Northwest Atlantic Fisheries Organization

Serial No. N1748

NAFO SCR Doc. 90/31

SCIENTIFIC COUNCIL MEETING - JUNE 1990

The Effect of Emigration on VPA-Assessments of Subarea 1 Cod

by

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Introduction

Since 1931 (Schmidt, 1931), the migration of Atlantic cod (Gadus morhua L.) from West to East Greenland and further to the spawning grounds in Icelandic waters is known. Following the definitions of McKeown (1984), the migration of the cod off Greenland is classified to a long-distance oceanodromous migration. The information about this migration derived from extensive tagging experiments is limited to the main route and covered distance (Harden Jones, 1968), whereas quantitative migration rates are not derivable.

In detail, the migration is regarded to be a one way migration of mature cod from West to East Greenland and further to Iceland. Tagging experiments proved that also mature cod and sometimes immature cod migrate from East Greenland to Iceland (Anon., 1973). On the contrary, a migration of cod from Iceland to Greenland hardly occurs. Therefore, the Working Groups of the ICES and NAFO designate the interrelation between these stocks as a complex (Anon., 1989). Particularly as on easy hydrographical conditions a larval drift with currents from Iceland to Greenland seems evident (Hovgard and Messtorff, 1987). The variation of the contribution of this larval drift to the recruitment of the cod stocks off East and West Greenland is reflected by the abundance indices from the Icelandic O-group survey (Vilhjalmsson and Magnusson, 1986).

The assessments of the cod stocks off East and West Greenland are carried out separately. They are based on annual groudfish surveys established by the Federal Republic of Germany in the beginning of the 1980-89 decade. Both assessments are affected with unknown emigration and immigration rates. Due to the non assessable loss of emigrants, VPA-calculations of the cod stock off West Greenland were rejected so far. Nevertheless, in 1990 the ICES Working Group on cod stocks off East Greenland decided to use a VPA incorporating a constant emigration coefficient of E=0.15 in order to assess the cod stock off West Greenland (Anon., 1990). This E-value and the total mortality rates Z were chosen in order to validate the required number of immigrants in the assessment of the cod stock off East Greenland in 1990. In the author's opinion, the reconstruction of the yearclass strengths of the West Greenland cod stock by this procedure is not practicable, since the chosen E- and Z-values are not measured directly and they produce nothing but the wanted figure of immigrants for the assessment of the cod stock of East Greenland.

Additionally, the VPA of the cod stock off West Greenland calculated by the ICES Working Group seems to be doubtful on the account of biologically improbable presumptions. The coefficient of emigration is not only assumed to be E=0.15, but E is also expected to be constant for all cod at an age of 5 years and older

and for all years taken into consideration. For this reason, the presented VPA is compared to a new calculated VPA with regard to increasing emigration coefficients with increasing age. The coefficients of emigration applied in the second VPA are determined by the utilization of typical otolith formations as a natural tag (Rätz, 1989).

Materials and Methods

The applied VPA-calculation follows the method of cohort analysis (Pope, 1972) and the method of virtual population analysis (Gulland, 1965) as described by Rivard (1982). Both VPAs of the cod stock off West Greenland, the VPA incorporating constant coefficients if emigration as well as the VPA distinguished by increasing coefficients of emigration for older age groups, are calculated using the catch in numbers statistic given in the last report of the Working Group off cod stocks off East Greenland (tab. 1). Additionally, the chosen natural mortality amounts to M=0.2 for the cod at an age of 5 years and older, whereas the M-values of the youngest age groups 3 and 4 are increased to M=0.3 due to discards for both VPAs. The chosen terminal F-values are identical for both VPAs too and listed in tab. 8 and 9, respectively.

As mentioned already, the VPA presented by the Working Group incorporates a constant coefficient of emigration E=0.15 for the age groups 5 and older and for all years from 1975 till 1989. On the contrary, the new calculated VPA takes the coefficients of emigration E into consideration as given in tab. 2. In this matrix the E-values of the years 1984 and 1985 are observed directly. During 1984 and 1985, the coefficients of emigration are estimated by the utilization of typical otolith structures as a natural tag (Rätz, 1989). The method of otolith typing enables the identification of the adolescent areas of West and East Greenland with an error of 20 % on individual basis supposing no further emigration from East Greenland to Iceland. Regarding the remaining years of the second VPA, the relative high E-values observed in 1984 are chosen for the period from 1975 till 1989.

The numbers of emigrants derived from both VPAs are determined by the formula

$$\text{nos. emigrants} = E / Z * (1 - EXP(-Z)) .$$

The calculated emigrants are compared to the figures of immigrants of the cod stock off East Greenland, which are calculated from the annual groundfish survey (Anon., 1985, 1987, 1989, 1990).

Results

The calculated numbers of the cod stock off West Greenland of both VPAs distinguished by different coefficients of emigration are nearly identical. Fig.1 and tab.3 give the numbers of individuals as calculated from the first VPA (constant coefficients of emigration) presented by the Working Group on cod stocks off East Greenland, whereas the strengths of the age groups resulting from the second VPA (increasing coefficients of emigration) are illustrated in fig. 2 and listed in tab. 4.

In contrast to the calculated numbers of individuals, the computed figures of emigrants differ widely from one another. The numbers of emigrants for both VPAs are shown in fig. 3 and 4 and entered in tab. 5 and 6, respectively. The most remarkable feature of the emigration pattern resulting from the VPA presented by the Working Group is the computation of 32 million emigrants of the year class 1984 in 1989 (fig. 3). This result was the motive for the choice of the coefficient of emigration of E= 0.15. During the period from 1975 till 1989, only the remaining strong year classes 1973, 1977 and 1979 show a pronounced emigration, but the cohort 1984 is far dominating. At an age of 5 years the emigration of the individuals starts suddenly and decreases strongly with increasing age.

The emigration of cod derived from the second VPA (increasing coefficients of emigration) is characterized by a more difficult migration pattern (fig. 4). In 1989, the emigrants of the 1984 year class amount only to 15 million, but their dominance is less pronounced than in the first VPA. In particular, the strong cohort 1973 as well as the year classes 1977 and 1979 show remarkable numbers of emigrants. The great majority of the cohorts have a typical emigration pattern in common with. The numbers of emigrants are increasing with age and reach a maximum value at an age of 6 years. Thereafter, the emigrants are decreasing in the age group 7.

The total numbers of emigrants calculated by the VPAs are compared to the numbers of immigrants derived from the results of the ground fish survey of the cod stock off East Greenland, assuming that the emigrants of the cod stock off West Greenland are equivalent to the immigrants of the cod stock off East Greenland. This comparison considers the age groups 6+ only. The corresponding figures are illustrated in fig. 5 and given in tab. 7. The estimated emigrants by means of the two VPAs are different (fig. 5, bars of the second and third row). The numbers of emigrants calculated with regard to the increasing coefficients of emigration (second VPA) are considerably higher (fig. 5, dotted bars in the last row).

In the years 1984 and 1985, directly determined coefficients of emigration are available and applied to the second VPA. In this period, the agreement between the survey results and the second VPA is remarkable (fig. 5, black bars compared to dotted bars). Additionally, the years 1983, 1986 and 1988 are characterized by a good agreement between the numbers of emigrants of the survey results and the second VPA, whereas both emigration models applied to the VPAs do not fit with the emigration of the recent year 1989.

Discussion

The assessments of the subarea 1 cod stock by means of both VPAs are nearly identical, although different coefficients of emigration are applied (fig. 1 and 2). The constant coefficients of emigration amounting to E=0.15 as well as the increasing coeficients E as given in tab. 2 produce negligible differences in the strengths of the year classes over the life-span of 10 years.

The first VPA presented by the Working Group on cod stocks off East Greenland (Anon., 1990; constant coefficients of emigration) results in a very simple emigration pattern, which depends on the strength of the cohorts only. In fact, both models disregard possible important migration factors determining the transport of individuals. Imaginable migration factors are the chanceable environmental conditions (temperature) or the availability of food. Consequently, the calculated numbers of emigrants of the age groups 6+ by the first VPA do not correspond with the observed numbers of emigrants derived from the groundfish surveys (fig. 5).

In contrast to the first VPA, the second VPA presented in this paper (increasing coefficients of emigration) takes the maturation into account as a possible starting mechanism of the migratory behaviour of the cod. Following the general concept of fish migration developed by Harden Jones (1968), the presumption is obvious, that the migration of the cod off Greenland beginning at the age of 4 years is a matter of the homing phenomenon. This phenomenon designates the impulse of the movement back to the location of the own origin. In conformity with the process of maturation, the increase of the coefficients of emigration with increasing age seems explainable. The good agreement between the emigration model applied to the second VPA and the observed numbers of emigrants derived from the groundfish surveys in the years 1984 and 1985 (fig. 5) validates the directly estimated coefficients of emigration by means of otolith typing.

The correspondence between the emigrants estimated by means of the second VPA (increasing coefficients of emigration) and the survey results is generally higher than the agreement between the outcome of the first VPA (constant coefficients of emigration) and the survey results. However, the discrepancy of both emigration models and the numbers of emigrants derived from the survey in 1989 demonstrates the importance of the direct determination of the coefficients of emigration. For the present, the assessment of the cod stock off West Greenland by means of a VPA seems not recommendable, due to the year to year variations of the coefficients of emigration.

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Tab. 1 Cod Stock off West Greenland (Anon., 1990). Catch in numbers (n*1,000).

age	year1975	year1976	year1977	year1978	year1979	year1980	year1981	year1982
3.0	275.0	10760.0	634.0	287.0	286.0	2999.0	12.0	1204.0
4.0	3595.0	4026.0	46649.0	5494.0	10656.0	4513.0	16864.0	1210.0
5.0	2677.0	2243.0	6053.0	30039.0	12505.0	4580.0	6374.0	17960.0
6.0	1803.0	1216.0	1515.0	1004.0	18970.0	1978.0	2391.0	2965.0
7.0	5855.0	302.0	618.0	509.0	709.0	8014.0	1053.0	2078.0
8.0	1388.0	1594.0	425.0	83.0	400.0	125.0	3382.0	807.0
9.0	619.0	139.0	446.0	41.0	78.0	60.0	45.0	610.0
10.0	291.0	148.0	168.0	13.0	52.0	24.0	65.0	45.0
11.0	84.0	53.0	79.0	7.0	55.0	1.0	1.0	88.0
12.0	69.0	84.0	112.0	16.0	106.0	22.0	8.0	27.0

age	year1983	year1984	year1985	year1986	year1987	year1988	year1989
3.0	77.0	595.0	456.0	12.0	8626.0	832.0	40.0
4.0	12356.0	2018.0	1266.0	113.0	2474.0	49766.0	10442.0
5.0	2011.0	10384.0	1303.0	706.0	415.0	1060.0	74960.0
6.0	17228.0	688.0	4915.0	318.0	1001.0	497.0	689.0
7.0	1581.0	3656.0	161.0	1193.0	641.0	646.0	101.0
8.0	995.0	106.0	750.0	12.0	1037.0	519.0	191.0
9.0	344.0	365.0	42.0	332.0	11.0	744.0	195.0
10.0	343.0	97.0	140.0	80.0	45.0	21.0	489.0
11.0	3.0	69.0	15.0	13.0	2.0	83.0	1.0
12.0	43.0	3.0	22.0	35.0	11.0	1.0	69.0

Tab. 2 Matrix of coefficients of emigration E as applied in VPA 2.

age	year1975	year1976	year1977	year1978	year1979	year1980	year1981	year1982
3.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.0	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030
5.0	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
6.0	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
7.0	0.650	0.650	0.650	0.650	0.650	0.650	0.650	0.650
8.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

age	year1983	year1984	year1985	year1986	year1987	year1988	year1989
3.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4.0	0.030	0.030	0.020	0.030	0.030	0.030	0.030
5.0	0.070	0.070	0.000	0.070	0.070	0.070	0.070
6.0	0.250	0.250	0.090	0.250	0.250	0.250	0.250
7.0	0.650	0.650	0.130	0.650	0.650	0.650	0.650
8.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Tab. 3 Stock assessment by means of VPA 1 (constant coefficients of emigration). Numbers (n*1,000).

age	year1975	year1976	year1977	year1978	year1979	year1980	year1981	year1982
3.0	27072.0	272175.0	55854.0	55939.0	38500.0	146157.0	9656.0	96080.0
4.0	17690.0	19820.0	192407.0	40834.0	41194.0	28276.0	105705.0	7143.0
5.0	7383.0	10191.0	11253.0	102856.0	25559.0	21458.0	17097.0	63920.0
6.0	3960.0	3002.0	5324.0	3012.0	47678.0	7807.0	11328.0	6812.0
7.0	10963.0	1317.0	1118.0	2500.0	1296.0	18035.0	3866.0	6002.0
8.0	2275.0	2966.0	678.0	286.0	1340.0	337.0	6153.0	1854.0
9.0	1273.0	482.0	795.0	135.0	133.0	614.0	135.0	1591.0
10.0	520.0	392.0	225.0	199.0	61.0	31.0	383.0	58.0
11.0	156.0	131.0	155.0	25.0	129.0	3.0	3.0	216.0
12.0	128.0	207.0	219.0	58.0	249.0	61.0	22.0	66.0

age	year1983	year1984	year1985	year1986	year1987	year1988	year1989
3.0	18653.0	13930.0	4557.0	13196.0	630120.0	99561.0	1565.0
4.0	70146.0	13753.0	9810.0	2986.0	9765.0	459409.0	73043.0
5.0	4260.0	41429.0	8466.0	6186.0	2116.0	5131.0	297806.0
6.0	30208.0	1359.0	20607.0	4884.0	3772.0	1147.0	2737.0
7.0	2373.0	7326.0	398.0	10455.0	3177.0	1831.0	401.0
8.0	2520.0	402.0	2180.0	148.0	6375.0	1707.0	759.0
9.0	646.0	959.0	196.0	919.0	94.0	3632.0	775.0
10.0	620.0	176.0	376.0	103.0	375.0	57.0	1943.0
11.0	5.0	159.0	45.0	150.0	9.0	227.0	0.0
12.0	77.0	7.0	66.0	404.0	52.0	0.0	274.0

Tab. 4 Stock assessment by means of VPA 2 (increasing coefficients of emigration). Numbers (n*1,000).

age	year1975	year1976	year1977	year1978	year1979	year1980	year1981	year1982
3.0	28832.0	300177.0	62044.0	62525.0	40907.0	156214.0	9240.0	99816.0
4.0	21415.0	21124.0	213157.0	45423.0	46073.0	30057.0	113151.0	6835.0
5.0	7887.0	12380.0	11811.0	114185.0	28037.0	24205.0	17819.0	67183.0
6.0	5091.0	3714.0	7507.0	3842.0	61203.0	10676.0	14511.0	8114.0
7.0	14564.0	1848.0	1423.0	3600.0	1666.0	24266.0	5256.0	7375.0
8.0	2000.0	2714.0	602.0	240.0	1221.0	289.0	5503.0	1594.0
9.0	1310.0	411.0	806.0	118.0	122.0	641.0	125.0	1504.0
10.0	557.0	520.0	212.0	263.0	60.0	31.0	471.0	62.0
11.0	312.0	197.0	293.0	26.0	204.0	4.0	4.0	327.0
12.0	256.0	312.0	416.0	59.0	394.0	82.0	30.0	100.0

age	year1983	year1984	year1985	year1986	year1987	year1988	year1989
3.0	22454.0	17057.0	4988.0	13190.0	628181.0	100923.0	1565.0
4.0	72909.0	16568.0	12126.0	3305.0	9761.0	457971.0	74056.0
5.0	3699.0	42048.0	10216.0	7734.0	2281.0	4949.0	287382.0
6.0	35767.0	1258.0	23121.0	7190.0	5291.0	1382.0	2860.0
7.0	2876.0	9590.0	278.0	13092.0	4333.0	2589.0	496.0
8.0	1880.0	313.0	1898.0	68.0	4846.0	1452.0	709.0
9.0	586.0	653.0	161.0	883.0	45.0	3035.0	724.0
10.0	686.0	174.0	210.0	94.0	426.0	27.0	1816.0
11.0	11.0	256.0	56.0	48.0	7.0	308.0	4.0
12.0	160.0	11.0	82.0	130.0	41.0	4.0	256.0

Tab. 5 Assessment of emigrants (n*1,000) by means of VPA 1 (constant coeficients of emigration).

age	year1975	year1976	year1977	year1978	year1979	year1980	year1981	year1982
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	730.0	1125.0	938.0	10764.0	2205.0	2378.0	1677.0	6745.0
6.0	360.0	286.0	560.0	305.0	4574.0	841.0	1258.0	632.0
7.0	918.0	144.0	92.0	279.0	107.0	1658.0	411.0	602.0
8.0	173.0	247.0	50.0	30.0	140.0	33.0	506.0	172.0
9.0	112.0	51.0	64.0	14.0	10.0	73.0	14.0	155.0
10.0	42.0	38.0	14.0	24.0	3.0	2.0	44.0	3.0
11.0	13.0	12.0	13.0	3.0	12.0	0.0	0.0	21.0
12.0	11.0	20.0	19.0	6.0	23.0	6.0	2.0	6.0

age	year1983	year1984	year1985	year1986	year1987	year1988	year1989
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	381.0	4473.0	977.0	732.0	237.0	572.0	32126.0
6.0	2422.0	117.0	2244.0	595.0	403.0	107.0	295.0
7.0	167.0	637.0	38.0	1237.0	355.0	183.0	43.0
8.0	242.0	43.0	219.0	18.0	731.0	177.0	82.0
9.0	54.0	93.0	22.0	91.0	11.0	405.0	84.0
10.0	51.0	14.0	37.0	6.0	44.0	6.0	210.0
11.0	0.0	15.0	5.0	18.0	1.0	22.0	0.0
12.0	6.0	1.0	7.0	49.0	6.0	0.0	30.0

Tab. 6 Assessment of emigrants (n*1,000) by means of VPA 2 (increasing coefficients of emigration).

age	year1975	year1976	year1977	year1978	year1979	year1980	year1981	year1982
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	495.0	481.0	4757.0	1081.0	1019.0	702.0	2646.0	157.0
5.0	388.0	602.0	497.0	5946.0	1258.0	1326.0	863.0	3489.0
6.0	800.0	597.0	1329.0	651.0	9982.0	1912.0	2636.0	1263.0
7.0	4585.0	722.0	432.0	1430.0	511.0	8219.0	1995.0	2613.0
8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

age	year1983	year1984	year1985	year1986	year1987	year1988	year1989
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	1682.0	394.0	195.0	83.0	213.0	10982.0	1740.0
5.0	163.0	2215.0	0.0	450.0	126.0	267.0	14992.0
6.0	4972.0	162.0	1587.0	1411.0	945.0	216.0	492.0
7.0	751.0	3086.0	19.0	5393.0	1713.0	944.0	188.0
8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Tab. 7 Comparison of the calculated numbers of emigrants (n*1,000), survey results, VPA 1 (constant coefficients of emigration), VPA 2 (increasing coefficients of emigration)

year	survey	VPA 1	VPA 2
1975		1629.0	5385.0
1976		798.0	1319.0
1977		812.0	1761.0
1978		661.0	2081.0
1979		4869.0	10483.0
1980		2613.0	10131.0
1981		2235.0	4631.0
1982		1591.0	3876.0
1983	6605.0	2942.0	5723.0
1984	2708.0	920.0	3248.0
1985	789.0	2572.0	1606.0
1986	4907.0	2014.0	6804.0
1987	0.0	1551.0	2997.0
1988	988.0	900.0	1160.0
1989	1268.0	744.0	680.0

Tab. 8 Fishing mortalities of VPA 1 (constant coefficients of emigration).

age	year1975	year1976	year1977	year1978	year1979	year1980	year1981	year1982
3.0	0.012	0.047	0.013	0.006	0.009	0.024	0.001	0.015
4.0	0.263	0.266	0.326	0.169	0.352	0.203	0.203	0.217
5.0	0.550	0.299	0.968	0.419	0.836	0.289	0.570	0.400
6.0	0.751	0.638	0.406	0.493	0.622	0.353	0.285	0.704
7.0	0.957	0.314	1.012	0.274	0.996	0.725	0.385	0.518
8.0	1.201	0.967	1.263	0.415	0.430	0.566	1.003	0.704
9.0	0.828	0.412	1.037	0.439	1.116	0.123	0.493	0.592
10.0	1.032	0.580	1.840	0.081	2.750	2.074	0.223	2.035
11.0	0.970	0.639	0.893	0.394	0.683	0.548	0.558	0.643
12.0	0.970	0.639	0.893	0.394	0.683	0.548	0.558	0.643

age	year1983	year1984	year1985	year1986	year1987	year1988	year1989
3.0	0.005	0.051	0.123	0.001	0.016	0.010	0.030
4.0	0.227	0.185	0.161	0.045	0.344	0.133	0.180
5.0	0.792	0.348	0.200	0.145	0.262	0.278	0.350
6.0	1.067	0.880	0.329	0.080	0.373	0.700	0.350
7.0	1.425	0.862	0.637	0.145	0.271	0.531	0.350
8.0	0.616	0.370	0.516	0.101	0.213	0.440	0.350
9.0	0.953	0.586	0.290	0.547	0.148	0.276	0.350
10.0	1.014	1.011	0.569	2.038	0.153	0.557	0.350
11.0	1.037	0.704	0.493	0.108	0.285	0.557	0.000
12.0	1.037	0.704	0.493	0.108	0.285	0.000	0.350

Tab. 9 Fishing mortalities of VPA 2 (increasing coefficients of emigration).

age	year1975	year1976	year1977	year1978	year1979	year1980	year1981	year1982
3.0	0.011	0.042	0.012	0.005	0.008	0.023	0.002	0.014
4.0	0.218	0.251	0.294	0.152	0.314	0.193	0.191	0.231
5.0	0.483	0.230	0.853	0.354	0.696	0.242	0.517	0.360
6.0	0.563	0.509	0.285	0.386	0.475	0.259	0.227	0.587
7.0	0.830	0.272	0.930	0.231	0.902	0.634	0.343	0.517
8.0	1.302	1.014	1.430	0.476	0.444	0.639	1.097	0.801
9.0	0.724	0.462	0.920	0.478	1.173	0.109	0.501	0.585
10.0	0.840	0.374	1.897	0.056	2.510	1.835	0.165	1.528
11.0	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350
12.0	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350

age	year1983	year1984	year1985	year1986	year1987	year1988	year1989
3.0	0.004	0.041	0.112	0.001	0.016	0.010	0.030
4.0	0.220	0.154	0.130	0.041	0.349	0.136	0.180
5.0	0.861	0.328	0.151	0.110	0.231	0.278	0.350
6.0	0.866	1.060	0.279	0.056	0.265	0.575	0.350
7.0	1.368	0.770	1.079	0.144	0.243	0.445	0.350
8.0	0.857	0.464	0.565	0.215	0.268	0.496	0.350
9.0	1.014	0.935	0.337	0.529	0.312	0.313	0.350
10.0	0.786	0.933	1.276	2.394	0.126	1.725	0.350
11.0	0.350	0.350	0.350	0.350	0.350	0.350	0.350
12.0	0.350	0.350	0.350	0.350	0.350	0.350	0.350

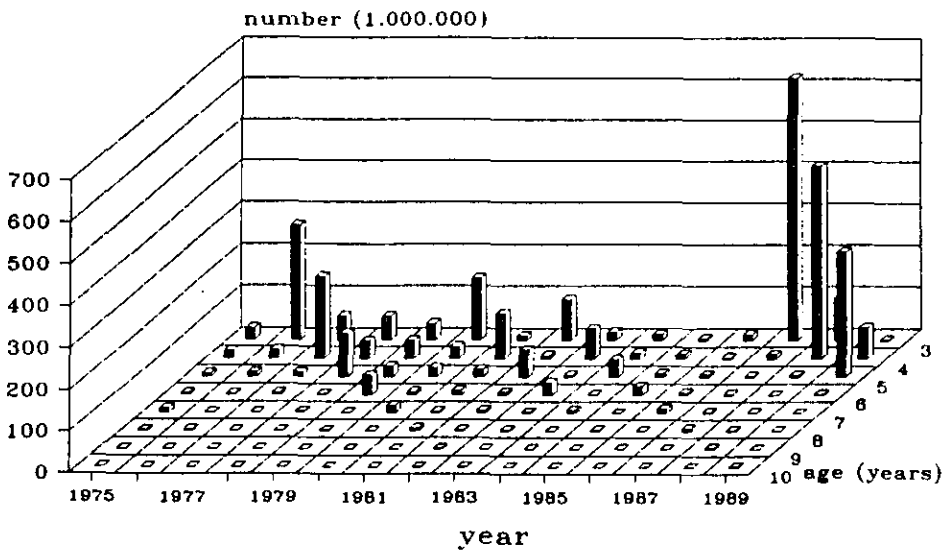

Fig. 1 Stock assessment by means of VPA 1 (constant coefficients of emigration)

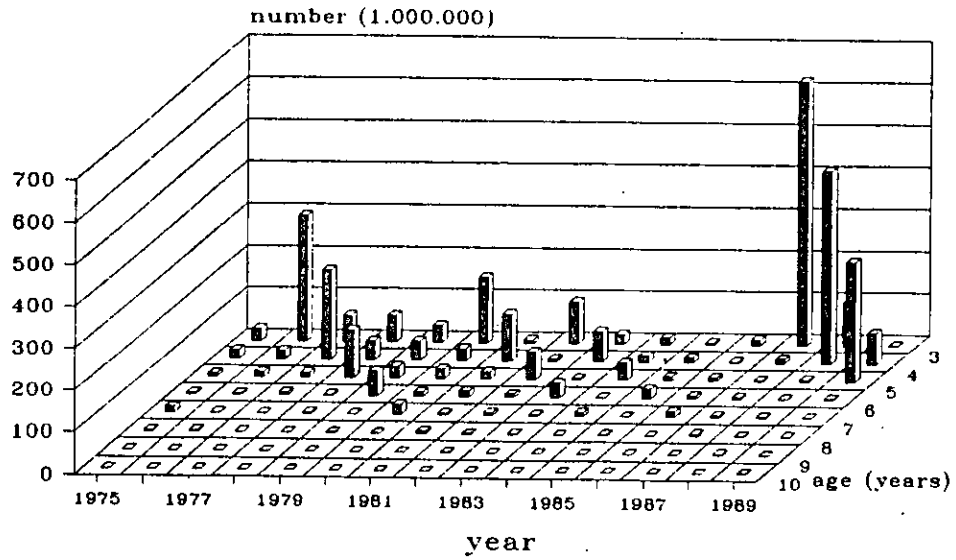

Fig. 2 Stock assessment by means of VPA 2 (increasing coefficients of emigration)

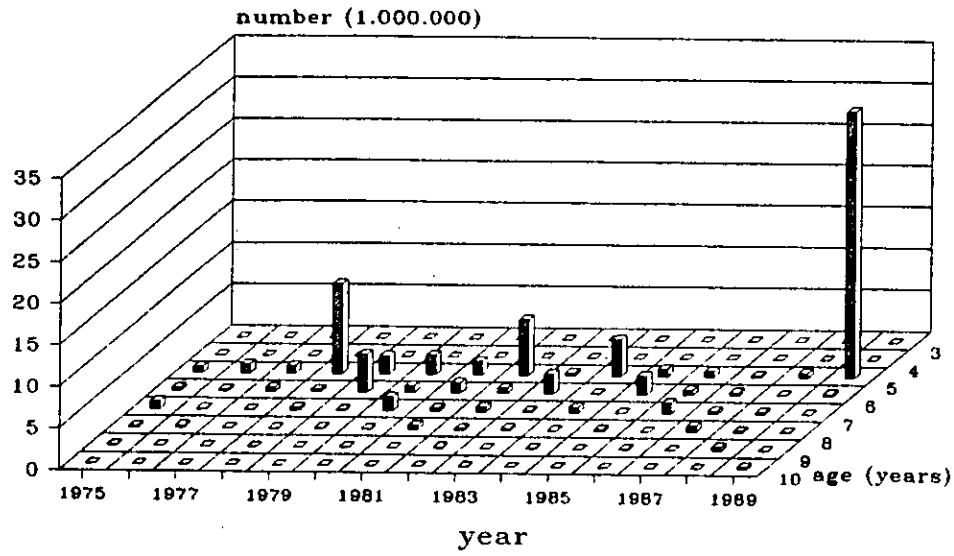

Fig. 3 Assessment of emigrants by means of VPA 1 (constant coefficients of emigration)

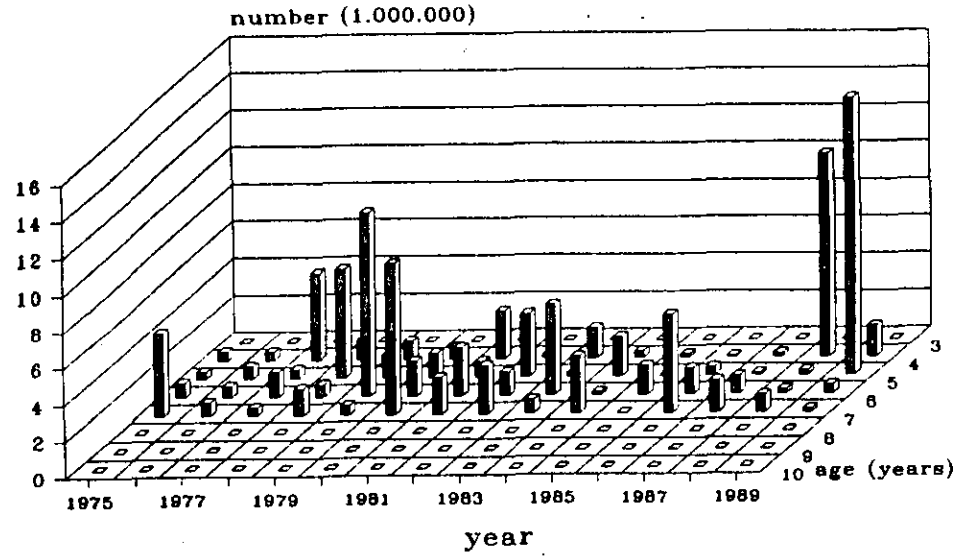

Fig. 4 Assessment of emigrants by means of VPA 2 (increasing coefficients of emigration)

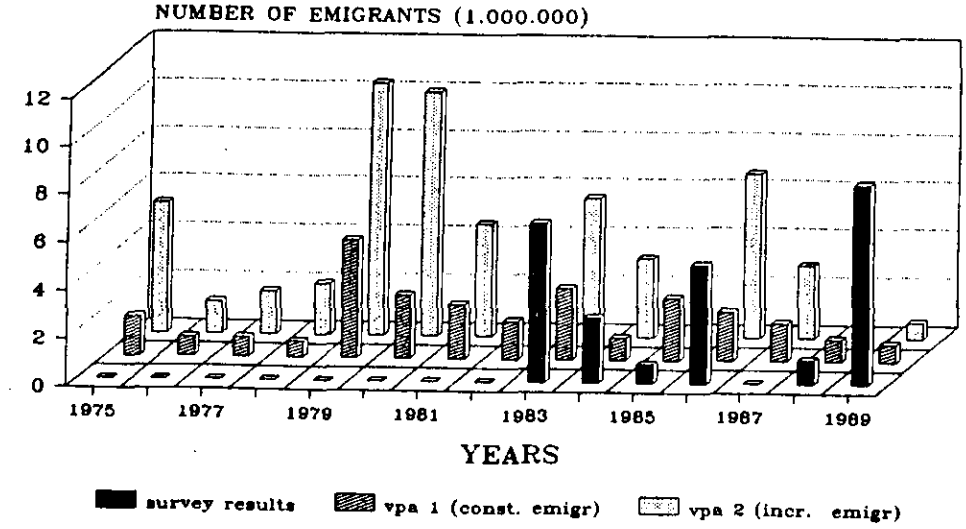

Fig. 5 Comparison of the total numbers of emigrants at an age of 6 years and older.