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GROWTH AND CANADIAN EXPLOITATION OF WITCH FLOUNDER (*Glyptocephalus cynoglossus*) IN THE MARITIMES AREA OF THE NORTHWEST ATLANTIC OCEAN

by

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ABSTRACT

Beacham, Terry D. 1982. Growth and Canadian exploitation of witch flounder (*Glyptocephalus cynoglossus*) in the Maritimes area of the Northwest Atlantic Ocean. Can. Tech. Rep. Fish. Aquat. Sci. 1122: iv + 30 p.

Variability in growth rates of witch flounder (*Glyptocephalus cynoglossus*), as well as witch size and age compositions, was investigated in the southern Gulf of St. Lawrence and the Scotian Shelf fisheries. Mean lengths-at-age for witch flounder derived from Canadian groundfish surveys indicated that linear regressions adequately described witch flounder growth up to age 16 for females and age 14 for males. Females grew faster than did males, and both sexes grew faster in warmer waters than those in cooler waters. There has been no unidirectional trend in size at age through time. Instantaneous growth rates of female witch were generally above 0.15 for ages 10 and under and for males above 0.15 for ages 8 or 9 and under. In the 1970s these ages comprised between 60-70% of the landings in Div. 4W for Canadian otter trawlers.

Key words: *Glyptocephalus cynoglossus*, growth, Maritimes, otter trawler, population dynamics, Scotian Shelf, witch.

RÉSUMÉ

Beacham, Terry D. 1982. Growth and Canadian exploitation of witch flounder (Glyptocephalus cynoglossus) in the Maritimes area of the Northwest Atlantic Ocean. Can. Tech. Rep. Fish. Aquat. Sci. 1122: iv + 30 p.

Ce rapport présente une étude de la variabilité des taux de croissance et des compositions par âge et longueur de la plie grise (Glyptocephalus cynoglossus) des pêcheries du sud du golfe St-Laurent et de la plate-forme Scotian. La longueur moyenne de la plie grise à un âge donné, dérivée des levés canadiens des poissons de fond, révèle que les régressions linéaires décrivent adéquatement la croissance des femelles jusqu'à l'âge de 16 ans et des mâles jusqu'à l'âge de 14 ans. Les femelles grossissent plus vite que les mâles, et la croissance des deux sexes est plus rapide dans des eaux chaudes. Il n'y a pas de tendance unidirectionnelle de la longueur à un âge donné dans le temps. En général, les taux instantanés de croissance des plies grises sont supérieurs à 0,15 pour les femmelles âgées de 10 ans et moins et pour les mâles âgés de 8 ou 9 ans et moins. Dans les années 1970, ces âges constituaient de 60 à 70 % des débarquements des chalutiers canadiens dans la division 4W.

Mots-clés: Glyptocephalus cynoglossus, croissance, Maritimes, chalutier, dynamique des populations, plate-forme Scotian, plie grise.

INTRODUCTION

The witch flounder (*Glyptocephalus cynoglossus*) is widely distributed in Northwest Atlantic Fisheries Organization Subarea 4 from the southern Gulf of St. Lawrence (Div. 4T) to the Scotian Shelf (Divs. 4VWX) (Scott 1976) (Fig. 1). Although widespread, witch are not generally abundant, although localized areas of higher abundance occur along the edge of the Laurentian Channel in Subdiv. 4Vn, between Banquereau and Sable Island Banks, and in deeper areas of the Bay of Fundy (Halliday 1973). Powles and Kohler (1970) indicated distributions of witch by depth, but little is known about stock structure or seasonal movements of witch flounder on the Scotian Shelf, although Powles and Kohler (1970) suggested seasonal movements from the Gulf of St. Lawrence to the Scotian Shelf in winter and back in summer. Bowering (1979) indicated the diurnal movements of witch flounder off Newfoundland.

Growth of witch flounder in the Canadian Northwest Atlantic has been investigated by Powles and Kennedy (1967) and Bowering (1976). If natural mortality rates are known, age-specific instantaneous growth rates may be analyzed to determine the age at which a year-class reaches maximum biomass in order to optimize yield from a fishery. Yield could be increased if exploitation of ages in which the instantaneous growth rate is greater than the instantaneous mortality rate is reduced. An analysis of trends in growth rates may indicate whether or not there is selective removal of fast-growing individuals by the fishery and thus if genetic change in the stock is plausible. Regional differences in growth rates may be of value in defining stocks. The major purpose of this paper is to indicate some aspects of growth and changes in size compositions of witch flounder in the landings of the Canadian commercial fishery in relation to these problems.

MATERIALS AND METHODS

The stratified random design Canadian groundfish surveys began in 1970 (Halliday and Kohler MS 1971). A #36 Yankee otter trawl with 3/4 in (19 mm) mesh was used in the July surveys of the A.T. CAMERON on the Scotian Shelf and the September surveys of the E.E. PRINCE in the Southern Gulf of St. Lawrence. Otoliths in the commercial and research samples were collected in a sampling design stratified by length, the design based on a method described by Gulland (1955). The age of witch was determined from otoliths by the method of Powles and Kennedy (1967). Total length of witch flounder was measured to the nearest cm in both the groundfish surveys and commercial samples.

Length and age compositions of witch were determined for 5-yr periods. The estimation of age compositions first required increasing the number sampled at each 1-cm length interval to the total catch of the sampled boat. Values from each sample were weighted by the ratio of catch weight of sampled boat to weight of sampled fish. Age-length keys were applied to the total length frequency to give age compositions. For the research surveys only data from the July surveys on the Scotian Shelf (Divs. 4VWX) and the September surveys in Div. 4T were grouped in 5-yr periods. Grouping of the data increased the number of fish in the youngest and oldest ages, thereby allowing more reliable estimation of mean lengths and weights at these ages. However, grouping of the data in this way will allow only regional and long-term fluctuations in growth to be detected.

RESULTS

AGE AND LENGTH FREQUENCIES

Canadian groundfish surveys have indicated that the 1971 and 1972 year-classes were relatively abundant in Subdiv. 4Vs, accounting for about 40% of the research catch of both males and females in 1976 and 50% in 1977. However, in the other areas surveyed, there was little evidence to indicate the presence of relatively strong year-classes. Most year-classes comprised under 15% of the research catch during the annual surveys.

When the data from groundfish surveys were grouped in 5-yr intervals, length frequencies indicated that larger female witch were caught in Div. 4X as compared with other areas, and they also indicated that smaller witch were caught in Subdiv. 4Vs than in other areas (Fig. 2). Length frequencies and age compositions of male witch flounder showed trends similar to those of the females, and are omitted for simplicity. Witch in Div. 4T had the oldest age compositions of any population sampled, whereas witch in Subdiv. 4Vs had the youngest age distribution (Fig. 3). All witch were caught with the same type of net, thus eliminating changes in selectivity. However, the smaller sizes and younger ages of witch in Subdiv. 4Vs may be due to increased recruitment of younger age classes of strong year-classes to the population or increased availability to the gear. Age compositions were younger for witch in Divs. 4W and 4X than for witch in Div. 4T, but the witch were not smaller, which suggests that younger witch in the southern areas were larger than those in the northern areas. About 40% of the females caught on the Scotian Shelf in the research cruises was usually under age 10.

CHANGES IN LENGTH

The data covering the available age ranges for females suggests that growth was essentially linear after age 3 (Fig. 4). The data for males suggests a more curvilinear relationship (Fig. 5), but this relationship was difficult to determine empirically because the mean lengths-at-age in the older age groups were variable. Even though the surveys were grouped in 5-yr intervals, the number of otoliths read for ages 6 and under and ages 15 and older were in many cases less than 10 per age. For females, because there was little evidence of asymptotic growth over the range of ages in this analysis, linear regressions were used to describe variability in growth rates. Bowering (1978) followed a similar procedure in describing growth of Greenland halibut (Reinhardtius hippoglossoides). Linear regressions were also fitted to the male mean length-at-age data to allow for a comparison with females. Linear regressions were fitted to the mean length-at-age data between ages 4-16 for females and ages 4-14 for males. Linear regressions accounted for the variability in mean length-at-age quite well (all $r^2>0.90$) (Table 1). The intercepts were generally higher during 1975-79 than earlier, which suggests that young witch were larger during 1975-79 than during 1970-74. There was some tendency for the intercept to increase with decreasing latitude, which suggests that younger witch in the more southerly area grew faster than those in the more northerly ones, as indicated in Figs. 4 and 5. Females generally grew faster than males, with average rates of 2.1 cm/yr and 1.9 cm/yr, respectively, over the range of ages investigated.

Regional variability in growth rates was investigated by comparing mean length-at-age of same age witch between 1970-79 over all areas and among years on an annual basis, with separate analyses for males and females. Sign test analysis (Mendenhall, 1971) was used to evaluate growth rates. When the mean length of witch in a sourtherly area was greater than in a northerly one, the comparison was scored "+"; when it was lower, it was scored "-". Div. 4T witch were excluded because the survey in that area was in September, whereas on the Scotian Shelf (Divs. 4VWX) it was in July. This sign test analysis indicated that witch of the same age were generally larger in more southerly areas than those in more northerly ones. (Table 2). This same trend is apparent in Figs. 4 and 5, although witch in Subdiv. 4Vs were smaller than those in Div. 4W until age 10 to 12, after which they were larger, and this accounts for the nonsignificance of the sign test (Table 2). A similar sign test analysis based on all areas and on age 6+ witch indicated that females were larger than similar-aged males (150+, 32-, $P<0.01$).

The effect of bottom water temperatures on growth rates was investigated by comparing mean length at age 7 and mean bottom water temperatures as derived from the July groundfish surveys. Mean length at age 7 was correlated with water temperature for males ($r=0.92$, $n=8$, $P<0.01$) and females ($r=0.74$, $n=8$, $P<0.05$) (Table 3). An increasing rate of growth of witch flounder was coincident with increasing bottom water temperature.

Table 4 illustrates that the mean age of the catch by the research vessels was lowest in Subdiv. 4Vs for both males and females. Mean age of males in the catch was less than that of females in all areas, which is probably indicative of a higher natural mortality rate for males than for females. Witch in Div. 4V also had the smallest mean weights compared with other areas. The exponent in the length-weight relationship was generally greater for males than for females, which indicates that the rate of increase in weight with respect to length was greater in males than in females.

CHANGES IN WEIGHT

Mean weights-at-age for Div. 4T witch flounder (September) and Divs. 4VWX witch (July) based on the groundfish surveys are presented in Table 5. In the more southerly areas (Divs. 4WX), males and females had similar weights until about age 5 or 6, while in the northerly areas weights between the sexes were similar until about age 10 (Table 5). After age 10, there was a greater difference between male and female weights in the more southerly areas as compared with the northerly ones. Weights of witch under age 6 tended to be higher from 1975-79 as compared with 1970-74, which agrees with the trends in elevations of the regression lines indicated in Table 1.

Instantaneous growth rates derived from the weights-at-age in Table 5 tended to be very variable with age. In an attempt to smooth out this variability and to better indicate trends in growth rate with age, 3-point running averages of instantaneous growth rates over ages in each combination of time, sex, and location were calculated (Table 6). Instantaneous growth rates of female witch were usually above 0.15 until age 10. The smoothed growth rates were still rather variable, but there may be a tendency for witch in more southerly areas to have lower instantaneous growth rates after age 11 than witch in more northerly areas. Instantaneous growth rates of males were above 0.15 until age 8 or 9.

COMMERCIAL SAMPLING

The landings of otter trawlers and Danish seiners have been the most extensively sampled for all the gears that have taken part in the Canadian fishery for witch flounder. Age compositions and length frequencies of witch are presented in detail only for females in the otter trawl landings, as males had trends similar to those of females. The analysis of the landings from the Danish seiners indicated that length frequencies shifted towards smaller fish compared with those in the otter trawl landings.

The mean age and mean length of female witch flounder in the landings of Canadian otter trawlers from Div. 4W was always greater than those of males in each period examined (Table 7). Witch between 42 and 51 cm usually accounted for about 60% of the female landings, and before 1975, age 10 and under witch comprised about 50% of the landings of females (Fig. 6). During the same interval, witch age 10 and under comprised over 70% of the landings of males.

DISCUSSION

Studies on variability in growth of witch flounder have indicated that there is regional variability in growth rates (Bowers 1960; Bowering 1976). However, there was no clear correlation with latitute, as Bowering (1976) found that witch in the northern Gulf of St. Lawrence (Divs. 4RS) had the slowest growth rates of any area examined from southern Labrador to the southern Grand Bank of Newfoundland, although the water temperatures for the northern Gulf were among the highest of any area examined. However, there may be an interaction between water temperature and food availability in determination of growth rates, with high water temperatures not necessarily synonomous with high growth rates. Brett et al. (1969) experimentally showed that for sockeye salmon (*Oncorhynchus nerka*), the optimum temperature for growth was dependent upon the ration available, with fish growing faster at lower temperatures if less than maximum ration was provided. Kohler (1964) noted that temperature may influence growth by controlling the amount of food consumption of cod (*Gadus morhua*).

The influence of stock biomass on growth rates has not been investigated because it has been difficult to determine reliable estimates for stock biomass. However, in flatfish, stock density has been suggested to have an impact on growth rates (Pitt 1975; Bannister 1977), and this avenue could be explored further when information on witch flounder stock size is available.

In addition to environmental influences on variability in growth rates, genetic changes in the stock may influence growth rates. The selective removal of fast-growing individuals by fishing has been suggested to account for the decrease in size over time of pink salmon (*Oncorhynchus gorbuscha*) (Ricker et al. 1978) and brown trout (*Salmo trutta*) (Favro et al. 1979). This mechanism is potentially of significance in witch flounder, owing to catch of young, immature, and possibly fast-growing fish. However, mean lengths-at-age for Div. 4W witch apparently changed little over 15 yr, with those in 1964-65 (Powles and Kennedy 1967) similar to those derived from the groundfish surveys in the 1970s. There has been no detectable downward trend in mean lengths, nor in mean weights (Table 5). This suggests that either the fishery has not been selectively removing fast-growing individuals, or that environmental factors rather than genetic changes have more influences on the growth phenotype.

Mean lengths-at-age for witch in the southern Gulf of St. Lawrence (Div. 4T) and the Scotian Shelf (Divs. 4VWX) were larger than those recorded by Bowers (1960) for witch in the Irish Sea. Mean lengths-at-age for southern Gulf (Div. 4T) witch were larger than those recorded for northern Gulf (Divs. 4RS) witch by Bowering (1976). The present study indicated that witch inhabiting warmer waters have higher initial rates of growth than those in cooler waters, but that there was no practical way of defining stocks of witch based upon variability in growth rates presently available.

Instantaneous growth rates of witch derived from the groundfish surveys were generally above 0.20 for females up to age 9 or 10, and for males up to age 8 or 9 (Table 7). Instantaneous rates of natural mortality for witch are uncertain but a rate of between 0.11 and 0.16 has been reported for Div. 4T. If the instantaneous rate of natural mortality is near 0.15, then this result suggests that yield is being lost from a year-class when witch under age 10 constitute a sizeable proportion of the catch. At these ages, the instantaneous growth rate is greater than the instantaneous mortality rate, resulting in a net increase in biomass of the year-class. Further work is necessary to evaluate natural mortality rates for different witch stocks. Future research should also identify stock boundaries and investigate annual variability in growth rates in relation to changes in stock biomass.

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Table 1. Growth rates (cm/yr) of witch flounder caught in Canadian groundfish surveys in the southern Gulf of St. Lawrence (Div. 4T) in September and on the Scotian Shelf (Divs. 4VWX) in July, 1970-79. Linear regressions of mean length-at-age were fitted for males from the ages of 4-14 and for females from ages 4-16.

	Males					Females				
	4T	4Vn	4Vs	4W	4X	4T	4Vn	4Vs	4W	4X
					1970-74					
Rate	1.77	1.90	2.43	2.14	2.19	1.72	2.00	2.52	2.34	2.57
S.E.	0.31	0.19	0.13	0.17	0.17	0.21	0.15	0.15	0.12	0.14
Intercept	17.53	15.61	16.15	18.89	22.19	19.80	16.17	15.50	18.35	20.45
r2	0.90	0.94	0.98	0.95	0.95	0.92	0.96	0.97	0.98	0.98
					1975-79					
Rate	1.70	1.36	1.85	1.84	2.00	1.73	1.56	1.99	1.89	2.26
S.E.	0.08	0.17	0.16	0.18	0.11	0.10	0.12	0.16	0.18	0.19
Intercept	20.32	20.96	19.75	21.79	22.93	19.72	19.45	19.20	22.44	21.95
r2	0.99	0.90	0.94	0.93	0.98	0.97	0.96	0.94	0.93	0.94

Table 2. Results of sign test analysis on mean lengths-at-age of witch flounder as derived from Canadian groundfish surveys on the Scotian Shelf in July, 1970-79. When mean length of witch in a southern area was greater than that of northern area, the comparison was scored "+"; when it was lower, it was scored "-".

	Area		
	4T	4Vs	4W
	Males		
4X	41+, 2-**	41+, 2-**	31+, 9-**
4W	39+, 2-**	24+, 23-	
4Vs	38+, 5-**		
	Females		
4X	49+, 0-**	56+, 4-**	51+, 12-**
4W	48+, 2-**	39+, 24-	
4Vs	46+, 4-**		

**P<0.01

Table 3. Mean length (cm) at age 7 for witch flounder caught during Canadian groundfish surveys and bottom water temperatures during the July surveys.

Area	Age 7		Bottom water temperature (°C)
	Male	Female	
		1970-74	
4Vn	29.7	28.9	3.65
4Vs	31.2	32.0	3.51
4W	35.5	33.3	5.63
4X	36.0	39.9	6.90
		1975-79	
4Vn	30.4	30.0	3.80
4Vs	32.5	35.7	3.99
4W	34.2	34.9	6.48
4X	39.0	35.5	7.19

Table 4. Length, weight, and age parameters for witch flounder caught during survey cruises of Canadian research vessels from 1970-79. Cruises in Division 4T were in September and cruises in the other areas were in July.

		Males				
		4T	4Vn	4Vs	4W	4X
			1970-74			
Mean length (cm)		40.8	35.5	34.7	39.2	41.7
Mean weight (kg)		0.53	0.30	0.32	0.43	0.54
Mean age (yr)		12.7	10.3	7.8	9.0	8.8
Length (cm)-	a	0.000109	0.00045	0.00055	0.00147	0.00155
Weight (g)	b	3.513	3.730	3.681	3.403	3.385
Relation	n	247	310	349	470	192
$W=aL^b$	r^2	0.93	0.96	0.96	0.96	0.96
			1975-79			
Mean length (cm)		42.8	34.7	35.1	38.2	43.5
Mean weight (kg)		0.64	0.29	0.32	0.40	0.62
Mean age (yr)		13.8	9.5	8.0	8.8	9.8
Length (cm)-	a	0.00054	0.00085	0.00205	0.00142	0.00115
Weight (g)	b	3.706	3.560	3.319	3.410	3.467
Relation	n	237	79	213	315	199
$W=aL^b$	r^2	0.90	0.93	0.96	0.96	0.96

Table 4 (cont'd)

		Females				
		4T	4Vn	4Vs	4W	4X
			1970-74			
Mean length (cm)		40.3	38.4	31.6	29.0	34.0
Mean weight (kg)		0.62	0.41	0.31	0.22	0.43
Mean age (yr)		12.8	11.0	6.7	5.5	6.2
Length (cm)-	a	0.00081	0.00065	0.0097	0.0070	0.0019
Weight (g)	b	3.584	3.624	2.972	3.045	3.404
Relation	n	327	518	1041	2400	116
$W=aL^b$	r^2	0.94	0.97	0.98	0.97	0.97
			1975-79			
Mean length (cm)		45.6	37.4	30.3	30.4	35.4
Mean weight (kg)		0.81	0.40	0.27	0.25	0.46
Mean age (yr)		15.4	10.9	5.9	5.5	5.2
Length (cm)-	a	0.00062	0.00147	0.0097	0.0128	0.0045
Weight (g)	b	3.659	3.418	2.964	2.869	3.183
Relation	n	361	128	797	1809	160
$W=aL^b$	r^2	0.92	0.96	0.97	0.97	0.97

Table 5. Mean weights-at-age (kg) for witch flounder caught during Canadian groundfish surveys in the southern Gulf of St. Lawrence (Div. 4T) (September) and Scotian Shelf (Divs. 4VWX) (July). Number of otoliths read for each age is in parentheses.

	Males					Females				
Age	4T	4Vn	4Vs	4W	4X	4T	4Vn	4Vs	4W	4X
					1970-74					
3	- (0)	0.03 (2)	0.05 (5)	0.04 (3)	0.11 (3)	- (0)	- (0)	0.07 (4)	0.05 (3)	0.12 (8)
4	- (0)	- (0)	0.12(12)	0.08 (7)	0.18 (3)	- (0)	- (0)	0.13 (2)	0.11 (5)	0.18 (1)
5	- (0)	0.09 (4)	0.11(10)	0.14 (3)	0.18 (4)	- (0)	- (0)	0.13(12)	0.18 (2)	0.18 (4)
6	- (0)	0.07 (3)	0.17(16)	0.18 (4)	0.34 (2)	- (0)	0.14 (2)	0.15 (4)	0.22 (4)	0.26 (6)
7	- (0)	0.15(11)	0.18(22)	0.28(11)	0.31(11)	0.20 (2)	0.13 (9)	0.21(20)	0.23 (6)	0.43(10)
8	0.17 (1)	0.17(13)	0.25(36)	0.36(17)	0.41(15)	0.19 (4)	0.19(17)	0.25(38)	0.38(13)	0.45(18)
9	0.28 (4)	0.26(25)	0.43(18)	0.44(20)	0.56(18)	0.36 (9)	0.25(14)	0.33(28)	0.47(13)	0.51(20)
10	0.33 (7)	0.24(24)	0.48(17)	0.46(18)	0.60(14)	0.37 (7)	0.34(25)	0.46(18)	0.44(10)	0.77(31)
11	0.36 (7)	0.33(27)	0.61 (2)	0.52 (4)	0.66(12)	0.42 (7)	0.39(26)	0.66 (9)	0.64(16)	0.86(14)
12	0.44(11)	0.39(12)	0.74 (7)	0.63 (9)	0.90 (3)	0.51(11)	0.37(17)	0.76(20)	0.72(16)	1.01(22)
13	0.45 (2)	0.40 (4)	0.79 (3)	0.65 (7)	0.84 (5)	0.52 (7)	0.52(14)	0.86(10)	0.83(14)	1.13(19)
14	0.54(10)	0.53 (4)	0.94 (2)	0.72 (1)	- (0)	0.60 (4)	0.66(15)	1.14 (6)	0.96(10)	1.21(13)
15	0.56 (5)	0.54 (3)	- (0)	0.72 (5)	- (0)	0.75 (8)	0.77(10)	1.40 (6)	0.73 (1)	1.30 (5)
16	0.72 (3)	0.53 (2)	1.20 (1)	- (0)	- (0)	0.86 (3)	1.21 (6)	1.09 (3)	1.00 (4)	1.33 (3)

Table 5 (cont'd)

	Males					Females				
Age	4T	4Vn	4Vs	4W	4X	4T	4Vn	4Vs	4W	4X
					1975-79					
3	- (0)	0.02 (3)	0.05 (5)	0.05 (7)	- (0)	- (0)	- (0)	0.06 (5)	0.09 (4)	- (0)
4	- (0)	- (0)	0.09(24)	0.16 (5)	0.14 (2)	0.11 (1)	0.09 (3)	0.10(28)	0.14(10)	0.14 (3)
5	- (0)	0.10 (6)	0.14(34)	0.12(14)	0.24(10)	0.11 (1)	- (0)	0.14(35)	0.20 (7)	0.22 (5)
6	0.18 (1)	0.24 (1)	0.21(24)	0.22(24)	0.28(12)	0.16 (4)	0.18 (3)	0.21(25)	0.23(15)	0.35 (5)
7	0.20 (2)	0.16(10)	0.22 (9)	0.25(21)	0.39(10)	0.19 (3)	0.16 (1)	0.29(14)	0.27(10)	0.29 (8)
8	0.23 (3)	0.28 (7)	0.32(14)	0.36(18)	0.40 (8)	0.31 (3)	0.21 (9)	0.23(12)	0.37(11)	0.52(11)
9	0.35 (5)	0.24(12)	0.34(18)	0.41(23)	0.48 (9)	0.29 (6)	0.22 (7)	0.39(17)	0.57 (7)	0.61(11)
10	0.35(13)	0.30 (9)	0.44(20)	0.44(22)	0.51(11)	0.36 (6)	0.31(18)	0.36(14)	0.56(19)	0.72 (7)
11	0.43(25)	0.29 (8)	0.47(13)	0.50(22)	0.63(13)	0.39(13)	0.35 (7)	0.45(20)	0.55(19)	0.82 (9)
12	0.53(17)	0.33 (5)	0.43 (9)	0.61(14)	0.73 (8)	0.50(19)	0.32(10)	0.70(17)	0.70(24)	0.89(14)
13	0.59(22)	0.32 (2)	0.56 (7)	0.55(13)	0.85(15)	0.56(22)	0.43(10)	0.67 (8)	0.74(20)	0.87(18)
14	0.61(22)	0.45 (3)	0.60 (5)	0.56 (4)	1.00 (4)	0.67(25)	0.54(11)	0.73 (8)	0.71(16)	1.10(15)
15	0.66(22)	0.44 (3)	0.71 (4)	0.72 (8)	0.81 (7)	0.62(25)	0.56(10)	0.79 (7)	0.85 (9)	1.13(12)
16	0.73(24)	0.62 (3)	- (0)	0.94 (1)	0.96 (1)	0.81(27)	0.71 (3)	0.87 (1)	1.10 (9)	1.21 (5)

Table 6. Mean instantaneous growth rates as measured by changes in weight for witch flounder caught during groundfish surveys of Canadian research vessels from 1970-79. Growth rates listed are 3-point running average over age groups within an area.

	Males				
Age	4T	4Vn	4Vs	4W	4X
			1970-74		
4-5	-	-	0.388	0.470	0.376
5-6	-	-	0.135	0.405	-.181
6-7	-	0.180	0.274	0.315	0.275
7-8	-	0.457	0.309	0.298	0.167
8-9	-	0.157	0.327	0.165	0.220
9-10	0.250	0.221	0.297	0.123	0.159
10-11	0.151	0.135	0.181	0.120	0.158
11-12	0.103	0.170	0.166	0.115	0.112
12-13	0.135	0.158	0.144	0.108	-
13-14	0.080	0.108	-	0.044	-
			1975-79		
4-5	-	-	0.538	0.494	-
5-6	-	-	0.329	0.149	0.341
6-7	-	0.343	0.276	0.366	0.246
7-8	0.222	0.000	0.161	0.208	0.255
8-9	0.187	0.210	0.231	0.189	0.165
9-10	0.209	0.012	0.128	0.110	0.151
10-11	0.138	0.106	0.138	0.133	0.139
11-12	0.174	0.021	0.080	0.074	0.170
12-13	0.116	0.146	0.081	0.026	0.154
13-14	0.073	0.096	0.167	0.043	0.035

Table 6 (cont'd)

Age	Females				
	4T	4Vn	4Vs	4W	4X
			1970-74		
4-5	-	-	0.254	0.487	0.258
5-6	-	-	0.160	0.246	0.290
6-7	-	-	0.218	0.249	0.305
7-8	-	0.193	0.263	0.253	0.224
8-9	0.205	0.320	0.261	0.216	0.194
9-10	0.264	0.239	0.324	0.74	0.216
10-11	0.116	0.130	0.278	0.142	0.225
11-12	0.113	0.141	0.209	0.212	0.119
12-13	0.119	0.175	0.170	0.135	0.111
13-14	0.128	0.244	0.204	0.005	0.087
			1975-79		
4-5	-	-	0.423	0.313	-
5-6	-	-	0.369	0.219	0.243
6-7	0.345	-	0.166	0.205	0.289
7-8	0.198	0.067	0.207	0.302	0.185
8-9	0.213	0.221	0.126	0.243	0.303
9-10	0.076	0.170	0.277	0.132	0.152
10-11	0.182	0.125	0.248	0.068	0.126
11-12	0.147	0.109	0.207	0.056	0.063
12-13	0.180	0.145	0.161	0.048	0.098
13-14	0.071	0.149	0.040	0.028	0.071

Table 7. Mean length (cm), mean age (yrs), and sample sizes of witch flounder from sampling landings of Canadian otter trawlers, in Div. 4W, 1948-79.

		Sex	1948-59	1960-64	1965-69	1970-74	1975-79
Mean length (cm)		M	43.3	39.8	41.0	40.3	42.8
		F	46.4	44.4	47.3	45.3	47.0
(yrs)	4W	M	10.2	7.2	-	8.8	11.8
		F	11.0	9.1	-	10.3	13.9
Number of samples	4W		15	3	3	4	6
Number measured	4W		1300	484	503	858	1181
aged	4W		167	112	0	140	221

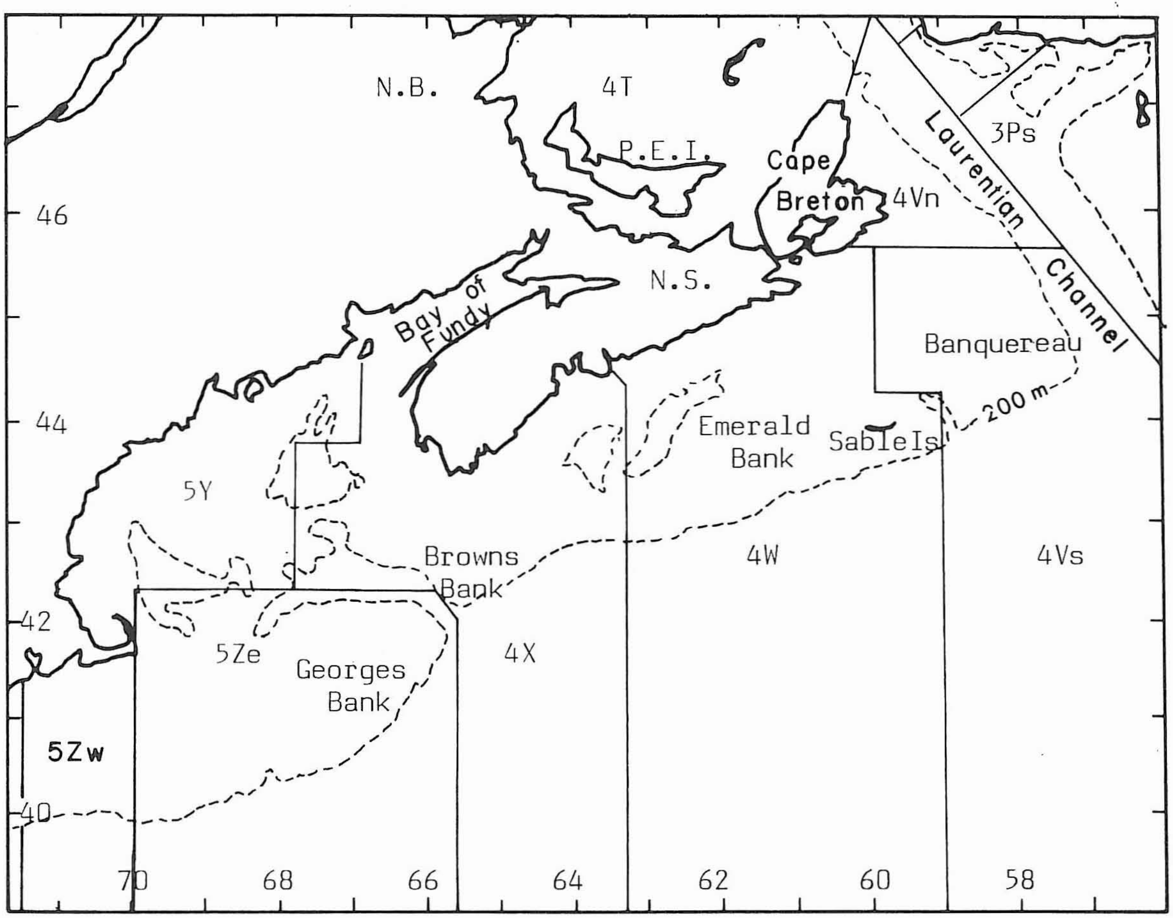

Fig. 1. Northwest Atlantic Fisheries Organization Divisions in Subarea 4.

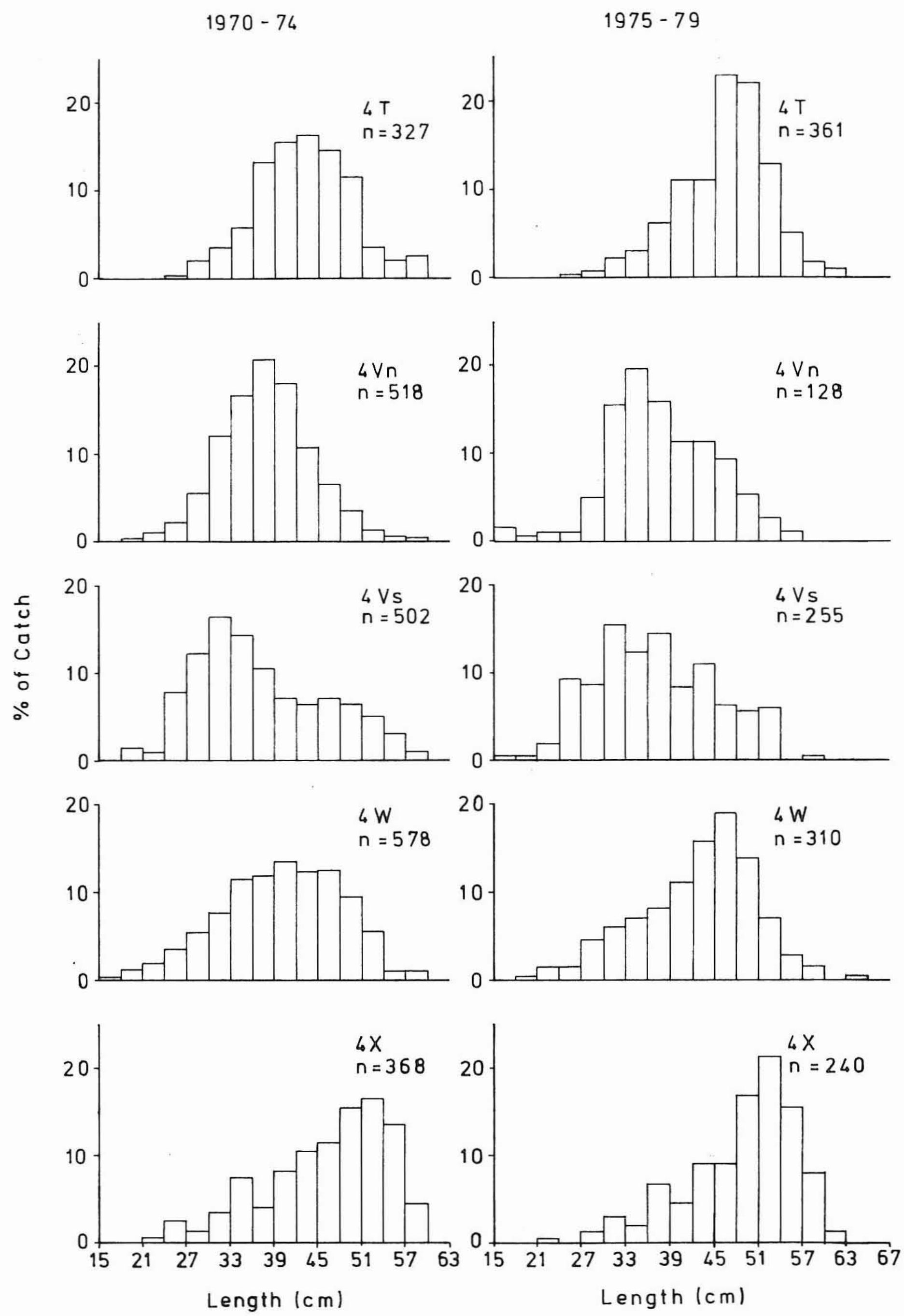

Fig. 2. Length frequencies of female witch flounder caught during Canadian groundfish surveys in Div. 4T (September) and Divs. 4VWX (July), 1970-79.

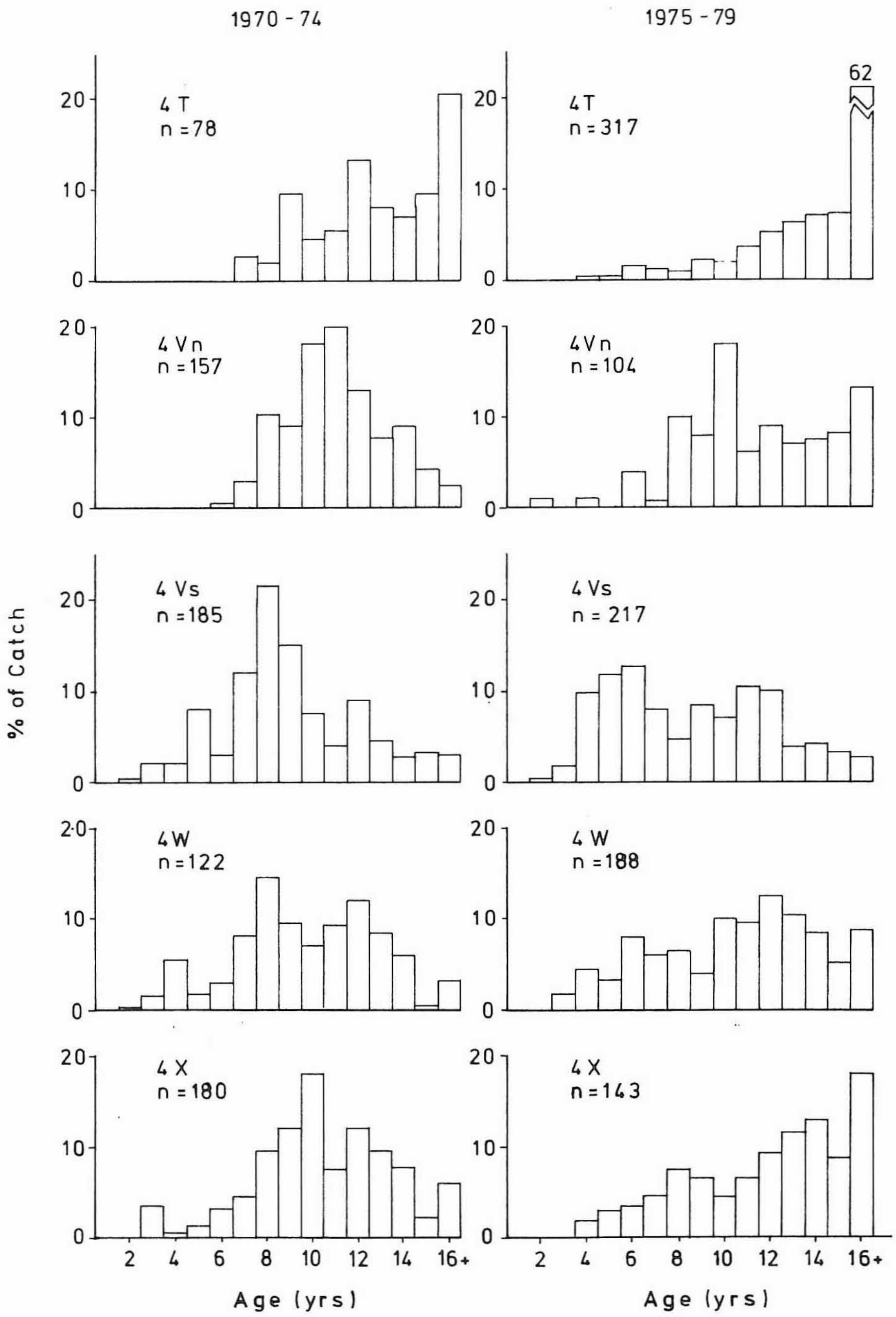

Fig. 3. Age compositions of female witch flounder caught during Canadian groundfish surveys from 1970-79.

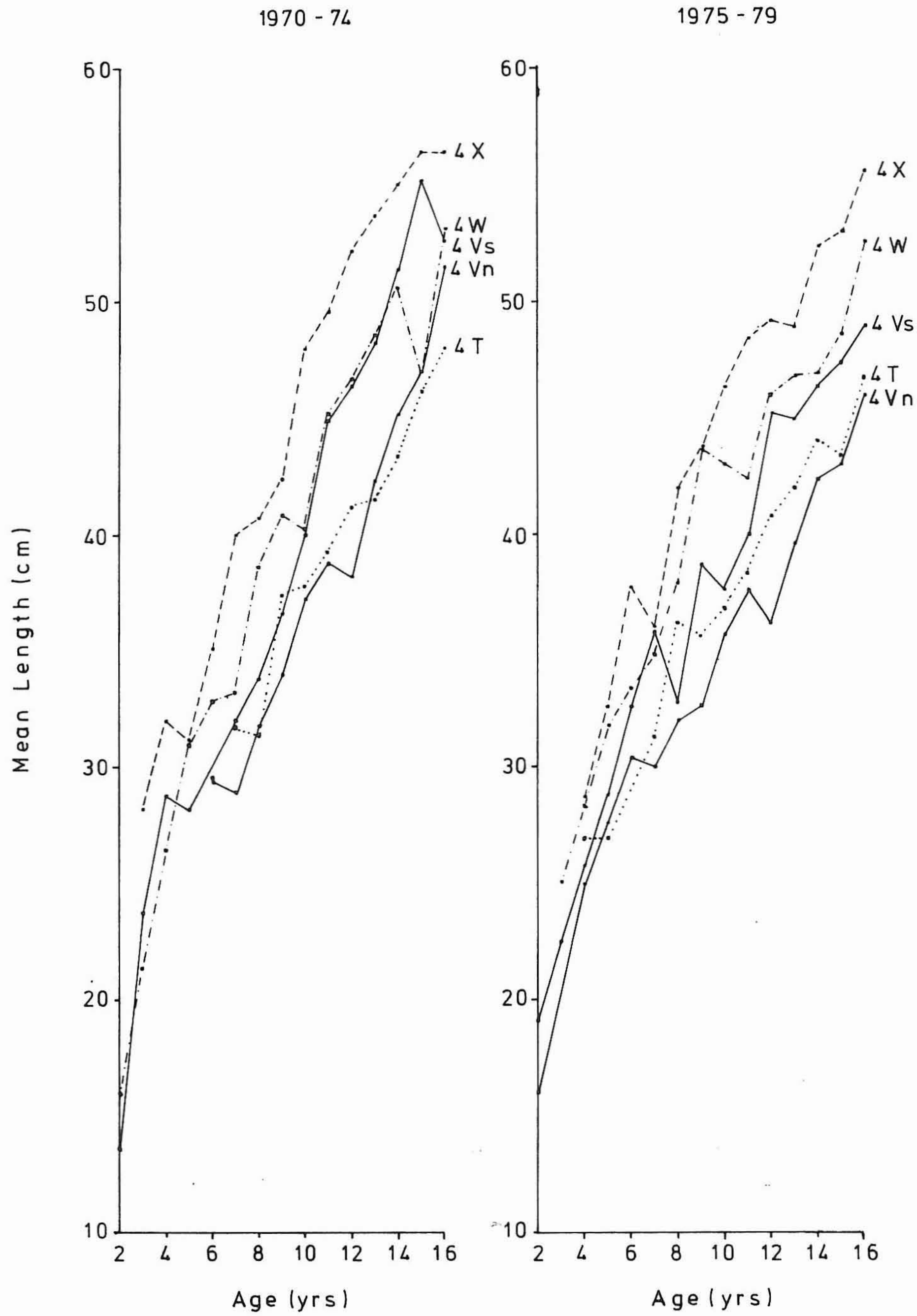

Fig. 4. Observed mean lengths-at-age for female witch flounder caught during Canadian groundfish surveys, 1970-79.

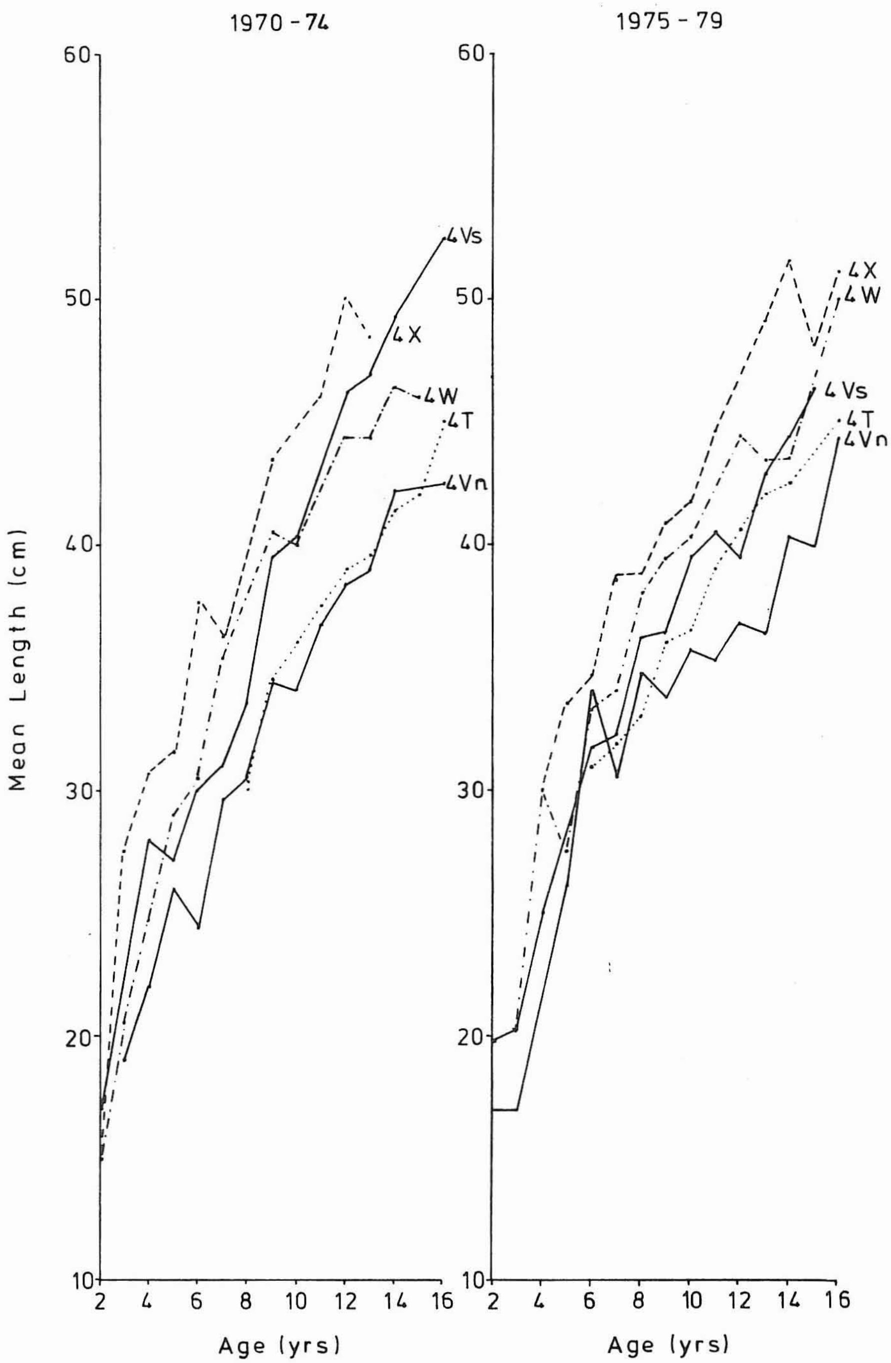

Fig. 5. Observed mean lengths-at-age for male witch flounder caught during Canadian groundfish surveys, 1970-79.

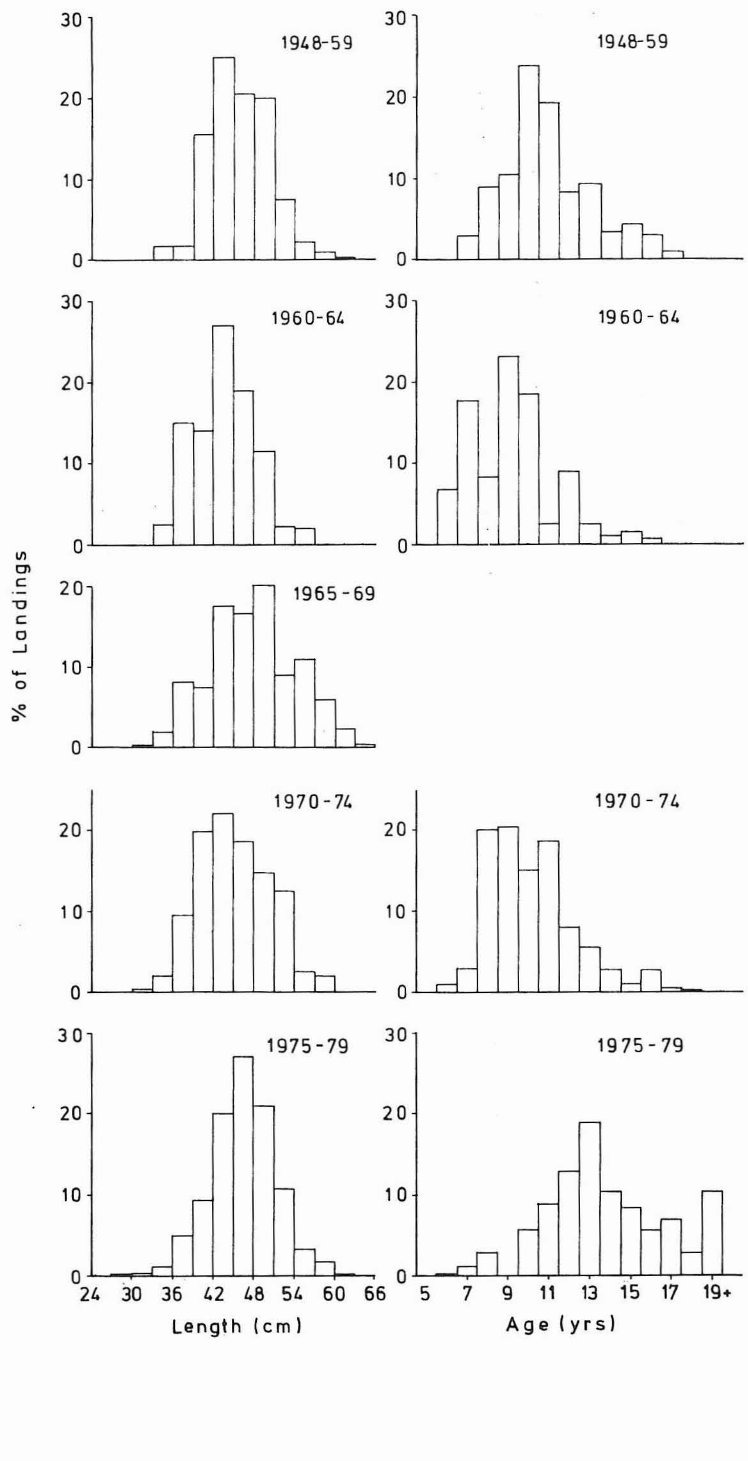

Fig. 6. Length frequencies and age compositions for female witch flounder landed by Canadian otter trawlers in Div. 4W, 1948-79.