INTERNATIONAL COUNCIL FOR THE
EXPLORATION OF THE SEA

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Demersal Fish Committee

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Introduction

The Flatfish Working Group annually updates the estimates of yearclass strength of sole and plaice on the basis of commercial catch data and c.p.u.e. provided by the nations fishing in the North Sea for these species.
Specifically the Virtual Population Analysis (VPA) provides estimates for each yearclass as 1 or 2 year old recruits.

Between 1969 and 1979 the Dutch beamtrawl fisheries took 80-85% of the total international landings of sole. Consequently the reliability of the estimates of yearclass strength of sole depend predominantly upon the Dutch landing statistics and the market sampling.

Since the introduction of TAC's for North Sea sole and plaice in 1975, an increasing part of the landings have been sold outside the fishing markets, without registration in the official landing statistics. The decreasing reliability of landings statistics greatly enhanced the relevance of other estimates of yearclass abundance.

DE VEEN (1978) analysed the R.V. "Tridens" prerecruit surveys for the years 1969-1977 and obtained correlations between indices of abundance from the combined April and September/October surveys of I-group, II-group and I + II group sole and indices derived from the c.p.u.e. and from VPA.

In this paper the 0-, I- and II-group catch data of sole collected during these surveys are reanalysed. Yearclass indices based on catch in numbers per 100 fishing hours are compared with VPA estimates of 2 year old recruits by means of regression analysis.

Methods

The flatfish prerecruit surveys in the North Sea have been carried out since August 1968. The station grid exists of 10 lines of stations, perpendicular or parallel to the Dutch, German and part of the Danish coast. In 1973 6 lines north of Esbjerg have been added (DE VEEN & VAN LEEUWEN, 1978), thus the programme now covers the continental coastal area from Scheveningen to the Kattegat (fig. 1). In general 2 surveys have been carried out annually, one in April and one in September/ October.

The gear used is a standard beam trawl with a 6 metre opening, 4 tickler chains and a 45 mm mesh size in all parts of the net. The fishing speed is 4 knots and the duration of each haul is 15 minutes. For a description of the gear see DE VEEN (1975).

In this paper only data from the Scheveningen to Esbjerg lines are dealt with, because the area north of Esbjerg appeared to be important only for plaice.

During the surveys samples of fishes were measured at each station. Simultaneously with the gear described above a 6 meter small mesh-sized shrimp-beamtrawl was operated on the same stations for other purposes. Otolith samples have been taken from the catches in both gears and from these length age keys have been derived for each line of stations separately.

Length compositions of the total catch per standard effort (100 fishing hours) in each line were converted to age compositions using the length age keys.

On some occasions not all the stations of a line could be fished (lack of time, bad weather etc.). Also sometimes hauls had to be rejected because of defective fishing gear. In the present analysis lines were excluded from the calculations if less than 2 stations were fished on that line during the survey.

The procedure of calculation is somewhat different from the one applied by DE VEEN (1978). In 1968 and 1969 soles were counted only on the catch data sheets with a note referring to the length of fishes on the otolith samples. Yet the samples also contained fishes from the parallel hauls made with the small meshed shrimp-beamtrawl. DE VEEN used the age compositions in the length age keys in proportion to the numbers of fish caught in the flatfish beamtrawl per line for his indices. However, the age compositions in these length-age keys cannot be considered to be representative for the age compositions in the catches made by each gear separately. After 1969 DE VEEN continued this procedure, although in these years length composition of the catches were available. Since we used the latter as the basis for our calculations the present indices differ from those published by DE VEEN (1975 and 1978) and DE VEEN & VAN LEEUWEN (1975, 1976, 1977, 1978, 1979 and 1980).

Because no reliable length data were available for the years 1968 and 1969, these years were excluded from the analysis.

Results

Mean catches of 0-, I- and II-group soles per 100 fishing hours are given in table 1 a-d for the different lines. Table 2 presents the yearclass indices for the April and September/October survey, separately which were calculated as the mean value on all the lines fished.

The 0-group indices and the I-group indices in April show large annual variations. The catch of 0- and I-group is highly affected by the following circumstances. The survey has been initiated as a prerecruit survey for I- and II-group flatfish. The fishing gear is not optimal for still younger fish. Therefore the majority of 0-group and small sized I-group soles (in case of small catches) may escape through the meshes. In case of large bycatches however, the chances for escape will decrease.

The main nursery areas for 0- and I-group soles in April covers the deeper parts of the Waddensea and estuaries, and a relative small area close to the beach along the continental coast. Only a few stations close to the coast lie within these nursery areas. This explains the zero catches on many of the lines for these categories (table 1a, 1b). Only in the case of stronger yearclasses 0-group and smaller I-group soles are present and caught further off the coast. For these reasons the indices for 0-group and I-group soles in April are liable to large errors.

In the course of their second year of life, most soles migrate to open sea. A small part of them returns to inshore waters in March and the beginning of April of the following year and gradually return to open sea again in the course of the same year. So the greater part of the 1 year old soles in September/October and of the 2 year old soles in April and almost all 2 year old soles in September/October are present in the area covered by the "Tridens" stationgrid.

From I- to II-group, the catches of sole decline drastically. This can only partially be explained by the assumed levels of natural and the estimated fishing mortality in sole assessment, leaving open the possibilities of migration out of the area of higher mortality rates than assumed until now. The catches of the II-group in September/October are of the same level as in April with a tendency to be somewhat higher in autumn, in spite of the fact that II-group soles are already exposed to the fishery. Natural and fishery mortality appear to be compensated by migration to the survey area of that part of the population which is still in the nurseries and increasing catchability may account from this difference.

Correlations between September/October I-group with both II-group estimates are not significant, but the correlation between both II-group estimates is highly significant (table 4) at the 99% level.

The high correlation between the independent April II-group indices and September/October II-group indices indicates that the surveys give reliable indices of yearclass strength of the continental sub-spawning stocks which may be better than the VPA estimates.

For correlation with these survey indices, numbers of 2 year old recruits were taken from the VPA in the 1980 report of the North Sea Flatfish Working Group for the yearclasses 1968-1976. (ANON, 1980).
Both VPA and "Tridens" estimates are subject to natural variability and measurement error. Also the size of sole yearclasses is not normally distributed, this must also be the case with "Tridens" estimates and VPA, and in the terminology of RICKER (1973), both sets of estimates can be considered symmetrical samples of "open ended" populations. In this situation a geometric regression equation is the most appropriate one for the functional as well as predictional relationship. The correlation coefficients and geometric regression equations are shown in table 3.
The correlation between the 0-group index and VPA and April I-group index and VPA is not significant as could be expected from the consideration above. Correlation coefficients between September/ October I-group, April II-group and September/October II-group are significant at the 95% level. 95% confidence limits of the regression lines were calculated using the equation given by RICKER (1973), and these are shown in figure 2 a-c.

The correlation coefficients of the regression equations are not exceptionally high. Very high correlations can also not be expected since both are subject to different sources of error.
The accuracy of VPA depends on the assumed value of natural mortality and the reliability of catch statistics, market sampling and input F estimates.

Also the VPA estimates for North Sea sole refer to the total North Sea stock whereas the surveys only cover the continental substocks. Although these substocks represent the major part of the the total North Sea population, British substocks may contribute 30% to the total (ANON., 1979b, annex 3). The most important source of error may be that the relative contribution of the separate stocks to the total recruitment may fluctuate considerably from year to year. Also seasonal changes in catchability caused by weather conditions introduce error in the survey estimates.

Discussion

Predicting yearclass strength from the regression lines is subject to restrictions. The regressions are only operative within the range of values from which they calculated. Extreme values for survey indices give only qualitative information in terms of very weak, strong or very strong yearclasses.

By its nature, the sole in the North Sea is vulnerable to extreme winters. In severe winter they flee the low temperatures in the coastal waters and migrate to deeper parts of the western North Sea. Low sea water temperatures also cause a higher natural mortality in all age groups (ANON., 1979a). Many dead soles with open wounds were reported by fishermen in the winter of 1962-1963. However, in the last sever winter of 1978-1979 this has not been the case. In this winter westward migration to deeper and warmer water took place but no indications were found for extra natural mortality in older soles. The yearclass 1978 however, which was the strongest 0-group on record in the "Tridens" series, diasppeared in this winter for the greater part and is now considered one of the weakest of the last ten years. Probably the 1977 yearclass has also suffered an extra natural mortality but as yet there are no direct observations to verify this.

In the 1979 April survey, no I-group and only very few II-group soles were caught on the lines in the German Bight. The reason for this is the migration from the sampling area mentioned above. At the time of the survey the commercial fleet had left that area for months and was fishing in the deeper parts of the western North Sea. The low catches during this survey suggest that the abundance index does not reflect the true strength of the yearclasses and must therefore not be used in future for estimating recruitment.
Because the yearclass 1978 was reduced so considerably during its first winter, estimates of this yearclass made before the winter, must also not be used for predicting recruitment.

DE VEEN (1978) calculated indices for I-group and II-group and I + II-group fish combined. We did not follow this procedure because the April I-group shows no significant correlation with VPA and from a statistical point of view samples of I- and both II-groups are not from the same population.

As "Tridens" surveys can provide now 3 independent estimates of the strength of a yearclass via the regression lines, it is preferable to average the estimates instead of having one estimate of a combined index.

Estimates of the recruiting yearsclasses 1977 and 1978 at 2 years of age can now be made using the regression equations. For the yearclass 1977 2 estimates can be made, one based on the I-group regression and one on the September/October II-group regression. The April II-group value is not valid because the April 1979 survey was held just after the severe winter 1978-1979, when circumstances were abnormal. The estimates for this yearclass are resp. 73 and 57 million 2 year old recruits with a mean of 65 million. The average recruitment of the yearclasses 1968 to 1976 according the VPA is 86 million 2 year old recruits. On basis of the surveys the estimate of this yearclass is 25% below average. For the yearclass 1978 also 2 estimates can be made, one from the I-group regression and one of the April II-group regression. For this yearclass the estimates are

42 and 37 million 2 year old recruits with a mean of 40 million. This yearclass therefore seems to be 54% below average.

Summary

Yearclass strength indices of 0-, I- and II-group sole from prerecruit surveys between 1968 and 1980 in the continental coastal part of the North Sea from Scheveningen to Esbjerg are analysed and compared with VPA estimates of 2 year old recruits by means of regression analysis. The correlations between the 0-group index and VPA and April I-group index and VPA are not significant. The correlations between September/October I-group, April II-group and September/October II-group indices and VPA are significant at the 95% level.
Restrictions for the use of the estimated regressions for predictive purposes are discussed.
Estimates of the yearclasses 1977 and 1978 at the age of 2 year from the regressions suggest that these yearclasses are 25% respectively 54% below the average of the yearclasses 1968-1976.

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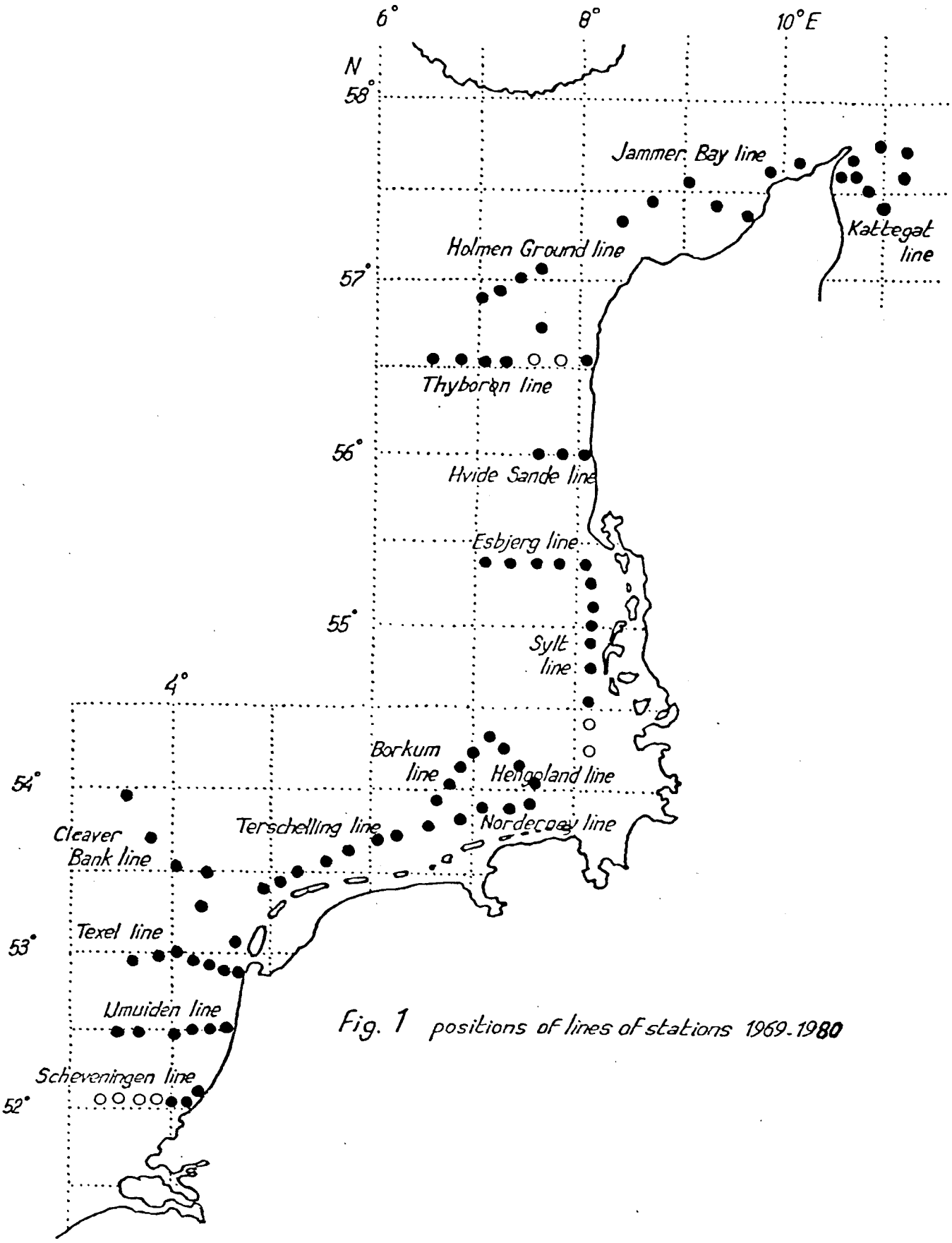
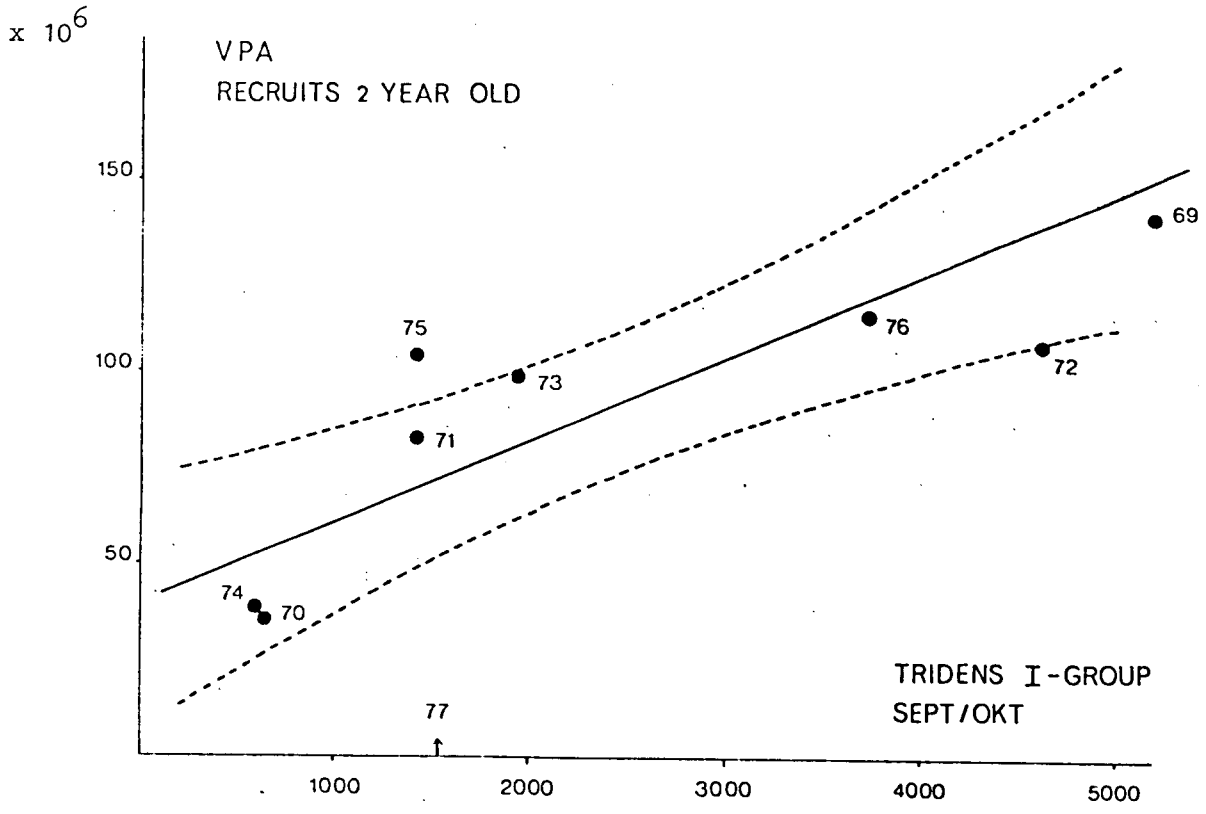
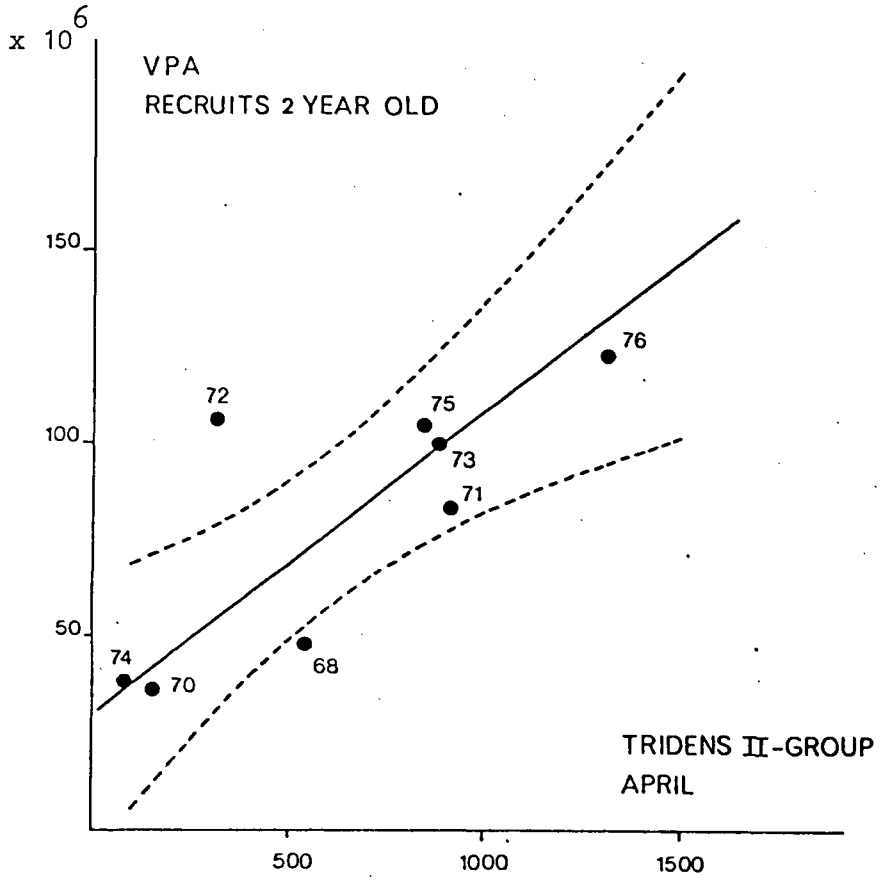


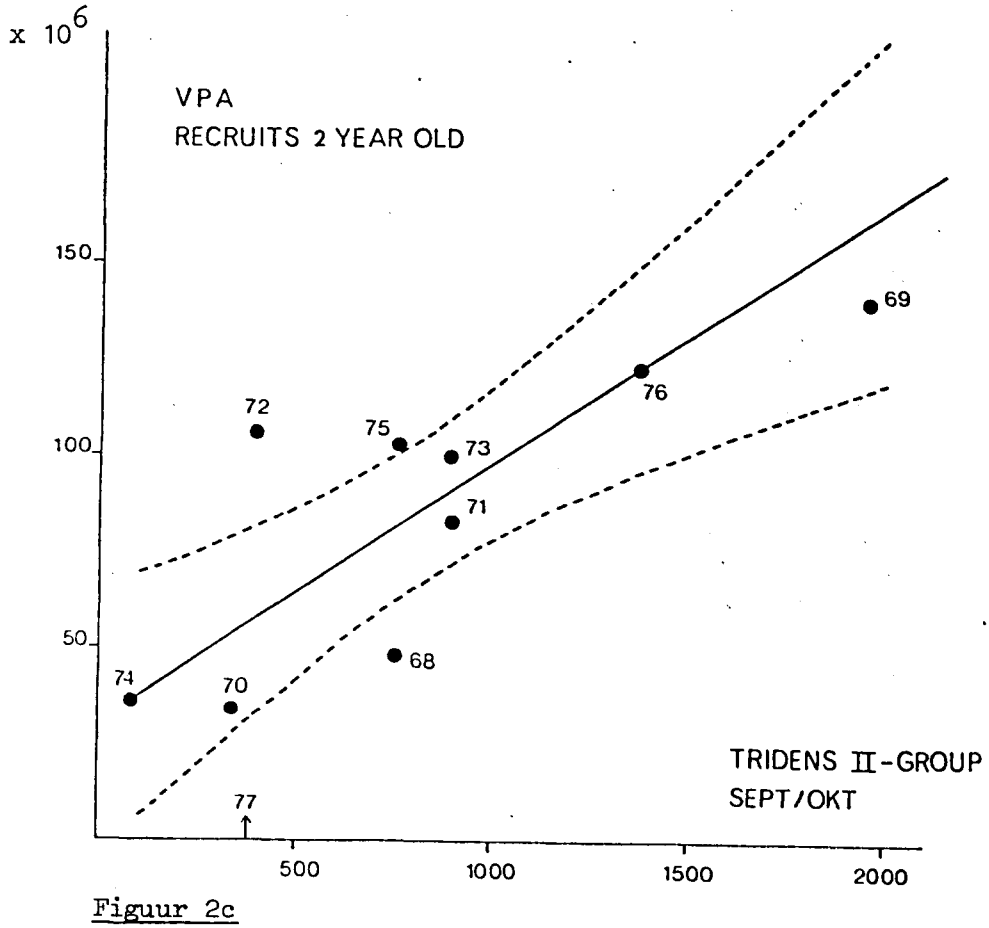
Fig. 1 positions of lines of stations 1969-1980


x 10^6
VPA
RECRUITS 2 YEAR OLD
150
100
50
75
73
71
74
70
77
69
76
72
TRIDENS I-GROUP
SEPT/OKT
1000
2000
3000
4000
5000

Figuur 2a



Figuur 2b



Figuur 2c

TABLE I - NORTH SEA SOLE "TRIDENS"-LINES (CATCH IN NUMBERS PER 100 FISHING HOURS).

Table 1a

0-group September/Oktober survey

Lines \ yearclass	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Scheveningen	200	48000	0	3500	0	0	1869	0	92798	19066
IJmuiden	6300	13667	0	3467	1133	199	865	0	1371	7667
Texel	0	67	0	1300	0	89	439	0	3480	1067
Claeverbank	0	0	0	0	0	0	0	0	0	0
Terschelling	133	0	0	0	215	0	400	3943	600	1120
Borkum	0	0	0	0	0	1120	0	0	0	400
Helgoland	0	0	0	0	0	2900	0	5200	0	0
Norderney	0	0	0	0	0	720	80	1080	160	640
Sylt	57	1533	240	200	50	550	400	3840	6880	9120
Esbjerg	0	0	0	0	0	67	0	2133	0	0
Mean	669	6327	24	847	140	565	475	1620	10529	3908
Numbers of lines fished	10	10	10	10	10	10	10	10	10	10

TABLE 1b

I-group April survey

Lines yearclass	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Scheveningen	1200		160			133	0	1867	0	266	2935
IJmuiden	3486		171	0		0	0	1800	0	67	200
Texel	133		57	0	80	0	57	266	44	0	398
Claeverbank	0		398		0	0	0	0	0	1500	1200
Terschelling			160	0	80	0	0	640	40	0	44
Borkum	800				200	0	320	267	0	0	0
Helgoland	400		1200		200	0	0	400	401	0	533
Norderney			300	0	266	0	133	0	0	0	80
Sylt	480		200	67	267	0	313	160	2160	0	4880
Esbjerg	0		0		0	0		0	67	0	0
Mean	812		294	13	137	13	91	540	271	183	1027
Numbers of lines fished	8	0	9	5	8	10	9	10	10	10	10

TABLE 1c

I-group Sept./Okt. survey

Scheveningen	4400	0	800	0	1601	266	1199	3267	0	266
IJmuiden	10756	423	501	402	2201	368	1533	4534	57	67
Texel	7516	633	915	1550	3650	665	500	3398	320	89
Claeverbank	227	200	100	540	100	665	0	1200	0	0
Terschelling	9800	1283	1520	2374	2651	750	2320	7386	1040	60
Borkum	931	0	925	1200	4340	1152	2398	1200	2533	400
Helgoland	5226	400	2700	8200	1900	1187	1900	5667	3202	0
Norderney	7250	2260	1505	9500	2800	400	2240	7160	160	0
Sylt	2810	868	4000	22134	0	250	240	640	1200	160
Esbjerg	467	67	933	955	0	267	1800	2788	7003	0
Mean	4938	613	1410	4686	1924	597	1413	3724	1552	104
Numbers of lines fished	10	10	10	10	10	10	10	10	10	10

TABLE 1d

II-group April survey

Lines \ yearclass	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Scheveningen	2100		160			6001	0	1732	5895	133	267
IJmuiden	1027		228	569		600	0	533	800	67	134
Texel	133		171	1626	160	286	57	378	1182	0	22
Cleaverbank	200		133		399	0	0	0	700	0	100
Terschelling			400	533	320	243	114	560	746	112	44
Borkum	533				400	320	560	800	534	0	0
Helgoland	80		160		200	500	0	1065	1821	266	266
Norderney			100	453	933	608	0	1680	880	0	80
Sylt	307		0	1366	0	150	29	1440	480	0	80
Esbjerg	0		0		67	134		267	67	0	0
Mean	548		150	909	310	884	84	846	1311	58	99
Numbers of lines fished	8	0	9	5	8	10	9	10	10	10	10

TABLE 1e

II-group Sept./Okt. survey

Scheveningen	200	600	133	0	0	933	0	133	1689	0
IJmuiden	1145	3730	171	334	334	567	0	468	942	0
Texel	467	1433	200	642	500	221	0	319	1616	0
Cleaverbank	272	703	0	460	600	228	0	0	500	0
Terschelling	0	2382	1600	506	89	200	80	613	680	407
Borkum	657	2533	791	1800	1073	3034	395	200	2105	924
Helgoland	1832	3467	400	2033	1150	2763	233	1000	2444	800
Norderney	1925	4190	50	100	160	560	80	1320	80	760
Sylt	112	335	0	200	0	50	0	320	160	320
Esbjerg	837	234	67	2979	67	312	0	3247	3571	667
Mean	745	1961	341	905	397	887	79	762	1379	388

TABLE II - NORTH SEA SOLE "TRIDENS"-CATCH PER 100 FISHING HOURS VPA 1980.

YEARCLASS	SEPT/OKT 0-gr.	APRIL I-gr.	SEPT/OKT I-gr.	APRIL II-gr.	SEPT/OKT II-gr.	VPA 1980 2 year old recruits males and females
1968				548	745	47889
1969		812 x	4938	- x	1961	140223
1970	669	- x	613	150	341	35639
1971	6327	294	1410	909	905	83799
1972	24	13	4686	310	397	106053
1973	847	137	1924	884	887	99370
1974	140	13	597	84	79	37603
1975	565	91	1413	846	762	104792
1976	475	540	3724	1311	1379	122070
1977	1620	271	1552	58 xx	388	
1978	10529 xx	183 xx	104	99		
1979	3908	1027				

x no April survey in 1971

xx should not be used for calculations in future

Table III - Geometric regression equations and correlation coefficients.

Type of regression	Equation	Correlation coefficient
1. "Tridens 0-group Sept./Okt. c.p.u.e. in numbers (x_1). VPA age 2 stock numbers (y_1).		r = 0.0033 n = 7 N.S.
2. "Tridens" I-group April c.p.u.e. in numbers (x_2). VPA age 2 stock numbers (y_1).		r = 0.6977 n = 7 N.S.
3. "Tridens" I-group Sept/Okt. c.p.u.e. in numbers (x_3). VPA age 2 stock numbers (y_1).	$y = 40203 + 21.13\ x_3$	r = 0.8269 n = 8 $p<0.05$
4. "Tridens" II-group April c.p.u.e. in numbers (x_4). VPA age 2 stock numbers (y_1).	$y = 29263 + 79.95\ x_4$	r = 0.7631 n = 8 $p<0.05$
5. "Tridens" II-group Sept/Okt. c.p.u.e. in numbers (x_5). VPA age 2 stock numbers (y_1).	$y = 31176 + 66.64\ x_5$	r = 0.7873 n = 9 $p<0.05$

TABLE IV - CORRELATIONS COEFFICIENTS.

Type of regression		Correlation coefficient
6. "Tridens" I-group Sept/Okt. c.p.u.e. in numbers (x_3). "Tridens" II-group April c.p.u.e. in numbers (x_4).		$r = 0.4466$ $n = 8$ N.S.
7. "Tridens" I-group Sept/Okt. c.p.u.e. in numbers (x_3). "Tridens" II-group Sept/Okt. c.p.u.e. in numbers (x_5).		$r = 0.6494$ $n = 9$ N.S.
8. "Tridens" II-group April c.p.u.e. in numbers (x_4). "Tridens" II-group Sept/Okt. c.p.u.e. in numbers (x_5).		$r = 0.9734$ $n = 8$ $p<0.01$