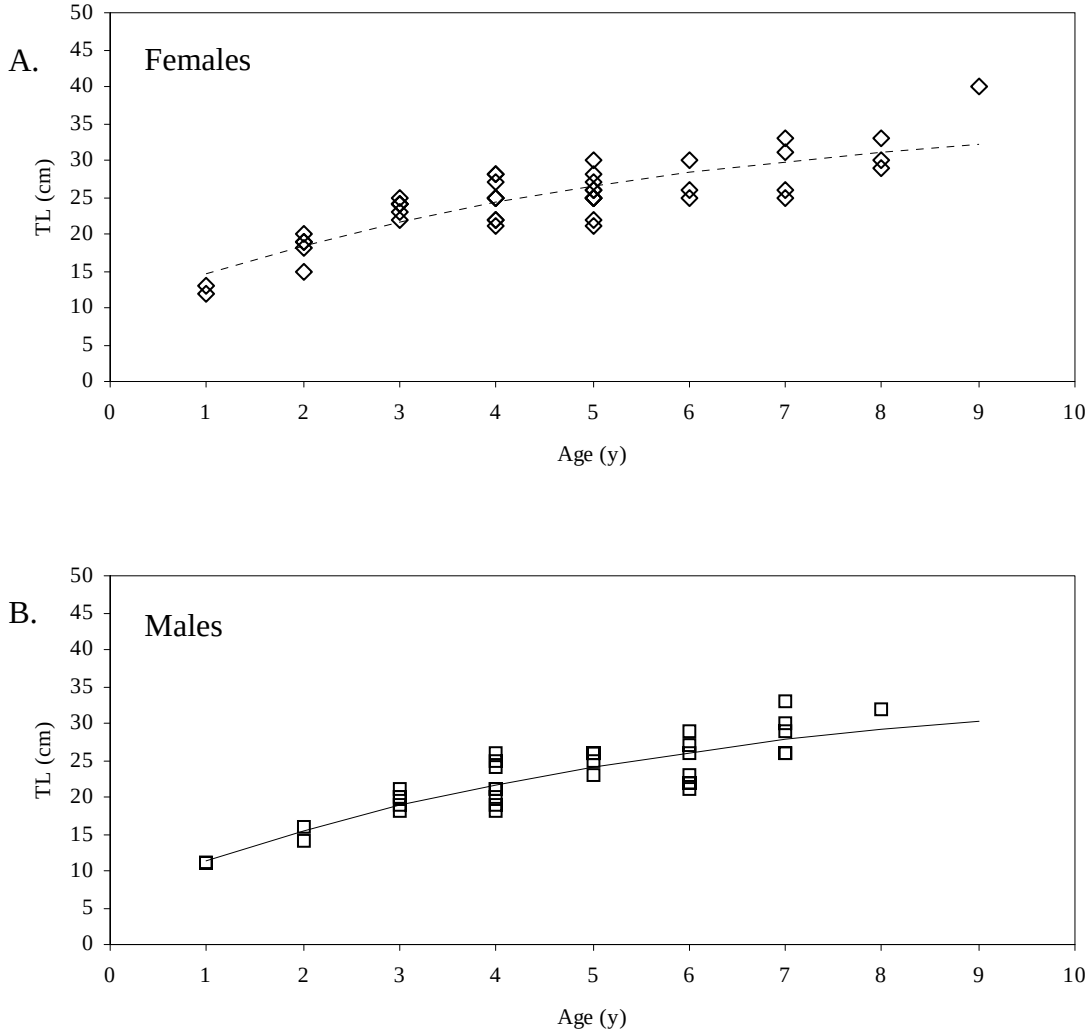

Figure 2 : Von Bertalanffy growth curves and lemon sole data of females (A.) and males (B.) in the North Sea.

In the North Sea, the observed asymptotic length was comparable to the value in the Scotland waters (Rae, 1965) (Table 2). However, the growth coefficient which determined the rate to which lemon sole reach its maximum size was much lower (this study : K=0.187 ; Rae, 1965 : K=0.420).

Growth coefficient (K) of flatfish species decreased with increasing asymptotic length (linear regression model ; F=12.019 ; P=0.006) (Fig. 3). Our estimations of growth parameters L_∞ (36.44 cm) and K (0.187 $years^{-1}$) for lemon sole from the North Sea were close to those described for the witch from Irish Sea (Jennings *et al.*, 2000) and sole in the North Sea (Wittmames *et al.*, 1995 ; Jennings *et al.*, 1998) (Table 3).

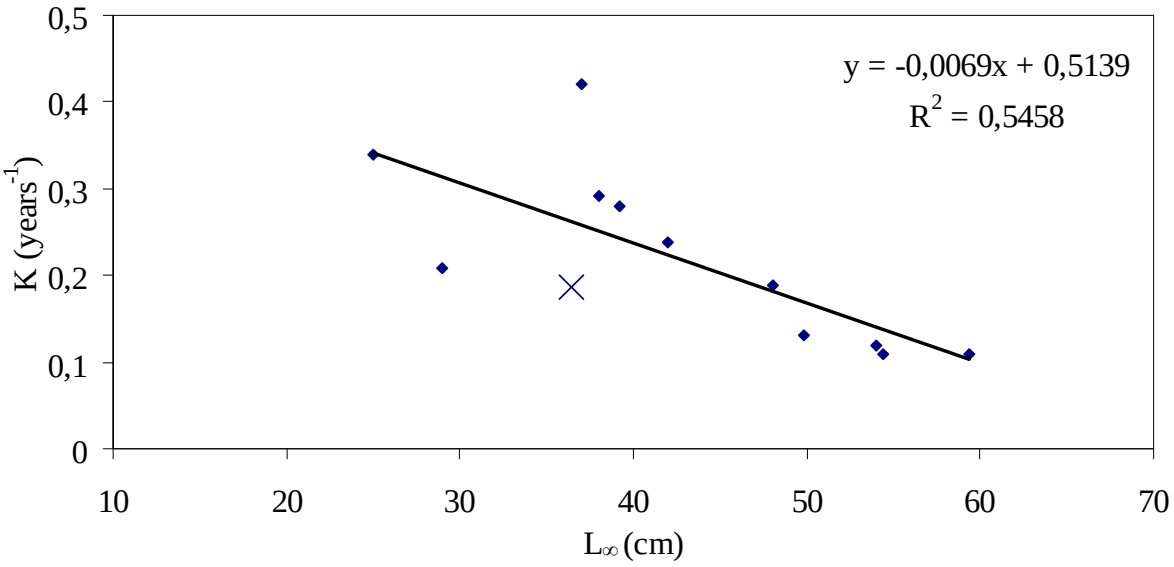

Figure 3 : Relationship between the von Bertalanffy growth parameters L_∞ and K of several flatfish (data of this study are indicated by a cross).

This study presented different growth of the lemon sole from Scotland waters (Rae, 1965) and Faroe Plateau (Rae, 1939) (Table 3). Growth was influenced by a combined effect of several factors : eutrophic conditions, fishing pressure (especially beam trawling introduced in the early 1960s), temperature, seabed disturbance, food availability and competition. Growth difference intra- and interspecific can be explained by spatial and/or temporal scale (Rijnsdorp & Van Beek, 1991; Millner & Whiting, 1996; Millner *et al*., 1996; Rijnsdorp & van Leeuwen, 1996; Pastoors *et al*., 2000; Magnussen, 2007).

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Table 3 : Parameters of the von Bertalanffy growth curve (L_∞, K) for several flatfish from different study areas.

Species	Study area	von Bertalanffy growth parameters		References
		TL_∞ (cm)	K (year s^{-1})	
Plaice (*Pleuronectes platessa*)	Celtic Sea	59,4	0,11	Jennings et al., 1998 Horwood, 1993b
Sole (*Solea solea*)	Celtic Sea	49,8	0,13	Jennings et al., 1999 Horwood, 1993a
Witch (*Glyptocephalus cynoglossus*)	Irish Sea	38	0,291	Jennings et al., 1999
Witch (*Glyptocephalus cynoglossus*)	North Sea	42	0,238	Jennings et al., 1999
Dab (*Limanda limanda*)	North Sea	29	0,208	Rijnsdorp et al., 1992
Plaice (*Pleuronectes platessa*)	North Sea	54,4	0,11	Jennings et al., 1998 Horwood et al., 1986
Sole (*Solea solea*)	North Sea	39,2	0,28	Jennings et al., 1998 Wittmames et al., 1995
American plaice (*Hippoglossoides platessoides*)	North Sea	25	0,34	Jennings et al., 1999 Ntiba, 1989
Megrim (*Lepidorhombus whiffiagonis*)	North Sea	54	0,12	Jennings et al., 1999 Moguedet & Perez, 1988
Lemon sole (*Microstomus kitt*)	waters of Scotland	37	0,42	Rae, 1965
Lemon sole (*Microstomus kitt*)	Faroe Plateau	48	0,189	Rae, 1939
Lemon sole (*Microstomus kitt*)	North Sea	36,44	0,187	this study

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