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Comparative study of the stock distribution of yellowtail (*Limanda ferruginea*, Storer, 1839) on Nova Scotia and Georges Banks

by

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Introduction

Meristic and morphometric characteristics of yellowtail were studied in four areas of the Scotian Shelf and in one on Georges Bank from sampling data derived from various cruises to the areas by the R/V *Cryos*. The study aims at distinguishing between the true groups of the different populations, if differences exist. The following definitions were adopted for the terms group and population:

- two groups are distinct if at least one characteristic (meristic or metric) has a different average value for each of the two samples; that is, if the samples studied belong to two statistical populations for the characteristic or characteristics;

- two populations are distinct if at least three characteristics (meristic or metric) each have a different average value for each of the two samples; that is, the samples studied belong to different statistical populations for each of at least the three characteristics studied.

Materials and Methods

1. Areas studied

The following areas were selected for study partly because of the bathymetric limitations of the yellowtail and partly because the species migrates very little (Fig. 1):

Area 1 : East of Banquereau (Eastern Shoals)
Area 2 : North of Sable Island
Area 3 : South of Sable Island
Area 4 : Sable Island Bank
Area 5 : Georges Bank

2. Characters studied

Meristic characters examined are: the number of dorsal fin rays (RD), the number of anal fin rays (RA), and the number of gillrakers on both limbs of the anterior gill arch.

Morphometric characters studied are: ratio of head length (LG^1) to total length (LT), and the ratio of snout length (Ls) to head length (LG^1):

where LT = total body length, taken from the anterior extremity of the lower jaw to the medio-posterior extremity of the caudal fin;
LG^1 = head length, taken from the anterior extremity of the lower jaw to the posterior part part of the cartilagenores edge of the upper gill cover;
Ls = snout length taken from the anterior extremity of the lower jaw to the anterior edge of the left eye socket.

3. Statistical methods

The available data were grouped by area (and also sex where necessary) to give a series of frequency distributions for each of the characters studied, and the samples treated statistically using the following parameters:

n = number of specimens
M = average
σ = standard deviation
σ^2 = variance
Sm = standard error (standard deviation of the mean)
MISm = 95% confidence limits.

The means and their 95% confidence limits are recorded graphically for each characteristic and each study area. In this way any differences can be distinguished graphically, or by homogeneity (Lamotte, 1962). This test involves calculating the parameter

$$t = \frac{M_1 - M_2}{Sd},$$

where M_1 and M_2 are the means of the two sampled characters being tested, and the standard error of the difference,

$$Sd = \sqrt{Sm_1^2 + Sm_2^2}$$

If t is greater than 1.96, the sample means are significantly different and the samples may be considered to have been taken from two different populations (positive test, +). The t-test is valid if the number of degrees of freedom ($n_1 + n_2 - 2$) is greater than 30, which is the case for all comparisons made in this study.

Results

The results of the t-tests are given in Table 1, and the frequency distributions and associated parameters for the various characters studied are given in Tables 2-7.

1. Dorsal fin rays (RD) (Table 1, 2; Fig. 2A)

Since no significant sexual dimorphism exists for this character, the area comparisons are based on the total number of individuals in the samples. Fig. 2A shows a very low average for area 5, and test 4-5 (Table 1) indicates that the samples were drawn from two different populations. The samples from area 1, 2, 3 and 4 are not distinctly different. Thus the yellowtail in area 5 may be considered to be distinctly different from those in the other areas which belong to the same population.

2. Anal fin rays (RA) (Table 1, 3; Fig. 2B)

As for dorsal fin rays, there is no significant sexual dimorphism for anal fin rays (Scott, 1954). The average recorded for area 5 (Georges Bank) is slightly higher than that obtained by Lux (1963). Fig. 2B shows a lower average for area 5 than for the other four areas. Since tests 1-2 and 2-5 (Table 1) are positive, the area 5 sample is different from the others. Furthermore, the fish in areas 1 and 4 do not belong to the same population.

3. Gillrakers (Table 1, 4; Fig. 2C)

Again there is no significant sexual dimorphism in gillraker counts and the areas are compared on the basis of the sexes combined. Fig. 2C shows a lower average for area 5, but the other areas do not have a common population as indicated by test 4-1. It seems that there are two populations: one in area 5 and the other consisting of two groups, areas 1 + 2 and areas 3 + 4.

4. Head length to total length ratio $\left(\frac{LG^1}{LT} \times 10^2\right)$ (Table 1, 6; Fig. 2D)

There is significant sexual dimorphism for each area for this character (Table 5, Fig. 3). For fish of equal length, females have a longer head than males. Although the ratio of males to females in the samples differ somewhat from area to area, comparisons by area for sexes combined give the same conclusions as comparisons by area for sexes separate. The samples from area 5 again differ from the others. In summary, we have two populations: one in area 5, and the other consisting of two groups, areas 1 + 2 and areas 3 + 4.

5. Snout length to head length ratio $\left(\frac{Ls}{LG^1} \times 10^2\right)$ (Table 1, 7; Fig. 2E)

For this character, the Ls : LG^1 ratio for males and females have the same value, when fish of the same length are compared. Since the head length of the female is greater than that of the male, the snout length is therefore also greater in the female. This character gives a greater difference in the averages for the various areas (Fig. 2E). It is distinctive in all areas, except between areas 1 and 4, where the RA character is distinctive. In summary, there are three populations: area 5 being one, groups 1 and 2 forming the second, and groups 3 and 4 forming the third.

Discussion and Conclusions

Two remarks can be made: (a) if the meristic characteristics do not vary during the adult life, they do not stabilize until the larva goes to the bottom (Bigelow and Schroeder, 1953); (b) the metric characteristics vary with age, however the year-class distribution was comparable in the areas studied, except in area 5.

Generally, the meristic characteristics do not show significant sexual dimorphism. The metric characteristics on the other hand, have this feature. When males and females are of equal length, the females have a longer snout nad head than the males.

From this study, we have found three distinct populations of yellowtail flounder. The first is found on Georges Bank, and the other two, off the narrows of Sable Island. The latter two are each formed of two groups (Table 8). They are both completely separate from the Georges Bank population. They are separated bathymetrically by the narrows of Sable Island, but certainly undergo interactions due to their geographic proximity.

References

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of Gulf of Maine. *Fish. Bull. U.S. depart. of Int.*, Vol. 74, p. 271-275.

Laevastu, T. 1967. Manuel des méthodes employées en biologie halieutique. *F.A.O.*, Vol. 1 (2, 9, 10).

Lamotte, M. 1962. Initiation aux méthodes statistiques en biologie. Paris, 2ème éd., MASSON et Cie, 141 p.

Lux, F.E. 1963. Identification of New England yellowtail flounder groups. *Fish. bull. U.S. depart. of Int.*, Vol. 63 (1), p. 1-10.

Scott, D.M. 1954. A comparative study of the yellowtail flounder from three Atlantic fishing areas. *Journ. Fish. Res. Bd. Canada*, Vol. 11 (3), p. 171-197.

Table 1 - Results of homogeneity tests mentionned in the text.

	Sm_1	Sm_1^2	Sm_2	Sm_2^2	$Sm_1^2 + Sm_2^2$	Sd	2 Sd	m_1	m_2	$m_1 - m_2$	test
RD : number of dorsal fin-rays											
4-5	0.263	0.069	0.224	0.050	0.119	0.344	0.688	81.672	80.704	0.908	+
RA : Number of anal fin-rays											
1-5	0.104	0.010	0.160	0.025	0.035	0.187	0.374	61.221	60.813	0.408	+
2-5	0.167	0.027	0.160	0.025	0.052	0.228	0.456	61.324	60.813	0.511	+
4-1	0.173	0.029	0.104	0.010	0.039	0.197	0.394	61.625	61.221	0.394	+*
number of gill-rakers											
4-1	0.146	0.021	0.072	0.005	0.026	0.161	0.322	17.849	17.527	0.322	+**
2-5	0.119	0.014	0.096	0.009	0.023	0.151	0.302	17.260	16.860	0.400	+
ratio : $\frac{LG'}{LT} \times 10^2$											
2-5	0.067	0.004	0.057	0.003	0.007	0.083	0.166	20.237	20.054	0.183	+
ratio : $\frac{Ls}{LG'} \times 10^2$											
2-1	0.102	0.010	0.061	0.003	0.013	0.114	0.228	24.787	24.427	0.360	+
2-4	0.102	0.010	0.103	0.010	0.020	0.141	0.282	24.787	24.508	0.279	+***
3-5	0.148	0.021	0.081	0.006	0.027	0.164	0.328	23.669	23.310	0.359	+

* the real value of 1.96 Sd is 0.386

** the real value of 1.96 Sd is 0.315

*** the real value of 1.96 Sd is 0.276

Table 2 - Data on the number of dorsal fin-rays for each zone (sex mixed).

Zones / Number of rays	1	2	3	4	5
73			1		2
74	1				
75	3			1	2
76	4	3		2	8
77	19	5	1	8	7
78	17	7	3	9	13
79	35	9	6	8	21
80	38	18	8	10	26
81	65	20	9	14	29
82	44	26	14	16	19
83	43	18	5	11	14
84	25	16	11	16	12
85	25	17	4	14	5
86	17	2	1	5	4
87	5	1	3	2	2
88	5	3	1		1
89					
90	1				
91			1		
92					
93					1
n	347	145	68	116	166
m	81.530	81.848	82.058	81.672	80.704
σ^2	7.460	6.397	8.223	7.977	8.330
σ	2.731	2.529	2.867	2.824	2.886
Sm	0.146	0.210	0.350	0.263	0.224
m - 2 Sm	81.238	81.428	81.358	81.146	80.256
m + 2 Sm	81.822	82.268	82.758	82.198	81.152

Table 3 - Data on the number of anal fin-rays for each zone (sex mixed).

Zones / Number of rays	1	2	3	4	5
55		1			
56	2	2	1		4
57	5	2		1	3
58	19	7		4	15
59	37	12	11	14	18
60	65	21	10	14	31
61	66	28	14	20	35
62	62	34	9	22	32
63	54	19	7	23	15
64	22	14	9	15	5
65	9	2	3	3	7
66	5	3	2	1	
67	1		2		
68					
69					1
n	347	145	68	117	166
m	61.221	61.324	61.691	61.615	60.813
σ^2	3.805	4.030	5.015	3.493	4.233
σ	1.950	2.007	2.239	1.868	2.057
Sm	0.104	0.167	0.273	0.173	0.160
m - 2 Sm	61.013	60.990	61.145	61.269	60.493
m + 2 Sm	61.429	61.658	62.237	61.961	61.133

Table 4 - Data on the number of gill-rakers for each zone (sex mixed).

Zones / Number of gill-rakers	1	2	3	4	5
14	1	2			4
15	19	14	2	5	13
16	50	26	6	17	47
17	105	39	13	30	57
18	98	34	22	24	31
19	45	19	14	18	10
20	18	7	10	14	2
21	5	1		4	
22	2			1	1
n	343	142	67	113	165
m	17.527	17.260	18.044	17.849	16.860
σ^2	1.807	2.001	1.678	2.399	1.519
σ	1.344	1.414	1.295	1.548	1.232
Sm	0.072	0.119	0.159	0.146	0.096
m - 2 Sm	17.383	17.022	17.726	17.557	16.668
m + 2 Sm	17.671	17.498	18.362	18.141	17.052

Table 5 - Data on the ratio : $\frac{LG'}{LT} \times 10^2$, for each zone (by sex)

Zones: / Values of the ratio	1		2		3		4		5	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
18									2	
18.5			3	2		1			2	
19	2		6						15	3
19.5	12	5	18	4					28	7
20	24	21	23	23	3	1	7	2	29	11
20.5	42	49	9	16	4	6	14	7	28	11
21	35	54	7	13	5	7	12	11	10	13
21.5	20	46	3	8	3	18	14	17	2	4
22	6	20		3		8	3	14		
22.5	1	6		1		8		9		
23		1				1		3		
23.5								3		
n	142	202	69	70	15	50	50	66	116	49
m	20.651	21.004	19.949	20.521	20.766	21.490	20.920	21.666	19.922	20.367
σ^2	0.482	0.505	0.498	0.593	0.311	0.637	0.340	0.701	0.497	0.491
σ	0.694	0.710	0.705	0.770	0.557	0.798	0.583	0.837	0.704	0.700
Sm	0.058	0.050	0.085	0.092	0.148	0.114	0.083	0.103	0.065	0.101
m - 2 Sm	20.535	20.904	19.779	20.337	20.470	21.262	20.754	21.460	19.792	20.165
m + 2 Sm	20.767	21.104	20.119	20.705	21.062	21.718	21.086	21.872	20.052	20.569

Table 6 - Data on the ratio : $\frac{LQ'}{LT} \times 10^2$, for each zone (sex mixed).

Zones / Values of the ratio	1	2	3	4	5
18					2
18.5		5	1		2
19	2	6			18
19.5	17	22			35
20	45	46	4	9	40
20.5	91	25	10	21	39
21	89	20	12	23	23
21.5	66	11	21	31	6
22	26	3	8	17	
22.5	7	1	8	9	
23	1		1	3	
23.5				3	
n	344	139	65	116	165
m	20.859	20.237	21.323	21.344	20.054
σ'	0.495	0.626	0.647	0.698	0.541
σ	0.703	0.791	0.804	0.835	0.735
Sm	0.037	0.067	0.100	0.077	0.057
m - 2 Sm	20.785	20.103	21.123	21.190	19.940
m + 2 Sm	20.933	20.371	21.523	21.498	20.168

Table 7- Data on the ratio : $\frac{Lm}{LG'} \times 10^2$, for each zone (sex mixed).

Zones / Values of the ratio	1	2	3	4	5
21			1		1
21.5	4		1	2	11
22	6	2	6		13
22.5	12	5	8	3	22
23	23	7	8	7	35
23.5	44	13	9	20	36
24	68	20	12	15	18
24.5	65	23	10	13	15
25	39	13	3	31	7
25.5	38	25	4	15	5
26	25	18	2	5	3
26.5	11	8	1	2	
27	5	2		1	
27.5	3	3		1	
28				1	
n	343	139	65	116	166
m	24,427	24.787	25.669	24.508	23.310
σ'	1.288	1.451	1.404	1.239	1.091
σ	1.134	1.204	1.184	1.113	1.044
Sm	0.061	0.102	0.148	0.103	0.081
m - 2 Sm	24,305	24.583	25.373	24.302	23.148
m + 2 Sm	24.549	24.991	25.965	24.714	23.472

Table 8 - Populations and groups distinguished in this study.

Populations	Groups
Georges Bank (zone 5)	
North Gully population	East Banquereau (zone 1)
	North of Sable Island Gully (zone 2)
South Gully population	South of Sable Island Gully (zone 3)
	Sable Island Bank (zone 4)

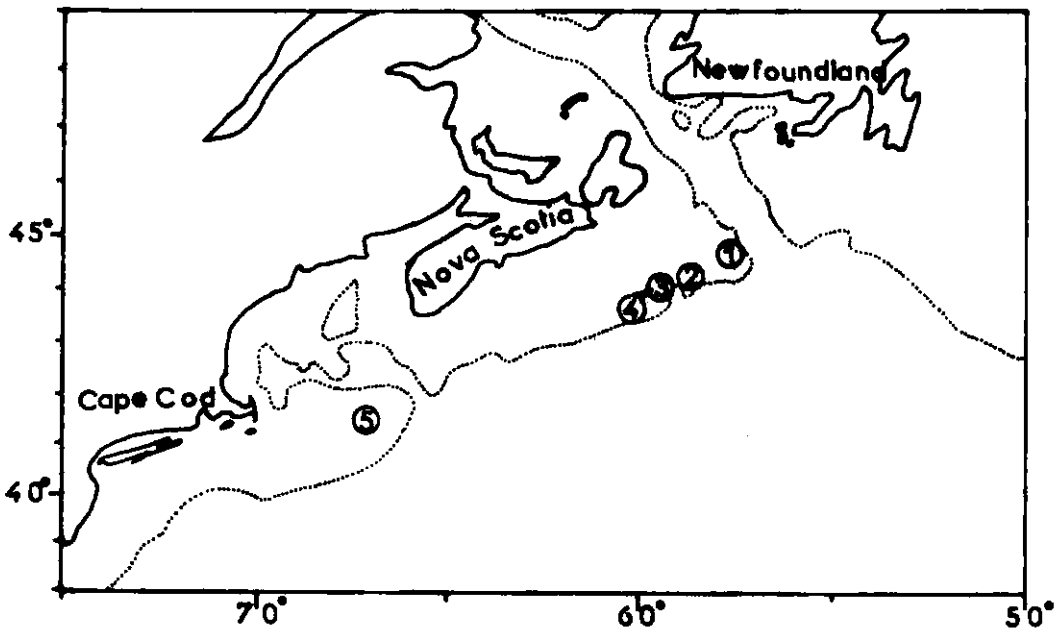

Fig. 1. Map showing zones studied.

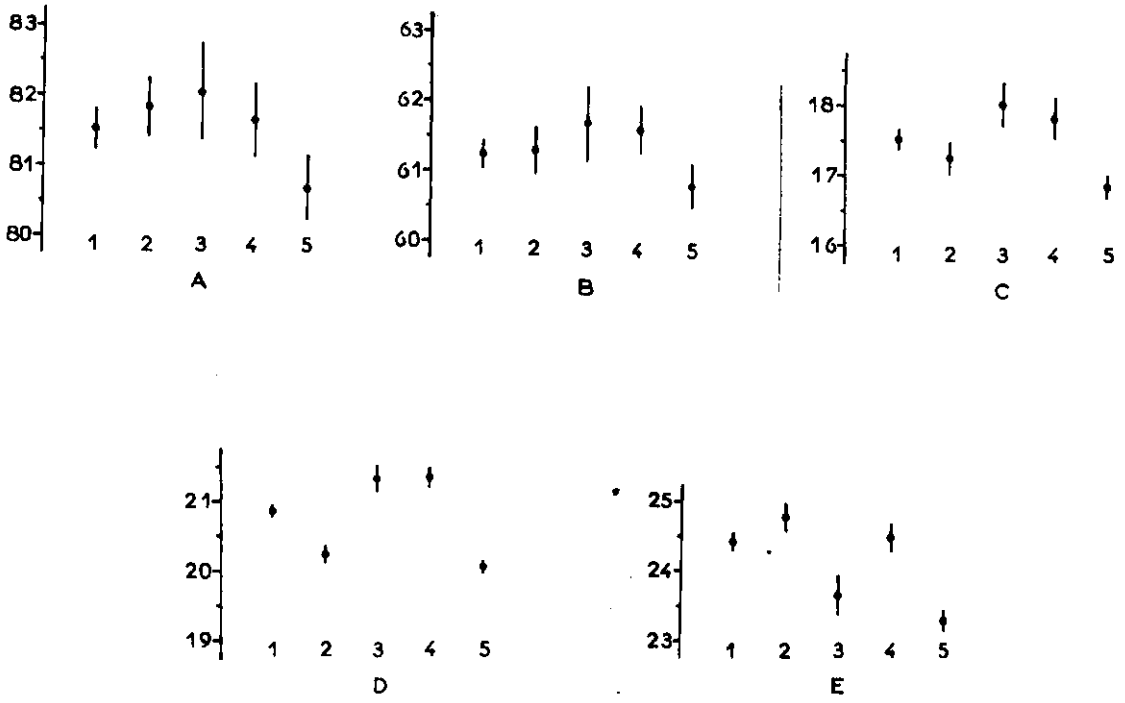

Fig. 2. Averages and their validity amplitudes for each character and each zone (sex mixed).

A = Number of dorsal fin rays : RD
B = Number of anal fin rays : RA
C = Number of gillrakers
D = Ratio: $\frac{LG^1}{LT} \times 10^2$
E = Ratio: $\frac{Ls}{LG^1} \times 10^2$

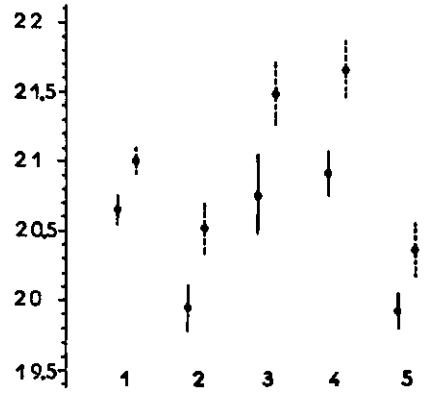

Fig. 3. Averages and their validity amplitudes, by sex, for the ratio:

$\frac{LG^1}{LT} \times 10^2$ (for each zone).