Northwest Atlantic Fisheries Organization

Serial No. N2540 NAFO SCR Doc. 95/31

SCIENTIFIC COUNCIL MEETING - JUNE 1995

Age and Growth of Redfish in Flemish Cap (Div. 3M)

by

F. Saborido-Rey

Instituto de Investigaciones Marinas, Vigo, Spain

Introduction

The age determination of redfish species is one of the most important unresolved questions until now. There has been controversy concerning the correct method for aging redfish (Nedreaas, 1990), and several attempts have been made to create a common criterion (ICES, 1983, 1984, 1991) but, at present, both scales and otoliths are used with different techniques.

Ex-USSR scientists read scales under ordinary light (ICES, 1991); German, Danish and Icelandic scientists read scales under polarized light after a silver nitrate treatment (Kosswig, 1980). North Americans use the break and burn otoliths technique, which is also used by Norwegian scientist (Nedreaas, 1990). Conversely, Spanish scientists use otoliths but with a different technique (Saborido-Rey, 1993). Both Norwegians and Spaniards have used scales routinely in past years.

Obviously, it is necessary to clarify the differences between age readings using scales and otoliths and develop a common procedure among laboratories.

There are many problems in identifying the redfish species accurately, so in many stocks two or more species are considered as a single one (Saborido-Rey, 1993). This has produced difficulties when comparing the growth in each species. In Flemish Cap redfish very few studies have been made to compare the growth in each sex and species and to validate the age readings which is very important for adequate fisheries management.

Material and methods

Both scales and otoliths have been collected from *Sebastes marinus*, *S. mentella* and *S. fasciatus* during EU surveys carried out in Flemish Cap from 1989 to 1994 (Vázquez, 1989,1990,1991, 1992, 1993, 1994). The scales were removed from the middle of fish body near the tip of the pectoral fin, dried and preserved in an envelope. Otoliths were also kept dry in envelopes.

Scales were read under polarized light after being treated with silver nitrate as described by Kosswig (1980). Otoliths were broken and burned as described by Saborido-Rey (1993). All age readings were made by the author.

In mentioned surveys *S. mentella* and *S. fasciatus* were considered as a single group (*Sebastes* spp.) due to the difficulty in the identification of species until 1990. In the years from 1991 to 1994 both species were identified routinely. So, in order to avoid possible differences in growth patterns between *S. mentella* and *S. fasciatus*, to compare the age readings from scales and otoliths only *S. marinus* data was used. Then, to compare growth between sexes and species length at age, date from the 1991 to 1994 surveys were used.

The von Bertalanffy growth equation has been fitted to length at age data derived from both scales and otoliths and from males-females and the three species present in Flemish Cap.

To validate the age readings of otoliths the length frequencies of *S. mentella* in the period 1988-1994 were used. In those surveys, youngest specimens could not be separated by species routinely, thus all redfish shorter than 15 cm were considered as a single group. Likewise, as mentioned above, in the 1988-1990 period *S. mentella* and *S. fasciatus* were also considered as a single group. Taking into account that *S. mentella* is the most abundant species in Flemish Cap (around 80 % of the total biomass and more than 90% of *S. fasciatus* plus *S. mentella*) we used the total frequency of redfish in 1988-1990 as *S. mentella*.

Results

Scales vs otoliths

Both age-length keys were constructed summarized every all years: 1989 and 1990 to scales and 1990 to 1994 to otoliths. Table 1 shows the mean length at age of *S. marinus* derived from scales and otoliths.

The von Bertalanffy growth equation parameters based on scales and otoliths are shown in Table 2 and the resulting curves in Figure 1. Scales age reading shows a faster growth than those based on otoliths. While the maximum recorded age using scales was lower than 20 years (19 in females and 18 in males), in otoliths it was 36 in females (26 in males). The age reading below 30 cm was approximately the same, i. e., until age 10 scales and otoliths gave similar values. However, above such size, scales gave lower values than otoliths age readings for the same length, showing a growth close to linear (Figure 1), while with otoliths the growth rate decreases considerably with age. The growth curve based on scales gives the highest L_∞ (517.41 and 462.39 cm, males and females respectively, compared to 52.50 and 57.44 cm) which are clearly inconsistent.

Age reading validation

To follow strong year classes provides an independent check on age determination of redfish. In the period analyzed here, four year classes dominate the length frequency (Figure 2) named A, B, C and G. Following as each modal class grow year to year, it is possible to identify seven modal classes between 8 and 26 cm corresponding to 8-9 cm, 12, 15 18, 21, 23 and 26 cm. The age frequencies using the age readings of otoliths are shown in Figure 3. Age frequency is

consistent with length frequency year to year. Thus the cohort named F in Figure 2 was assigned to age 2 in 1991 and, three years later, the same cohort was assigned to age 5; the same agreement can be observed in cohorts labeled as C-G.

It is necessary to take into account that redfish is totally recruited to gear used in the survey around age 3 and 4 (Figure 3) but until age 6 those redfish are not recruited to fishery. This point can produce a misinterpretation of age class evolution in 1991, when the strong year class of 1985 dropped heavily in abundance.

In this way, the modal classes named A-G in Figure 2 correspond with the following cohorts:

Modal class A→	1980 cohort
Modal class B→	1981 cohort
Modal class C→	1985 cohort
Modal class D→	1986 cohort
Modal class E→	1988 cohort
Modal class F→	1989 cohort
Modal class G→	1990 cohort

Sex growth

For each sex and species a von Bertalanffy growth equation using otoliths age readings from 1990 to 1994 was fitted (Table 3, Table 4, Table 5). Figure 4 shows the mean length at age by sex and species and the resulting curves. Table 6 show the von Bertalanffy growth equation parameters of males and females of the three species which live in Flemish Cap. There are few discrepancies in the growth between sex during the first 15-20 years, then females grow faster than males; so L_∞ is highest in females in all species. However, the analysis of variance run to compared slopes and intercepts of curves shows no significant differences between sexes in all species ($P>0.5$).

In redfish in Flemish Cap the females live longer than males, thus the maximum recorded age in females was 36, 32 and 25 years for *S. marinus*, *S. mentella* and *S. fasciatus* respectively, while in males this was 26, 26 and 17 years.

Intraspecific comparison of growth

Although the differences between sexes were not significant in any species of redfish, due to the discrepancy in the longevity, the growth by species was compared separately in males and females. Figure 5 shows the mean length at age for the three species. It was observed that the growth in males in the three species was similar until age 17 (maximum age recorded for *S. fasciatus*), which means more than 95 % of the total redfish caught in the surveys. Nevertheless, females of *S. marinus* show a mean length slightly higher than in the other two species, but this difference is marked since age 20 (5% of the Flemish Cap redfish population). So most of the redfish population displays a similar growth. To show this similarity the von Bertalanffy growth equation was calculated again, but deleting from original data males older than 17 years and females older than 22 years. The resulting curves are shown in Figure 6.

S. marinus has the longest life span of the three species and is larger in size: the maximum age recorded was 36 years in females and 26 in males. Conversely, in *S. fasciatus* the maximum age found was 17 and 22 years for males and females respectively.

Individuals shorter than, approximately, 15 cm, due to an inherent difficulty in identifying species, were analyzed as a single group, and then the age was determined without specific consideration. Those individuals were not used to compare the growth in each species. However, since the growth in the three species was similar, at least in younger ages, the age reading of "juveniles" is useful to examine the growth rates in early years of *Sebastes* life.

Discussion

Scales has been the most used structure, at least in Europe, in redfish age determination (Beamish and McFarlane, 1987; Nedreaas, 1990), though since several years go various laboratories began to use otoliths as a more useful structure (ICES, 1991), as North American scientists have to continued to do. The difficulty of age determination in *Sebastes* has been increased with the proper identification of the species (Saborido-Rey, 1994); in many stocks only an age-length key was constructed when two or more species cohabit. At present, there is no common criterion to determine the age in *Sebastes* species in the North Atlantic.

Several works have criticized the use of scales to determine the age accurately in redfish (Beamish and McFarlane, 1983; Leaman and Beamish, 1984, Nedreaas, 1990): scale age readings underestimate the true age. In this sense, it was found that several were older than in previous reports (Power, 1978; Beamish, 1979; Reimers, 1979; Beamish and McFarlane, 1983; Chilton and Beamish, 1982; Berkely and Houde, 1983).

Nedreaas (1990) carried out an investigation comparing the age readings of scales and otoliths in *S. marinus*, *S. mentella* and *S. viviparus* from Norway. Using the strong year class of 1982 as a tool to a suitable validation, he reported that only otoliths give consistent values, which is in accordance with the results presented here.

Scales readings give ages lesser than 20-25 years in *Sebastes* Atlantic populations (Kotthaus, 1958; Kosswig, 1971; Haunschild and Vaske, 1985; Rikther, 1987; Pavlov *et al.*, 1989) suggesting a faster growth. Otoliths validation works indicate that redfish grow slower, reaching 60 or more years (Kelly and Wolf, 1959; Sandeman, 1969; McKonne and Legge, 1980; Nedreaas, 1990). The results presented here show that otoliths age reading give values more consistent than those of scales; L_∞ calculated from scales is clearly incoherent.

Petersen's method is very unuseful as a validation tool in redfish in older groups because of the enlargement of the dispersion and the reduction of the distance between modal groups. In early years, however, a strong year class makes it possible to follow the modal classes until age 10 approximately. In the last 15 years in Flemish Cap, strong year classes mixed with weak ones. Using this method, the year classes of 1980,1981, 1985, 1986 , 1989 and 1990 were identified as a strong year classes. Redfish in Flemish Cap reach 8-9 cm at age 2 and around 23-24 cm at age 7. The age assignments give to each modal group one year more in the next year so the criterion used was homogeneous and consistent.

Power and Atkinson (1986) reported two strong modal groups in the 1982 Canadian survey on Flemish Cap situated around 12 and 8 cm, and no other strong modal groups appeared neither just before nor just after that year, so those two modal groups correspond with those named A and

B in Figure 2. Using our age-length key, the modal classes in the Canadian survey correspond with ages 3 and 2 respectively, so in 1988 their ages will be 9 and 8, which is in disagreement with our results. As mentioned above, between 8 and 26 cm sizes there are seven year classes so it may be concluded that the modal groups labeled A and B had a density-dependent growth and the incorrect age determination was produced due to the use of scales in 1988.

In the period 1990-1994, age determination using otoliths gives us a mean length in *S. mentella* at ages 7,8, and 9 of 23.5, 25.6 and 27.5 cm respectively. If A and B classes have age 9 and 8, their mean length is lower than expected. These two cohorts have been the strong ones in the last 20 years. Several authors have studied the density-dependent growth in exploited fish populations, reporting an inverse relation between growth rate and cohort abundance (Templeman and Bishop, 1979; Wells, 1983; P.-Gándaras and Zamarro, 1990). The density-dependence occurs in early years (Shepherd and Cushing, 1980) as a response to intracohort competition for a limited food resource. This feature can be extended to adult stages (Wooton, 1990; P.-Gándaras *et al.*, 1993). In Flemish Cap, density-dependent growth has been reported in cod (P.-Gándaras and Zamarro, 1990).

The size class of 8 cm is determined as age 2 by all authors in Flemish Cap, though several ones have questioned those results assigned it as age 1 (Templeman, 1976; Lilly and Gavaris, 1982; Lilly, 1987). Taking into account the growth rate between ages 2 and 6, 3 cm annually, the size of age 1, should be around 4-5 cm in summer season (Saborido-Rey, 1993). This growth rate is in accordance with that calculated by Anderson (1984). However, redfish with a size between larvae (2 cm of *S. mentella* in August) and juvenile (8-9 cm) has not reported in any survey.

S. mentella, the most abundant species in Flemish Cap, was born at late February-Mid March with a size of 6 mm aprox. The size increased to 12 mm in June (Anderson, 1984) and to 28 mm at late August (data from 1990 EU survey). An exponential growth of the larvae has been described after an initial phase of low growth (Ahlstrom, 1954; Kamler, 1992). Anderson (1984) calculated the growth rate of *Sebastes* larvae since the parturition to late August, reporting an exponential growth for *S. mentella* (born in March):

$$Y = 2.0e^{0.011x}$$

and for *S. fasciatus* (born in June-July):

$$Y = 0.1e^{0.022x}$$

where Y is the size in mm and x age in days.

Using these equations both species reach 5 cm at late Autumn. This size group was reported in November in Labrador waters (Bainbridge and Cooper, 1971), in the Gulf of Maine (Kelly and Barker, 1961), in Greenland (Wieland,1992) and in Svalbard (Nedreaas, 1990). The population of fishes in cold waters have a seasonal growth, being the winter the season with a lower growth rate (Wooton, 1990). So the redfish which sized 5 cm in early winter could reach 8 cm in the summer of the first year of life. So the size class of 8 cm corresponding to age 1 and the age reading made until now were incorrect in one year.

In this way, the stronger year classes in Flemish Cap redfish were 1980, 1981, 1986 and 1990. 1986 and 1990 year classes of other species were also very abundant as cod, American plaice and Greenland halibut (Vázquez, 1994; Junquera, 1994).

The growth rate in each sex in Flemish Cap is not significant different. In another areas of North Atlantic, male and female redfish grow with a similar pattern, as in Flemish Cap, and the females live longer (Surkova, 1961; Sandeman, 1961). Sandeman (1969) reported a different growth rate for sexes in Flemish Cap, but the sample size was very few and no statistical analysis was made.

It is difficult to compare the growth between species due to the problem in the identification of such species. In our analysis there are no significant differences in the growth between *S. marinus*, *S. mentella* and *S. fasciatus*. *S. marinus* live longer than another ones and *S. fasciatus* had a shorter life. However, this difference could be biased because of *S. fasciatus* living there where the fishery is higher (Saborido-Rey, 1993). Parsons *et al.* (1976) calculate the growth curve of se in Flemish Cap: L_∞ was lower both in males and females than those presented here, perhaps due to their considering all redfish as *S. mentella*, and perhaps due to different criterion of age readings.

References

Ahlstrom, E. H. (1954) Distribution and abundance of egg and larval populations of the Pacific Sardine. *U.S. Fish. Bull.*, **56**: 83-140.

Anderson, J. T. (1984) Early life history of redfish (*Sebastes* spp.) on Flemish Cap. *Can. J. Aquat. Fish. Sci.*, **41**:1106-1116.

Bainbridge, V. y G. A. Cooper (1971) Population of *Sebastes* larvae in the North Atlantic. *ICNAF Res. Bull.*, **8**: 27-35.

Beamish, R. J. y G. A. McFarlane (1983) The forgotten requirement for age validation in fisheries biology. *Trans. Amer. Soc.*, **112**: 735-743.

Beamish, R. J. y G. A. McFarlane (1987) Current trends in age determination methodology. En: *Age and growth of fish* (Ed. R. C. Summerfelt y G. E. Hall):15-41. Iowa State Uni. Press, 544 pp.

Beamish, R. J. (1979) New information on the longevity of Pacific Ocean Perch (*Sebastes alutus*). *J. Fish. Res. Board Can.*, **36**: 1395-1400.

Berkeley, S. A. y E. D. Houde (1983) Age determination of broadbill swordfish, *Xiphias gladius*, from the Straits of Florida, using anal fin spine sections. En: *Proceedings of the international workshop on age determination of oceanic pelagic fishes: tunas, billfishes, and sharks* (Ed. E. D. Prince y L. M. Pulos): 137-143. U.S. Dept. Commerce, NOAA Tech. Rep., NMFS, **8**.

Chilton, D. E. y R. J. Beamish (1982) Age determination methods for fishes studies by the Groundfish Program at the Pacific Biological Station. *Can. Spe. Publ. Fish. Aquat. Sci.*, **60**, 102 pp.

Haunschild, G. y B. Vaske (1985) Results of investigations on redfish (*Sebastes mentella*) in the Svalbard area from 1981 to 1984. *ICES C.M.*, **G:16**.

ICES (1983) Report of the redfish ageing workshop, Bremerhaven. 14-18 Feb. 1983. *ICES C.M.*, **G:2**.

ICES (1984) Report of the workshop on ageing of redfish. *ICES C.M.*, **G:2**.

ICES (1991) Report of the workshop on age determination of redfish. *ICES C.M.*, **G:79**.

Junquera, S. (1994) Analysis of the variations in the spacial distribution and spawning of the Greendland Halibut in divisions 3LMN (1990-93). *NAFO SCR Doc.*, **25**.

Kamler, E. (1992) *Early life history of fish*. Chapman y Hall, Londres, 267 pp.

Kelly, G. F. y A. M. Barker (1961) Observations on the behaviour, growth, and migration of redfish at Eastport, Maine. *ICNAF Spec. Publ.*, **3**: 263-275.

Kelly, G. F. y R. S. Wolf (1959) Age and growth of Redfish, *Sebastes marinus* (Linnaeus) in the Gulf of Maine. *Fish. Bull.* **60**: 1-31.

Kosswig, K. (1971) Polarisationsoptische untersuchungen an den Schuppen des Rotbarsches (*Sebastes marinus* und *S. mentella* Travin). *Ber. dt. wiss. Kommn. Meeresforsch.*, **22**: 219-225.

Kosswig, K. (1980) On the method and results of age determination of redfish in Subarea I. *NAFO SCR Doc.*, **91**.

Kotthaus, A. (1958) Age and growth of redfish *Sebastes marinus* L. *ICNAF Spec. Publ.*, **1**: 217-222.

Leaman, B. M. y R. J. Beamish (1984) Ecological and management implications of longevity in some northeastern Pacific groundfishes. *Int. N. Pac. Fish. Comm. Bull.*, **42**: 85-97.

Lilly, G. R. (1987) Synopsis of research related to recruitment of Atlantic Cod (*Gadus morhua*) and Atlantic Redfishes (*Sebastes* spp.) on Flemish Cap. *NAFO SCS Studies*, **11**: 109-122.

Lilly, G. R. y C. A. Gavaris (1982) Distribution and year-class strength of juvenile Redfish, *Sebastes* spp., on Flemish Cap in the winters of 1978-82. *J. Northw. Atl. Fish. Sci.*, **3**: 115-222.

McKone, W. D. y W. Legge (1980) Evidence for using otoliths to age Redfish. *NAFO SCR Doc.*, **79**.

Nedreaas, K. (1990) Age determination of Northeast Atlantic *Sebastes* Species. *J. Cons. int. Explor. Mer*, **47**: 208-230.

P.-Gándaras, G., J. M. Casas y J. Paz (1993) Summer feeding and its relationships with reproductive parameters of cod (*Gadus morhua*) on Flemish Cap. *NAFO Sci. Coun. Stud.*, **18**: 87-90.

P.-Gándaras y J. Zamarro (1990) Changes in the cohort growth rate of Flemish Cap cod. *NAFO SCR Doc.*, **90**, 13 pp.

Parsons, L. S., A. T. Pinhorn y D. Parsons (1976) An evaluation of the Northern Newfounland-Labrador and Flemish Cap Redfish Fisheries. *ICNAF Res. Bull.*, **12**: 37-48.

Pavlov, A. I., V. S. Mamylov, A. S. Noskov, A. N. Romanchenko y A. V. Ivanov (1989) Results of USSR Investigations of *Sebastes mentella* Travin in 1981-1988 (ICES Subareas XII and XIV). *ICES C.M.*, **G:17**.

Power, D. J. y D. B. Atkinson (1986) An estimate of redfish year-class strength from surveys to the Flemish Cap. *NAFO SCR Doc.*, **27**.

Power, G. (1978) Fish population structure in Arctic lakes. *J. Fish. Res. Board Can.*, **35**: 53-59.

Reimers, N. (1979) A history of a stunted brook trout population in an alpine lake: A lifespan of 24 years. *Calif. Fish. Game*, **69**: 196-215.

Rikhter, V. A. (1987) On estimating instantaneous natural mortality rate in the Irminger redfish (*Sebastes mentella* Travin). *ICES C.M.*, **G:27**.

Saborido-Rey, F. (1993) Distribution, abundance and biomass trends of the Genus *Sebastes* on Flemish Cap (Div. 3M). *NAFO SCR Doc.*, **24**, 12 pp.

Sandeman, E. J. (1961) A contribution to the problem of the age determination and growth rate in *Sebastes*. *Rapp. Cons. Expl. Mer.*, **150**(5): 276-284.

Sandeman, E. J. (1969) Age determination and growth rate of redfish, *Sebastes* spp., from selected areas around Newfoundland. *ICNAF Res. Bull.*, **6**: 79-105.

Shepherd, J. G. y D. H. Cushing (1980) A mechanism for density dependent survival of larval fiah as the basis of a stock-recruitment relationship. *J. Cons. int. Explor. Mer*, **39**: 160-167.

Surkova, I. (1961) Redfish, growth and age. *ICNAF Spec. Publ.*, **3**: 285-290.

Templeman, W. (1976) Biological and oceanographic backgrounds of Flemish Cap as an area for research on the reasons for year-class sucess and failure in cod and redfish. *ICNAF Res. Bull.*, **12**: 91-117.

Templeman, W. y C. A. Bishop (1979) Age, growth, yearclass strength, and mortality of haddock, *Melanogrammus aeglefinus*, on Saint Pierre Bank in 1948-75 and their relation to the haddock fishery of this area. *ICNAF Res. Bull.*, **14**: 85-89.

Vázquez, A (1989) Results from bottom trawl survey of Flemish Cap in July 1988. *NAFO SCR Doc.*, **60**.

Vázquez, A (1990) Results from bottom trawl survey of Flemish Cap in July 1989. *NAFO SCR Doc.*, **68**.

Vázquez, A (1991) Results from bottom trawl survey of Flemish Cap in July 1990. *NAFO SCR Doc.*, **28**.

Vázquez, A (1992) Results from bottom trawl survey of Flemish Cap in July 1991. *NAFO SCR Doc.*, **27**.

Vázquez, A (1993) Results from bottom trawl survey of Flemish Cap in July 1992. *NAFO SCR Doc.*, **19**.

Vázquez, A (1994) Results from bottom trawl survey of Flemish Cap in July 1993. *NAFO SCR Doc.*, **22**.

Wells, R. (1983) Changes in average length-at-age of cod on the Flemish Cap. *NAFO SCR Doc.*, **42**.

Wieland, K. (1992) Distribution of 0-group redfish (*Sebastes* spp.) off West Greenland in Autumn 1991. *NAFO SCR Doc.*, **32**.

Wootton, R. J. (1990) *Ecology of teleost fishes.* Chapman and Hall, Londres, 404 pp.

Table 1. Mean length at age of S. marinus *in Flemish Cap, July 1989-90 (scales) and July 1990-94 (otoliths)*

	Scales		Otoliths			Scales		Otoliths	
Age	Males	Females	Males	Females	Age	Males	Females	Males	Females
2	9,00				18	50,50	54,00	39,31	40,70
3	9,67			13,50	19		55,50	38,69	42,71
4	11,50	16,25	12,50	16,19	20			39,00	44,00
5	12,55	14,50	15,84	18,25	21			42,75	44,00
6	17,80	19,20	18,08	20,68	22			43,17	47,25
7	21,85	22,22	20,82	23,84	23			44,20	43,67
8	25,89	25,43	23,36	26,03	24				49,00
9	28,56	28,64	26,23	27,79	25			43,00	49,50
10	31,59	32,38	28,07	30,00	26			46,00	51,00
11	34,33	34,25	30,01	32,16	27			46,00	54,00
12	36,73	36,94	31,78	33,46	28				49,00
13	39,00	38,43	33,03	35,80	29				52,00
14	39,20	41,44	34,20	35,85	30				52,00
15	41,17	44,50	35,72	38,41	33				53,00
16	44,50	50,00	36,12	39,40	34				50,00
17	50,00	46,50	37,34	40,88	36				54,00

Table 2. Parameters of the von Bertalanffy equation of S. marinus *based in scales and otoliths*

	Scales		Otoliths	
	males	females	males	females
K	0,0053	0,006	0,080	0,072
L_∞	517,41	462,39	52,50	57,44
t_0	-1,7131	-1,656	-0,498	-0,29

Table 3.- Age-length key of females and males of S. marinus *in Flemish Cap.*

Age

Size	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
12	1																								1
13	1																								1
14		3																							3
15		13																							13
16		11	6	3																					20
17		9	41	2																					52
18		2	43	7	6																				58
19			30	40	4																				74
20			11	71	5	3																			90
21			4	72	16	2																			94
22				44	32	7																			83
23				19	49	6	2																		76
24				10	46	11	1	1																	69
25				5	32	18	6																		61
26					22	43	14	2																	81
27				1	2	36	11	2	1																53
28				1	2	21	24	12	1				1												62
29						17	21	13	3	2															56
30						3	21	23	14	1	1														63
31							2	20	14	10	1		1												48
32					1		1	12	15	9	11	2		1											52
33							1		13	11	5	1	2	1		1									35
34								1	7	15	15	8	2	1		1									50
35								2	1	7	14	14	3	1											42
36									2	3	3	6	5	5		1									25
37						1				1		6	2	5	3	2									20
38									1		2	8	3	7	1	1									23
39											2	2	2	4	4	1	1								16
40													2	2	1	2			1						8
41											1			2	2	2		1							8
42															2			1					1		4
43													1			1		1	2	2		1			8
44																1			2	1					4
45																		1	1	1			1	1	5
46																				1					1
47																								1	1
48																							1		1
	2	38	135	275	217	168	104	88	72	59	55	47	24	29	13	13	1	4	6	5	0	1	3	2	1361

Size	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30+	
12																													0
13	3																												3
14		6																											6
15	1	7	3																										11
16		10	7	1																									18
17		3	33	9	1	1																							47
18		2	42	5	3																								52
19			21	42	4																								67
20			14	53	7	3																							77
21			10	61	5	2																							78
22			1	32	20	2	3																						58
23				19	41	7	3																						70
24			1	7	39	5	6	3																					61
25				5	40	19	9	2																					75
26					16	30	8																						54
27				1	13	26	6	5																					51
28						21	23	4																					48
29					2	9	22	13																					46
30						1	18	16	13	4																			52
31		1					7	11	11	3																			33
32					1			13	22	9	3	1																	49
33							1	5	10	15	3	1																	35
34					1				4	12	6	2	1																26
35								1		6	8	7	3	2															27
36										3	10	3	1	1															18
37								1	1	2	3	3	2	5															17
38										1	2	1		1	2	1													8
39									1		3		4	2	3														13
40									1	1	1	1	4		1	3	1	1											14
41									1		1		1	1	1	3		1											9
42										1						3	2	1			1								8
43																	2	1			1								4
44											1						1	1	1										4
45													1				1			1									3
46																		1		2	1		1						5
47												1	1	1															2
48																		2											2
49																						2	1			1			4
50																							1					1	2
51													1								1							1	3
52																				1							1		2
53														1									1					3	5
54																									1				1
55																												1	1
	4	29	132	235	193	126	106	74	64	56	41	20	17	15	8	10	7	8	1	4	3	2	4	1	1	1	1	6	1169

Table 4. Age-length key of females and males of S. mentella *in Flemish Cap.*

Age

Size	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
13	1																								1
14	1	3																							4
15		6																							6
16	1	8																							9
17		3	9																						12
18		2	33	2																					37
19			39	16																					55
20			18	39	1																				58
21			5	33	4	1																			43
22				31	7																				38
23				20	28																				48
24				3	37	7																			47
25					27	15																			42
26					11	53	5																		69
27					5	47	18	5	1																76
28						10	48	9	1	1															69
29						6	30	18	2	1															57
30							23	28	18	3	1														73
31							2	18	32	11	6	1													70
32								1	21	26	20	5		1	1										75
33								5	8	25	18	17	8	4	1				1						87
34								1	2	13	20	17	15	7	1										76
35										2	13	13	13	18	5	2			1						67
36										1	8	17	22	11	6	8		2		1					76
37									1		1	5	8	8	6	2	5	3							39
38												3	4	5	4	5	4	1							26
39												1	3	1	4	3	4	3	3	1					23
40													2	1	2			2		1				1	9
41															2		1	1							4
42																	1		1						2
43															1										1
	3	22	104	144	120	139	126	85	86	83	87	79	75	56	33	20	15	12	6	3	0	0	0	1	1299

Size	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	Total
13																														0
14	1																													1
15	3																													3
16	6																													6
17	5	12																												17
18	1	15	1																											17
19	1	37	11																											49
20		21	27																											48
21		3	34	2		1																								40
22		1	37	11																										49
23			14	20																										34
24			6	41	5		2																							54
25				42	23																									65
26				11	44	6	1																							62
27				1	40	17	2																							60
28				2	15	26	7			1	1																			52
29			1		4	26	32	1			1																			65
30					1	11	35	16	3																					66
31					1	3	7	20	13	2																				46
32							4	16	13	7	3																			43
33					1			12	20	15	6	4	1																	59
34							2	4	15	19	14	8	6																	68
35									8	10	14	5	6	2	3	1	1													50
36								1	2	6	14	11	6	4	3	2														49
37										6	8	10	17	11	7	7	1			1										68
38							1		1	1	4	12	10	10	9	5	5		1											59
39										1		3	6	13	6	8	8	1												46
40												3	1	6	7	8	9	5	3	1	1	2								46
41												1		3		4	4	3	5	1	3	1				1				26
42													1	2	2	3	3	4	2	4									1	22
43																	2	3		2	1	1	1							10
44															1			1	2		1	1	1							7
45																		1			3			1						5
46																	1			1										2
	17	89	131	130	134	90	93	70	75	68	65	57	54	51	38	38	34	18	13	10	9	5	2	1	0	1	0	0	1	1294

Table 5. Age-length key of females and males of S. fasciatus *en Flemish Cap.*

	Age																								
Size	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
12																									0
13	2	1																							3
14																									0
15		5																							5
16		10	4																						14
17		10	39	1																					50
18		3	69	8																					80
19		2	55	50	1																				108
20			24	98	3																				125
21			4	94	12																				110
22			2	79	44	2																			127
23				27	79	3																			109
24				5	73	7																			85
25				4	28	27	2																		61
26					6	36	5																		47
27					3	19	8																		30
28					1	6	15	5				1													28
29						3	13	14																	30
30							2	9	5	1															17
31								3	6	1	3														13
32									1	2	1	2													6
33											2														2
34										1	1														2
35										1	1														2
36										1			1												2
37										1															1
38																									0
39															1										1
	2	31	197	366	250	103	45	31	12	8	8	3	1	0	1	0	0	0	0	0	0	0	0	0	1058

	Age																								
Size	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
12	1																								1
13	1																								1
14		4																							4
15		6																							6
16		16	3	1																					20
17		9	22	3																					34
18		4	63	2																					69
19		3	37	38																					78
20			21	89	6																				116
21			8	85	10																				103
22			1	73	30																				104
23				23	60	7	1																		91
24				9	75	9	1																		94
25				2	30	16																			48
26					8	29	2																		39
27					3	22	4		1																30
28						4	14	1																	19
29						2	6	3																	11
30							6	9	3	1															19
31								2	7	8	3														20
32								2	7	5		1			1										16
33								3	3	4	6														16
34										6		5	1												12
35											2	2	4												8
36											1		2	2											5
37										1	1		1		1	2									6
38													2	3	1										6
39																	1	2							3
40																	1						1		2
41													2					1							3
42																		1	1						2
	1	42	155	325	222	89	34	20	21	25	13	8	12	5	3	2	2	4	1	0	0	0	1	0	985

	S. marinus		*S. mentella*		*S. fasciatus*	
	Males	Females	Males	Females	Males	Females
L_∞	52.50	57.44	45.23	51.07	41.85	47.52
K	0.080	0.072	0.093	0.072	0.1221	0.096
t_0	-0.498	-0.29	-1.26	-1.9325	0.2112	-0.1665
Maximum age recorded	26	36	26	32	17	25

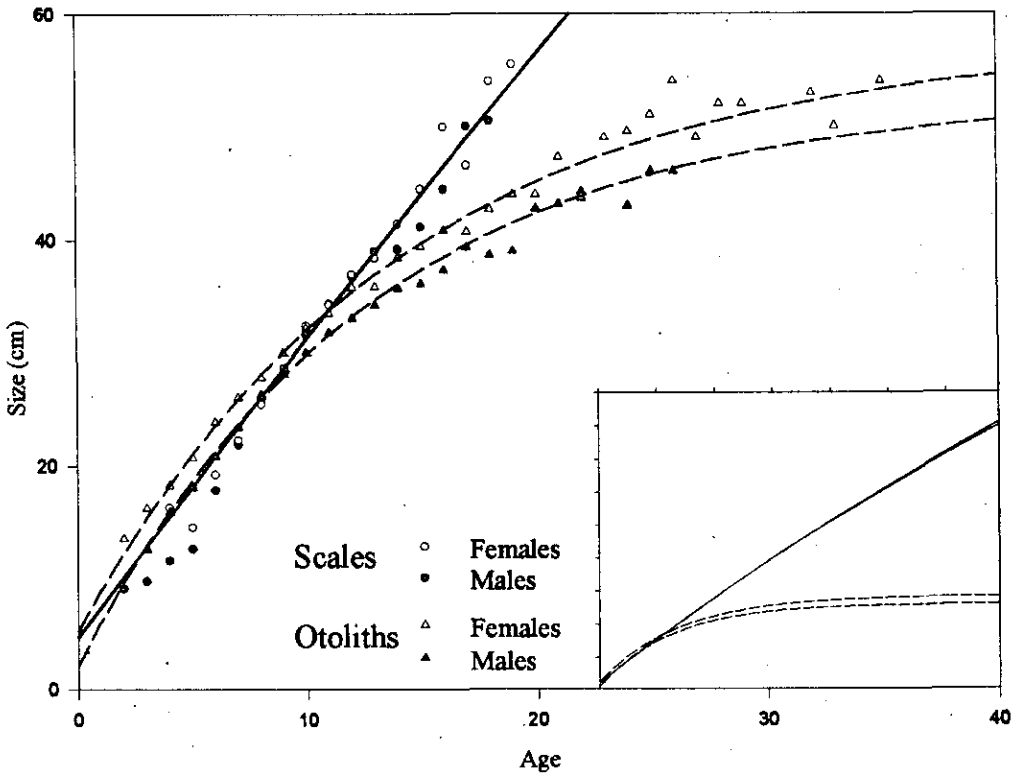

Figure 1.- Mean length at age and von Bertalanffy growth curves of S. marinus *based on age readings of scales and otoliths. Inside plot show a proyection to age 70.*

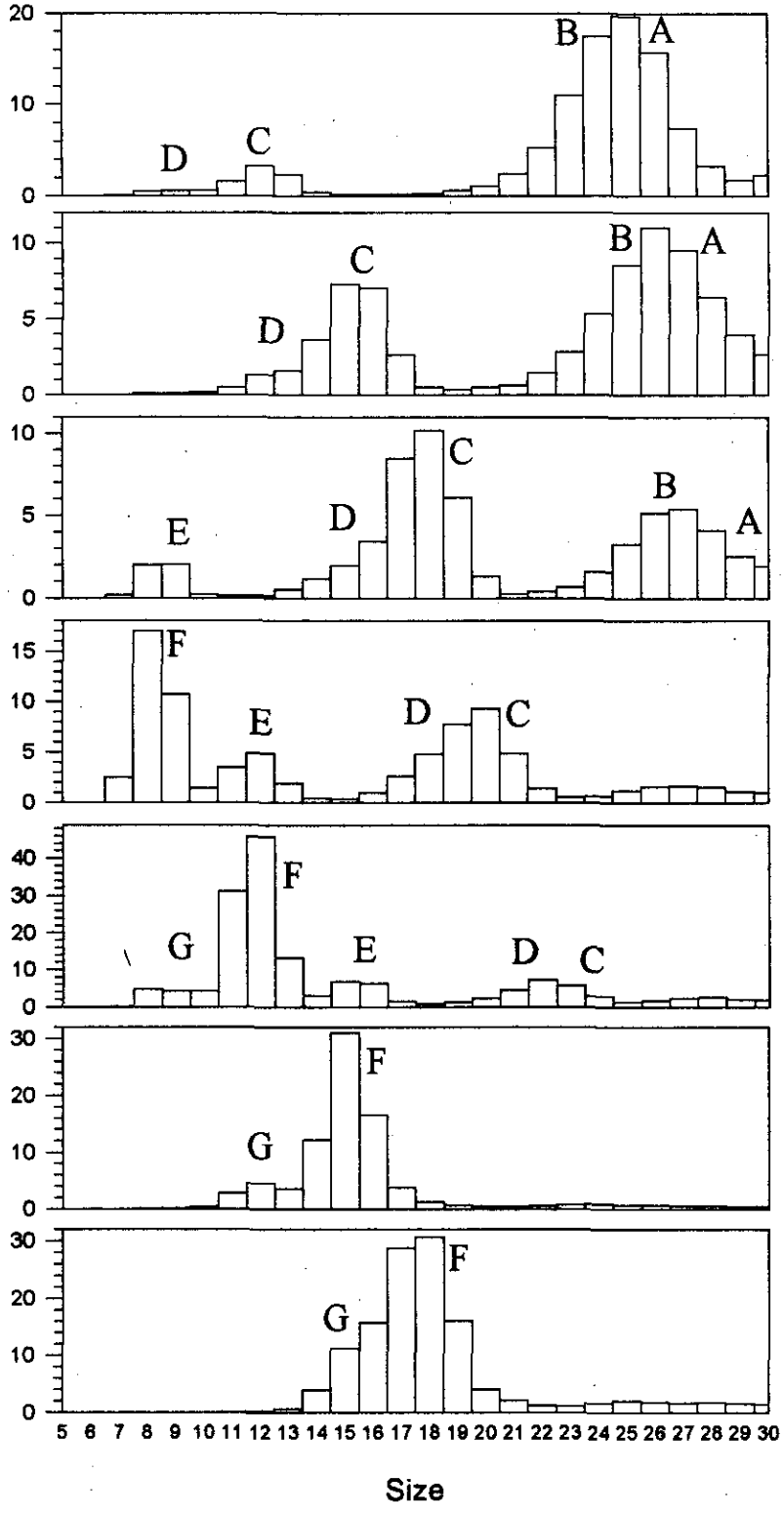

Figure 2.- Length frequency of Sebastes *in the period 1988-1994 (until 30 cm)*

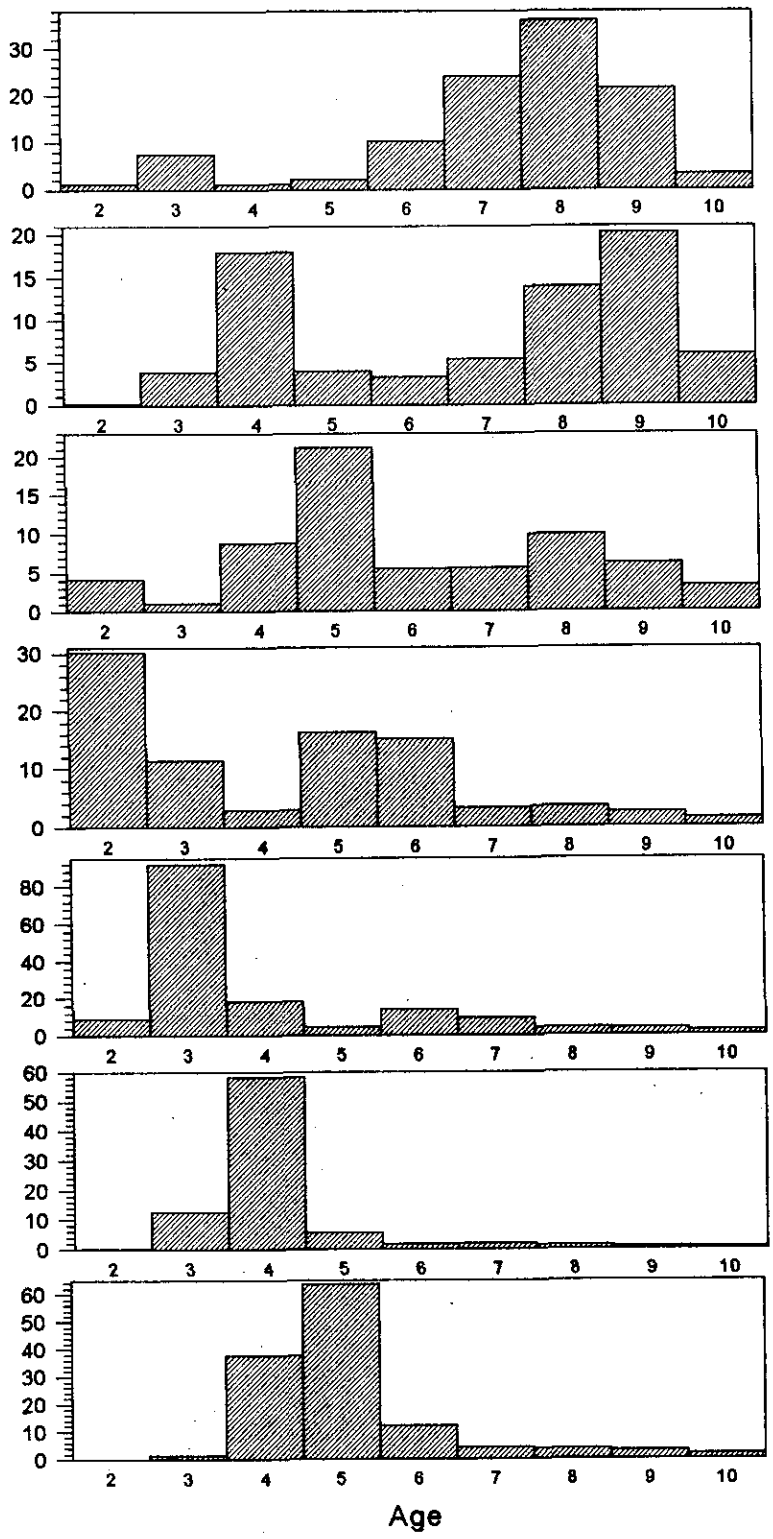

Figure 3.- Age frequency of Sebastes *in Flemish Cap in the period 1988-1994 (until age 10).*

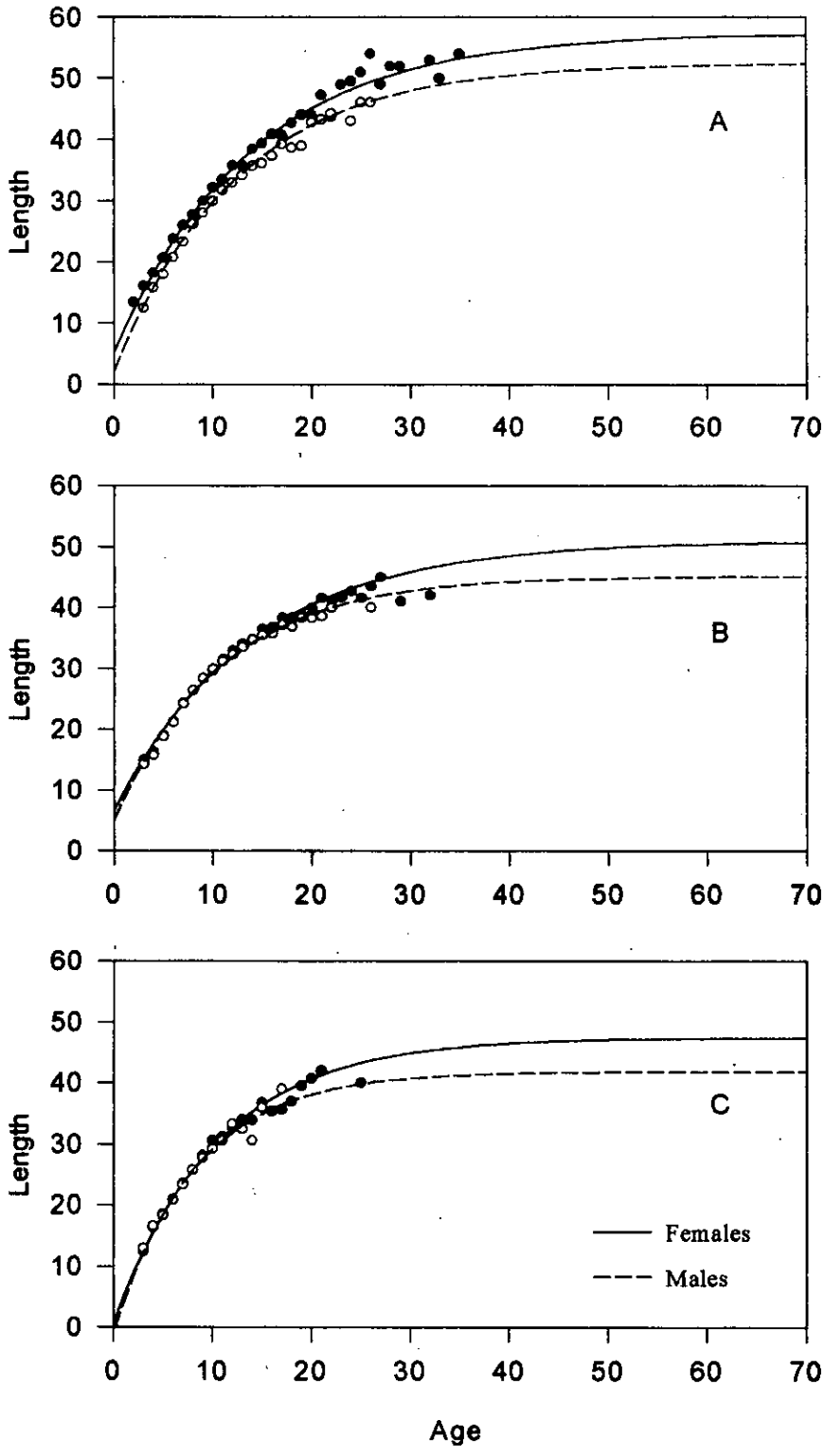

Figure 4.- Mean length at age and von Bertalanffy growth curve based in otoliths readings of Sebastes *during 1990-1994 in Flemish Cap. a)* S. marinus *b)* S. mentella *c)* S. fasciatus.

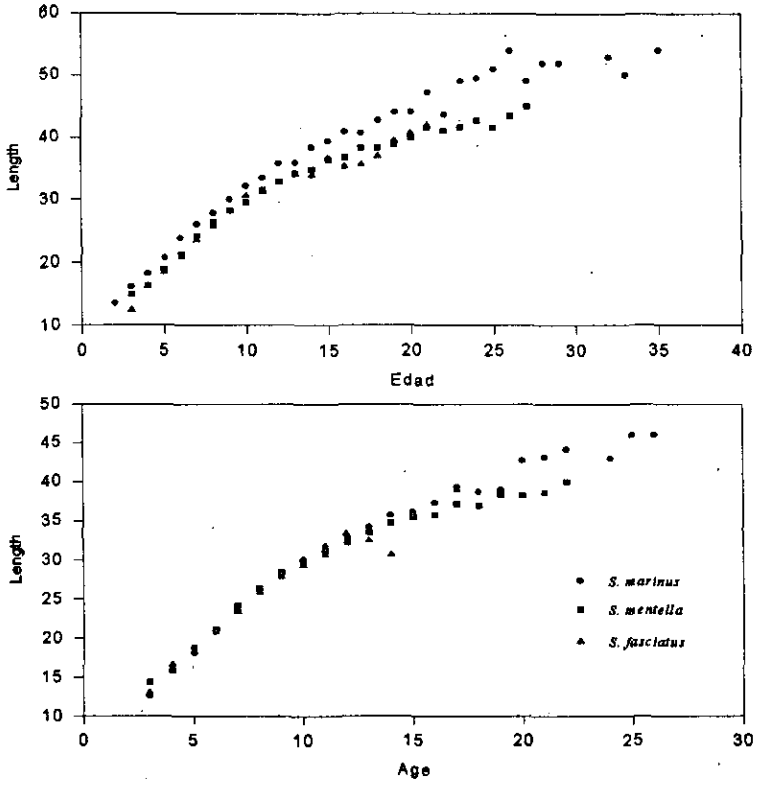

Figure 5.- Mean length at age of the three species of Sebastes *in Flemish Cap in females (above) and males (below).*

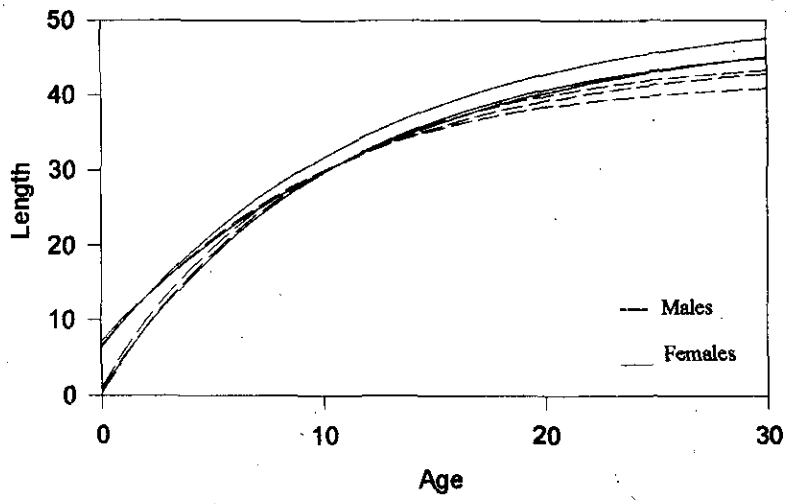

Figure 6-. von Bertalanffy curves of the three species of Sebastes *calculated with individuals younger than 17 years (males) and 22 years (females).*