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Yellowtail Flounder Length-at-maturity in the Grand Bank (1995–98)

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Abstract

Length-at-maturity estimates of yellowtail flounder (*Limanda ferruginea*) based on data collected in the spring Spanish surveys in the NAFO Regulatory Area of Divisions 3NO are presented. Female length at 50% maturity (L_{50}) decreased from 35 cm in 1995 to 23 cm in 1998. In males, this parameter decreased from 23 cm in 1995 to 19 cm in 1998. The differences in L_{50} estimates in females were significant between 1997 and the previous years, and between 1998 and both 1996 and 1995, and were not significant between 1997 and 1998. In males, differences were significant between all the years, except between 1997 and 1998. The covariance analysis between the linearized maturity curves was highly significant in both sexes.

Keywords: females, length-at-maturity, males, maturity curves, yellowtail flounder

Introduction

The yellowtail flounder (*Limanda ferruginea*) is a spring-early summer spawner species (Zamarro, MS 1988). In the past this stock had a northern distribution limit in commercial concentrations off Newfoundland coast, but at present it is concentrated on the Grand Bank, mainly in the southern part, where the juvenile and the adult components overlap in their distribution (Walsh, 1992; Brodie *et al*., 1998). There was a fishing moratorium for this stock from 1994 to 1997, and for 1998 the Scientific Council recommended reopening a limited fishery, stating also that this fishery should be carefully monitored and sampled.

Morgan and Walsh (MS 1997) presented estimates of length- and age-at-maturity for yellowtail flounder in Div. 3LNO from 1975 to 1995, based on the Canadian spring survey. They observed a decline in males length-at-maturity, but no decline was evident in females. Durán *et al*. (MS 1998) presented estimates of the length-at-maturity based on the Spanish spring survey in the Regulatory Area, where the decline was observed in both sexes. Variations in length-at-maturity can be caused by several factors: growth variability, geographic distribution and stock abundance. Besides, random natural variability can occur, though under stable population conditions this should be small (Walsh and Morgan, MS 1998).

In this paper additional data from the spring Spanish survey in Div. 3NO on this subject is examined, in order to determine the consistency of the declining trends in length-at-maturity observed in previous years.

Material and Methods

Yellowtail maturity data used in this study have been collected during the Spanish spring surveys conducted in the Regulatory Area in Div. 3NO from 1995 to 1998 (Paz *et al*., MS 1996 and MS 1997; Durán *et al*., MS 1998). The geographic distribution of the samples analysed in the successive surveys appears in Fig. 1, and the length ranges and numbers in Table 1. Fish were classified as mature or immature by visual examination of the gonads. A simple four-point scale was used to do it, where the first stage is defined as immature and all the others (maturing, spawning and post-spawning) as matures.

The proportion of mature males and females by size were adjusted to a logistic equation as described by Ashton (1972):

$$\hat{P} = \frac{e^{a+bL}}{1+e^{a+bL}}$$

and the logit transformation:

$$\ln \frac{\hat{P}}{1-\hat{P}} = a + bL$$

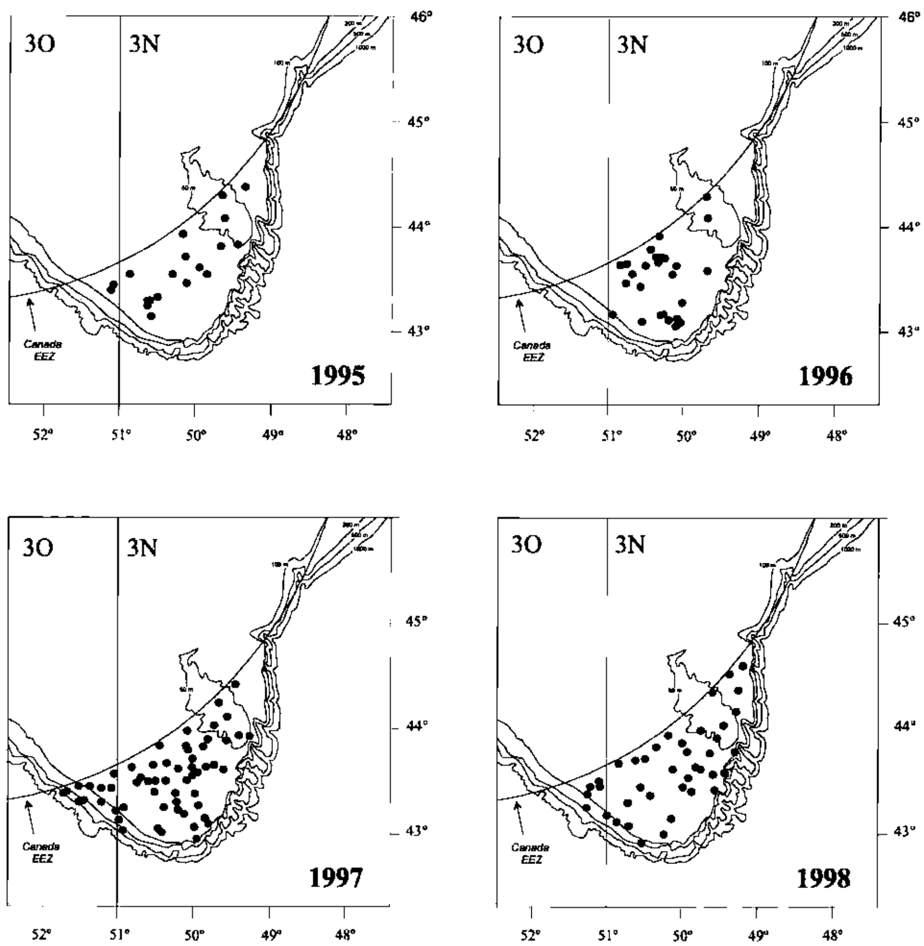

Fig. 1. Yellowtail flounder sampling area in the Spanish spring bottom trawl surveys in Div. 3NO (1995–98).

where $\hat{P}$ is the predicted mature proportion, a and b the coefficients estimated of the logistic equation and L the length. The size-at-maturity can be estimated as the minus ratio of the coefficients ($-a/b$) by substituting $\hat{P} = 0.5$ in the above equation.

To evaluate the differences in size-at-maturity between years, the variance of those parameters every year was calculated from the variances and covariance of the maturity curve coefficients (Ashton, 1972):

$$V(L_{50}) = \frac{1}{b^2}\left[V(a) + \frac{a^2}{b^2}V(b) - \frac{2a}{b}\mathrm{FRY}(a,b)\right]$$

Assuming that L_{50} estimates are normally distributed, then the Z statistic can be computed as:

$$Z = \frac{\frac{a_1}{b_1} - \frac{a_2}{b_2}}{\sqrt{V_1 + V_2}}$$

where a and b are the logistic regression coefficients and V_1 and V_2 the L_{50} variances of each year compared. Z values can be used to test the null hypothesis of parameters equality (Gunderson, 1977). The linear transformation of the maturity curves are also compared using a covariance analyses to evaluate between year differences in the curve slopes and the influence of the length distributions on the length-at-maturity estimates.

All the statistical analysis has been performed using the Statistica package (StatSoft. Inc., 1995).

Results and Discussion

The length range was approximately similar in the three years analysed (Table 1), but since 1997 the proportion of the smaller length-classes increased in the samples. This is reflected in a parallel decrease of

TABLE 1. Number of yellowtail flounder sampled by length, sex and year in the spring Spanish survey in Div. 3NO.

Length (cm)	Females 1995	1996	1997	1998	Males 1995	1996	1997	1998
>14			2	6		2	1	2
14–16	12		18	9	8	16	12	4
17–19	37	42	42	51	8	55	38	50
20–22	22	61	87	90	14	82	85	79
23–25	28	103	100	82	26	53	91	75
26–28	20	48	118	53	22	64	109	70
29–31	34	55	150	69	34	74	80	84
32–34	66	71	112	68	33	60	66	56
35–37	46	123	121	59	33	20	60	45
38–40	39	119	116	74	17	9	34	38
41–43	24	51	91	79	3	1	10	19
44–46	12	42	23	41			4	5
47–49	5	14	4	11			1	
50–52	3	2	1					
53–55		5	1					
Total	348	736	986	692	198	436	591	527

the yellowtail flounder lengths caught in the survey. In 1997 and 1998, the level of sampling was higher in Div. 3O compared with previous years, due an increase in the yellowtail flounder presence in that area during those surveys (Paz *et al.*, MS 1997), but it does not affect the parameter estimates.

The maturity curves for females and males are shown in Fig. 2, and the parameters of the fitted curves in Table 2. Female length at 50% maturity decreased slightly from 1995 (35 cm) to 1996 (34 cm), but a pronounced decrease was observed in 1997 (24 cm) and maintained in 1998 (23 cm). In males the L_{50} ranged from 23 cm in 1995 to 27 cm in 1996, and then decreased to 21 cm in 1997 and 19 cm in 1998. The differences in L_{50} estimates in females were significant between 1997 and the previous years (1995 and 1996), and between 1998 and both 1995 and 1996, and were not significant between 1997 and 1998 (Table 3). In males, the differences were significant between all the years, except between 1997 and 1998 (Table 3).

The covariance analyses of the maturity curves (Table 4) indicate that the slopes and intercepts were significantly different between years in both sexes. Thus, the mature proportions at length were different in the years analysed, not only due to a difference in the length distributions involved. Also the rate of increase of the mature proportions with length was different.

Decreases in both age- and length-at-maturity in coincidence with decreases in stock abundance has been observed in recent years in several shelf species from this same area (Stearns *et al.*, 1984; Morgan *et al.*, MS 1993; Saborido and Junquera, 1998). However it is difficult to assert that such could be the case of the yellowtail flounder, as the stock seems to be at present in a better situation than it was in the past (Anon., 1997). From Morgan and Walsh (MS 1997) results, which include a much longer time series (1975–95), few trends were evident, though a decline in males L_{50} since 1984 occurred from 30 cm to 25 cm at the end of their time series. The L_{50} estimates in the only coincident year with the present study (1995) are approximately similar in both sexes, but in contrast, Morgan and Walsh (MS 1997) found a more pronounced decreasing trend on males L_{50} while we found it in females.

The present study is based in a series of surveys which cover only partially the yellowtail flounder distribution range, namely the part of the stock in the Regulatory Area. The length-at-maturity results obtained in 1997 are consistent with the 1998 estimates, and can be reflecting a change in the species distribution pattern. In 1997 and 1998 significant amounts of small and mature

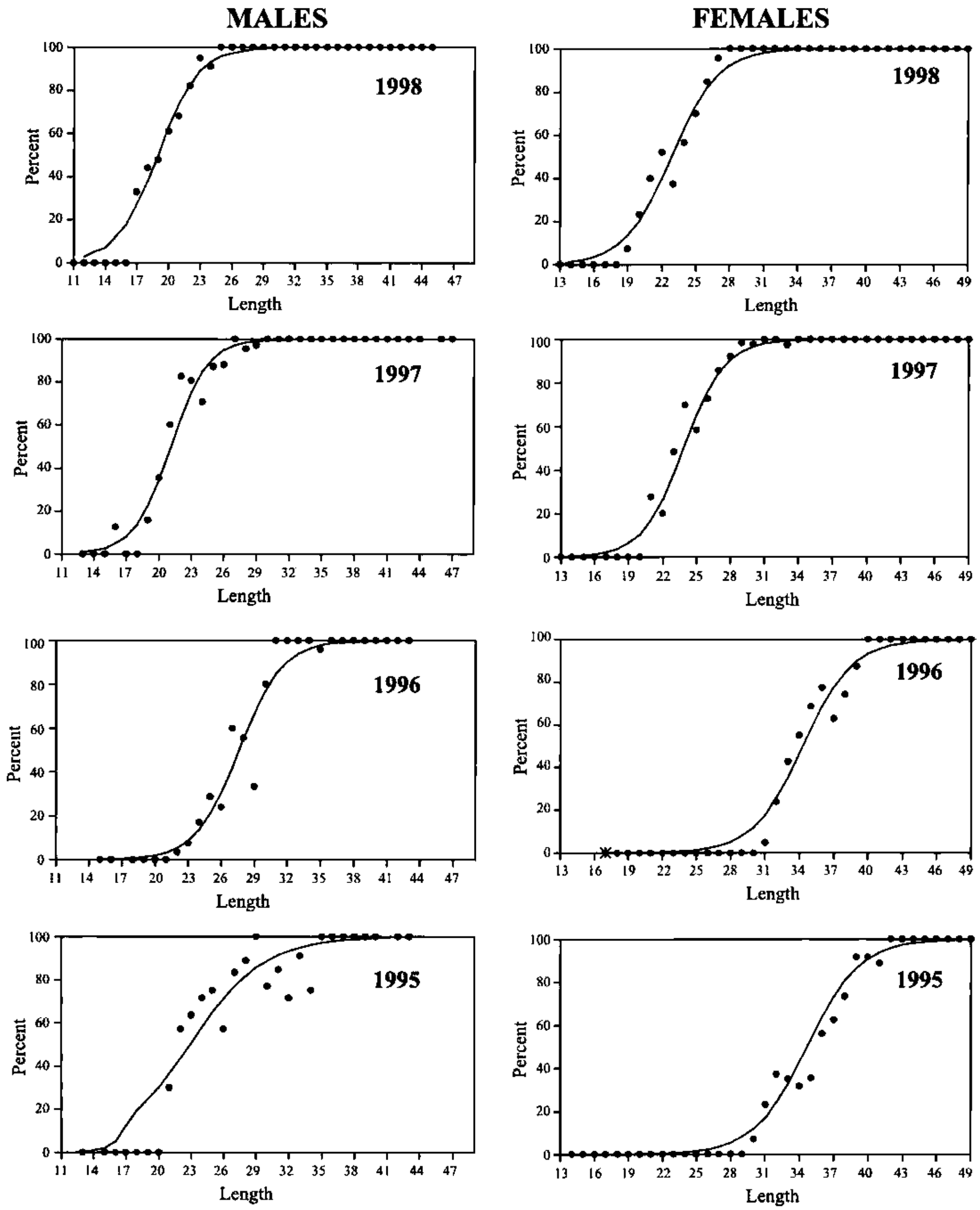

Fig. 2. Yellowtail flounder maturity curves by sexes in Div. 3NO (1995–98).

fish appeared in the survey area (Paz *et al.*, MS 1997, Durán *et al.*, MS 1998) and they were largely more concentrated than in previous surveys. Thus mature small fish, likely first spawners, could have become more available to the surveys in 1997–98 just because of a change in their distribution, or those small adults could have become more abundant because they belong to a large year-class.

TABLE 2. Parameters of the yellowtail flounder females and males maturity curves in Div. 3NO (1995–98). 'a' and 'b' = coefficients of the adjusted logistic curve; St. Error = standard error of the estimates; L_{50} = length at 50% maturity; Var. exp. = variance explained by the model; N = numbers sampled.

	Females							
	1995		1996		1997		1998	
	a	b	a	b	a	b	a	b
Estimate	-12.98	0.37	-15.65	0.46	-13.08	0.55	-10.98	0.48
St. error	1.50	0.04	1.34	0.03	0.85	0.03	1.34	0.06
L_{50}	**35 cm**		**34 cm**		**24 cm**		**23 cm**	
Var. exp.	54%		62%		64%		62%	
N	348		736		986		692	

	Males							
	1995		1996		1997		1998	
	a	b	a	b	a	b	a	b
Estimate	-6.65	0.29	14.06	0.50	-12.45	0.59	-9.63	0.51
St. error	1.41	0.06	1.27	0.04	1.46	0.07	1.38	0.02
L_{50}	**23 cm**		**27 cm**		**21 cm**		**19 cm**	
Var. exp.	35%		64%		50%		40%	
N	198		436		591		527	

TABLE 3. Z values of the comparative analysis of the yellowtail flounder length at maturity between years. *significance (p<0.05); **significance (p<0.01); otherwise not significant.

Z – Females	1996	1997	1998
1995	0.55	5.18**	14.1**
1996		8.53**	16.8**
1997			0.65
Z – Males	**1996**	**1997**	**1998**
1995	2.99**	2.15*	1.78*
1996		4.36*	5.26**
1997			0.41

TABLE 4. Covariance analysis between years (1995–98) of the mature proportions at length (effect) in Div. 3NO yellowtail flounder.

	Females				
	SS	df	MS	F	P-level
Effect	26.16	44	0.59	16.46	0.0000
Error	3.09	122	0.04		
	Males				
	SS	df	MS	F	P-level
Effect	17.12	38	0.45	12.84	0.0000
Error	2.07	93	0.03		

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