DFO Atlantic Fisheries
Research Document 95/114

MPO Pêches de l'Atlantique
Document de recherche 95/114

Correspondence Analysis of Length Frequencies of Cod Samples from 4T, 4Vn, and 4Vs

GA Nielsen, AF Sinclair
Science Branch
Gulf Region
Department of Fisheries and Oceans
P.O. Box 5030
Moncton, N.B. E1C 9B6

ABSTRACT

Length frequency samples collected from commercial landings of cod in NAFO Divisions and Subdivisions 4T, 4Vn, and 4Vs from 1988 to 1992 by port samplers and observers at sea were analyzed by correspondence analysis. Preliminary results indicate that fish originating in 4T are sometimes found in 4Vn and 4Vs in November and December, as well as the winter months.

RÉSUMÉ

Des échantillons de fréquence de longueurs prélevés par des échantillonneurs à quai et des observateurs en mer parmi les débarquements commerciaux de morue des divisions et subdivisions 4T, 4Vn et 4Vs de l'OPANO de 1988 à 1992 ont fait l'objet d'une analyse des correspondances. Les résultats préliminaires révèlent que du poisson originaire de 4T est parfois présent dans 4Vn et dans 4Vs en novembre et en décembre, ainsi que durant l'hiver.

INTRODUCTION

Cod in the southern Gulf of St. Lawrence (NAFO Division 4T) migrate out of the Gulf into 4Vn and 4Vs in the fall, returning to 4T in the spring. Examination of the length frequencies of samples taken in the 4Vn and 4Vs fisheries during the winter months may give information on the timing of the 4T migration and/or the amount of 4T cod in the 4Vn and 4Vs catches.

We wanted to see if correspondence analysis would be useful in classifying the length frequency samples with respect to their similarities and dissimilarities. Correspondence analysis can be used to analyze any rectangular table of data, finding a low-dimensional graphical representation of the 'correspondence' among rows and columns of a table. It is a weighted principal components analysis which represents the row and column profiles as points in Euclidean space. A good description of the method is given in Greenacre, 1984. Correspondence analysis is used here to try to determine the association among samples taken in 4T, 4Vn, and 4Vs during different months in the year. The question is whether or not this kind of analysis can be used to indicate when cod samples taken in 4Vn and 4Vs contain 4T cod.

METHODS

Data were available from Gulf and Scotia Fundy Observer Programmes and Gulf and Scotia Fundy Commercial Sampling Programmes. Gulf 1991 and 1992 Observer data were available, Scotia Fundy 1988 to 1992 Observer data were available, Gulf Commercial sampling data from 1984 to 1993 were available, and Scotia Fundy 1977-1990 Commercial sampling data were available. Samples were reformatted to produce one record/length frequency. Because Scotia Fundy commercial sampling data were recorded in 3 centimetre groupings, analysis of commercial data was limited to these intervals; observer samples were analyzed in 1 centimetre intervals.

The data consist of individual trawl samples with cod as main species; samples with few fish (<50) were excluded. In the case of Observer samples, only samples recorded as 'total catch' were used; in the commercial data, samples from separate categories were added together to create one sample for the catch. Lengths at the extremes of the length frequency distributions were combined into groups to lessen the effect of these lengths on the results. Because the shape of the length frequencies themselves were of interest, the data were converted to proportions of catch at length, resulting in equal weighting of samples in the analysis.

The data matrix, therefore, consisted of rows corresponding to samples or sets and columns corresponding to proportion of total fish sampled at each length.

The analyses were exploratory. First we looked at the amount of separation between samples from different areas when we felt the stocks were well separated. Cod in 4T, 4Vn, and 4Vs are assumed to be geographically separate in the fall months; to test the ability of correspondence analysis to differentiate the samples, we analyzed October or November of each year. Then we checked for similarity when we felt the stocks may be mixing. To see if 4Vs winter samples resemble 4T samples, they were compared to 4T fall samples since there was no fishing in 4T in January-March during these years. Finally, we examined the results of a correspondence analysis using all samples for a two year period (1991-1992) to see if anything could be learned by putting everything together for a common scaling factor. SAS was used for the analysis (PROC CORRESP).

RESULTS

Samples from 1988 to 1992 were used in the analysis, however the difference in commercial and observer programme samples (landings and catches, respectively) caused a discontinuity between 1990 and 1991. The number of samples in some of the categories (NAFO Division-month cells) was small or non-existent, causing some problems for comparisons (Table 1).

In 1988, 1989, and 1991, 4T and 4Vs fall samples appear to be separate, with very little overlap, and 4Vn overlaps them both (Figure 1-5). Between 69% and 83% of the total inertia (analogous to variability) in the samples was explained by the first two principal axes (Table 2). Samples for 1991 and 1992 are summed by day before analysis, to simplify the graphs; there was some increase in total inertia, but not much difference in the results when indivdual samples were used. In general, 4T samples tend to be associated with fish of smaller lengths, while 4Vn and 4Vs samples tend to be associated with fish of larger lengths.

The results of correspondence analyses of data sets combining January or February 4Vn and 4Vs samples with the October or November samples are shown in Figures 6-8. In January, 1989, samples from 4Vn overlap the 4T samples, while those from 4Vs overlap both 4Vs and 4T November samples. In February, 1989, both the 4Vn and 4Vs samples have moved away from 4T samples. In 1990, both January and February 4Vn samples overlap 4T samples, but 4Vs samples don't approach those from 4T until February. Both January and February 1992 4Vn and 4Vs samples overlap 4T October 1991 samples. Many samples from 4Vn in February are very similar to those from 4Vs in October.

Combining all data for 1991 and 1992 into one data matrix for correspondence analysis results in a common scaling of all the area-month categories, for direct comparison. The results of such an analysis are shown in Figure 9. It is obvious from this analysis that samples from 4T are at all times of the year associated with smaller fish than those from either 4Vn or 4Vs. Samples from these two Divisions appear in the '4T space' especially in January and February, but also to some extent in the fall and even in the summer.

DISCUSSION

Correspondence analysis classifies the length frequency samples of catches in 4T, 4Vn, and 4Vs consistent with the notion that the three stocks are separate during part of the year, but that in late fall/winter, 4T cod move into 4Vn and 4Vs. Good separation of the samples in the first two dimensions of Euclidean space indicates that they are different with respect to the shapes of their length frequencies.

Cod from different areas may have similar length frequencies but different growth rates. Perhaps an analysis of numbers at age in the samples rather than numbers at length would be informative.

On average, mesh sizes used in the 4T fishery were smaller than mesh sizes used in the 4Vn and 4Vs fisheries. Mesh sizes recorded in the observer samples for 4T were mostly between 130mm-140mm, for 4Vn were between 130mm-150mm, and mesh sizes for 4Vs ranged primarily from 140mm-155mm. To see how much effect this had on the separation of samples on the first principal axis, we regressed the dimension 1 co-ordinate from the 1991-1992 combined analysis on recorded meshsize. There is a significant relationship between mesh size and co-ordinate on the first axis ($P>0.0001$) with a difference in the co-ordinate of 0.7 from mesh size 130mm to 145mm. Thus, although some of the separation of samples may be explained by mesh size differences, it is interesting to speculate about effect of mesh sizes when the distributions overlap.

Mesh sizes, growth rates, recruitment, and mortality rates presumably all combine to help create

differentiable length frequencies. Results given here are preliminary; these and other variables such as location of a sample within an area (proximity to a neighboring Division), and actual sampling date within a month, are factors which could be examined with respect to the correspondence analysis results. The small numbers of samples in some of the categories as well as the empty cells create difficulties for more detailed analysis; simulation studies may be useful for exploring some of the effects of some of these variables.

ACKNOWLEDGEMENTS

The authors thank Jacques Allard, Ross Claytor, and Marc Dionne for their useful comments and suggestions.

REFERENCES

Greenacre, Michael. 1984, Theory and applications of correspondence analysis. Academic Press Inc., London, Eng.

SAS Instutute Inc. 1990. SAS/STAT Usser's Guide Volume 1, ANOVA-FREQ, Version 6, 4th Edition, Cary, N.C. USA.

Table 1. Number of cod length frequency samples in 4T, 4Vn, and 4Vs
(trawl samples with main species cod)
1988-1990 are from the Commercial Sampling Programme
1991-1992 are from the Observer Programmes

Year	Div	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1988	4T	1			11	27	1	4	12	19	9	17	1
	4Vn	9	4	3	1	3		1		1		2	1
	4Vs	4	8	4	9	2	4	1	2	5	7	6	10
1989	4T				6	31	24	10	16	2	16	27	
	4Vn	14	3	1	5				1	1		1	5
	4Vs	4	3	6	8	2			5	4	2	11	11
1990	4T				3	19	16	11	13	6	22	24	2
	4Vn	10	26		1	2	1				2	5	2
	4Vs	9	18	12	4	1	1			2	5	6	3
1991	4T				2	9	68	58	22	53	43	120	18
	4Vn	78	84	13	6	4					2	2	1
	4Vs	21	70	30	30	2	3	9	15	29	39		
1992	4T					126	113	151	171	88	97	224	30
	4Vn	76	24	1	58	9			1	2	9	31	
	4Vs	51	17	8	18	7		22	5	3	16	34	40

Table 2. Total inertia and percentage accounted for by first two principal axes in fall samples.

Year	Month	Total inertia	first dimension	second dimension	Total
1988	November	.83193	65.75%	17.71%	83.46%
1989	November	.78473	53.82%	15.45%	69.27%
1990	November	.49827	61.52%	18.37%	79.89%
1991	October	.59776	55.38%	20.93%	76.21%
1992	November	.54590	56.62%	22.61%	79.23%

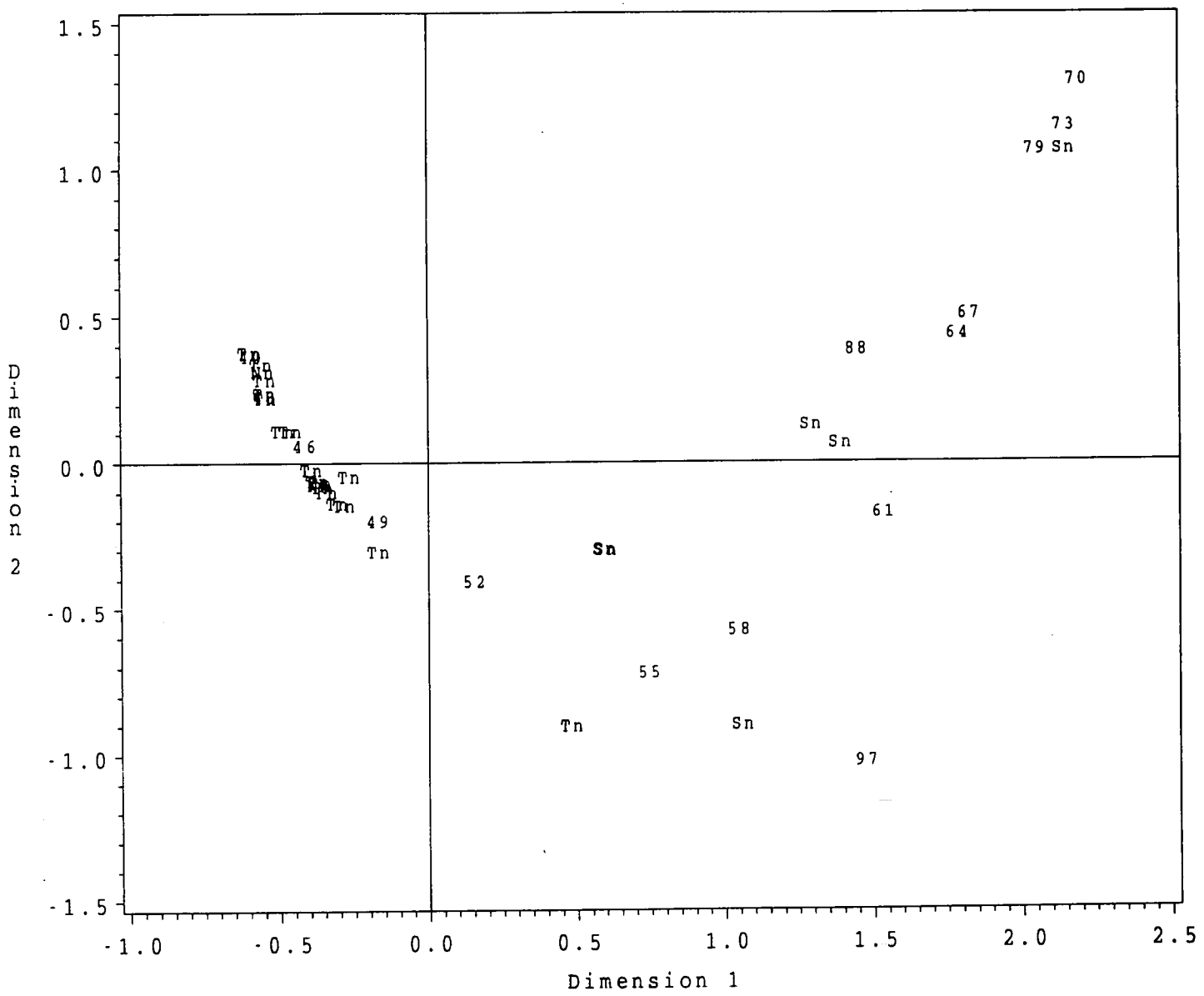


Figure 1. Length frequency samples from catches in November 1988
4T samples indicated by 'Tn'
4Vn samples indicated by 'Nn'
4Vs samples indicated by 'Sn'
Numbers in the graph refer to fish length

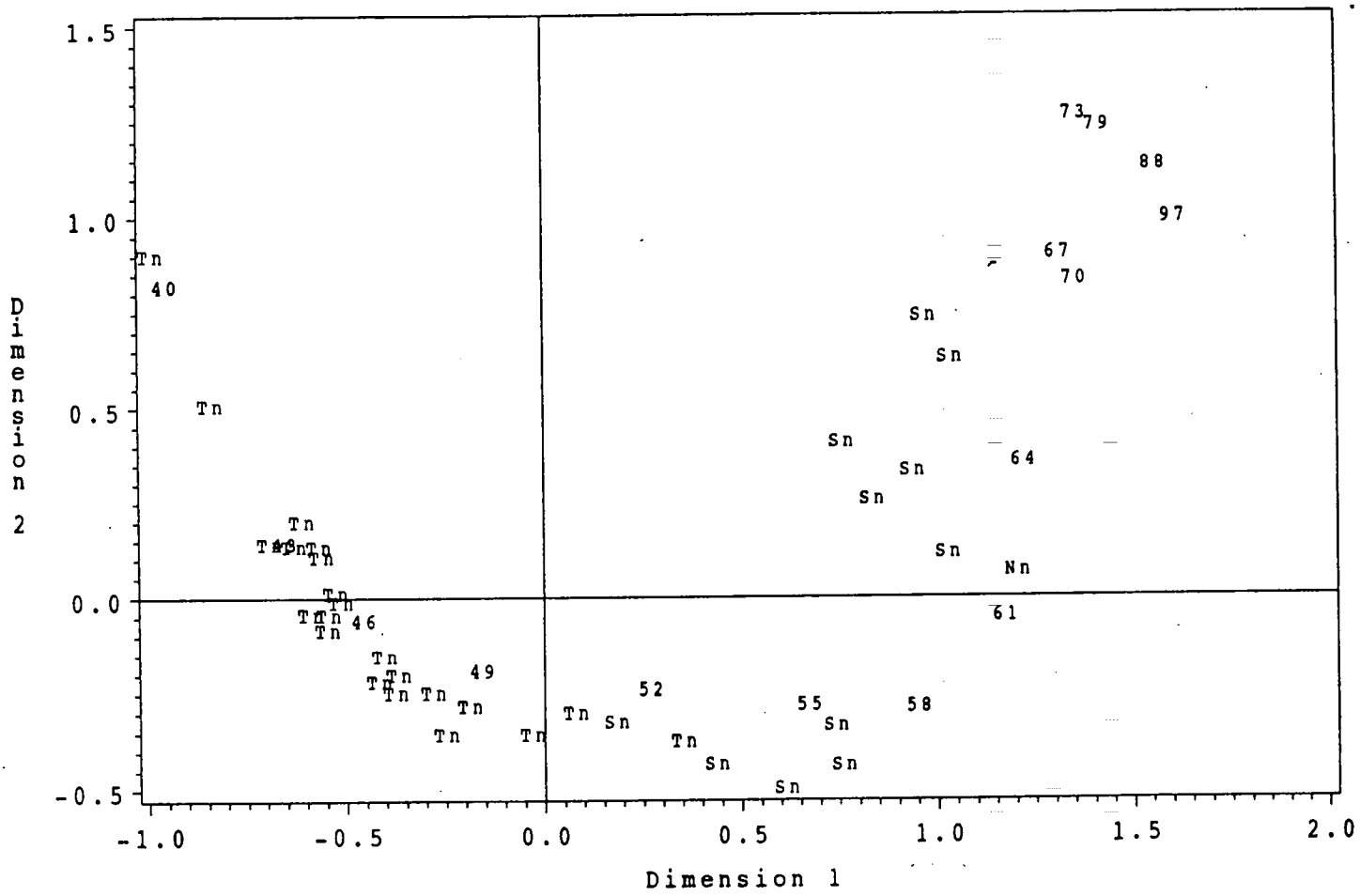


Figure 2. Length frequency samples from catches in November 1989

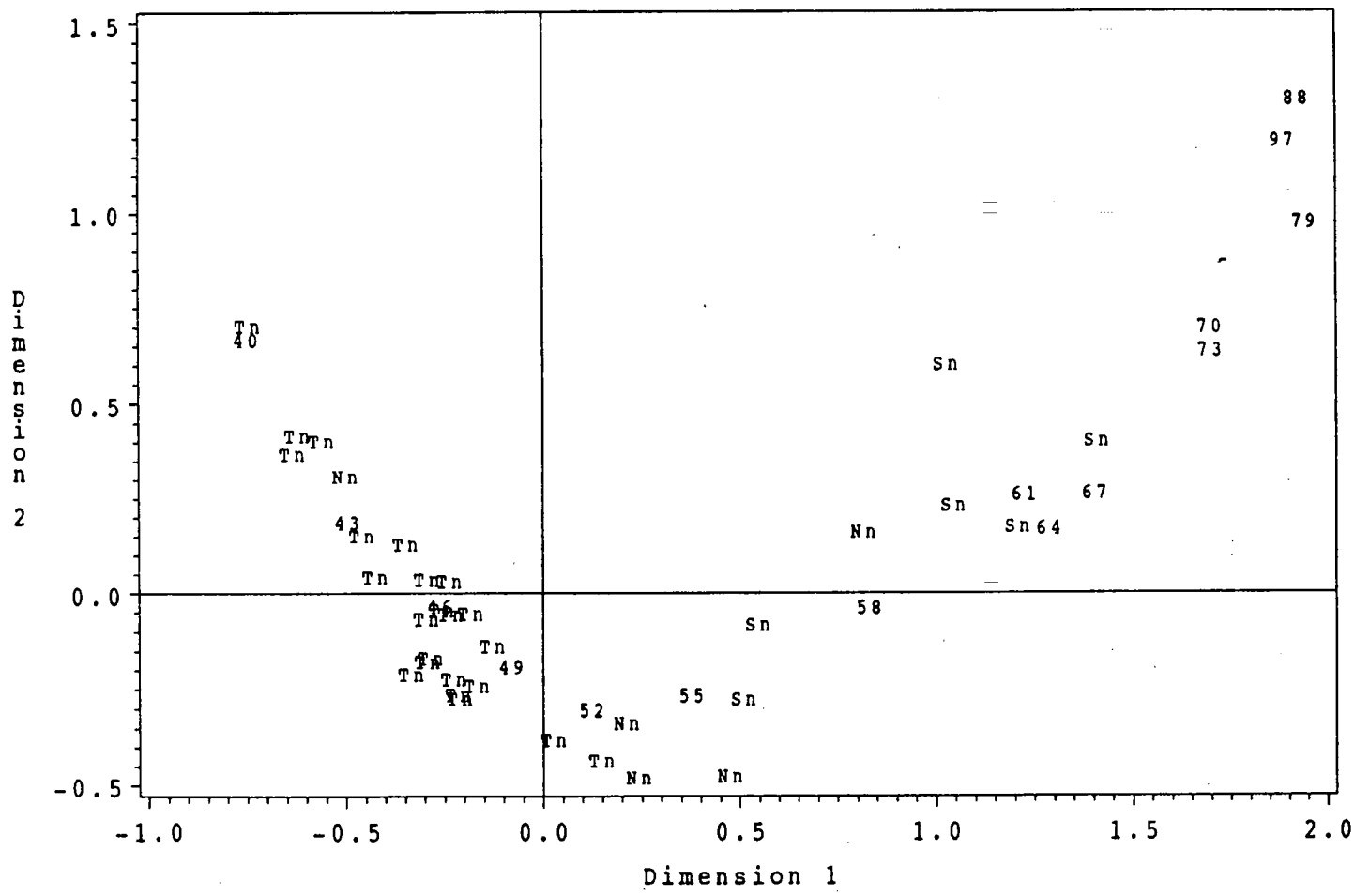


Figure 3. Length frequency samples from catches in November 1990

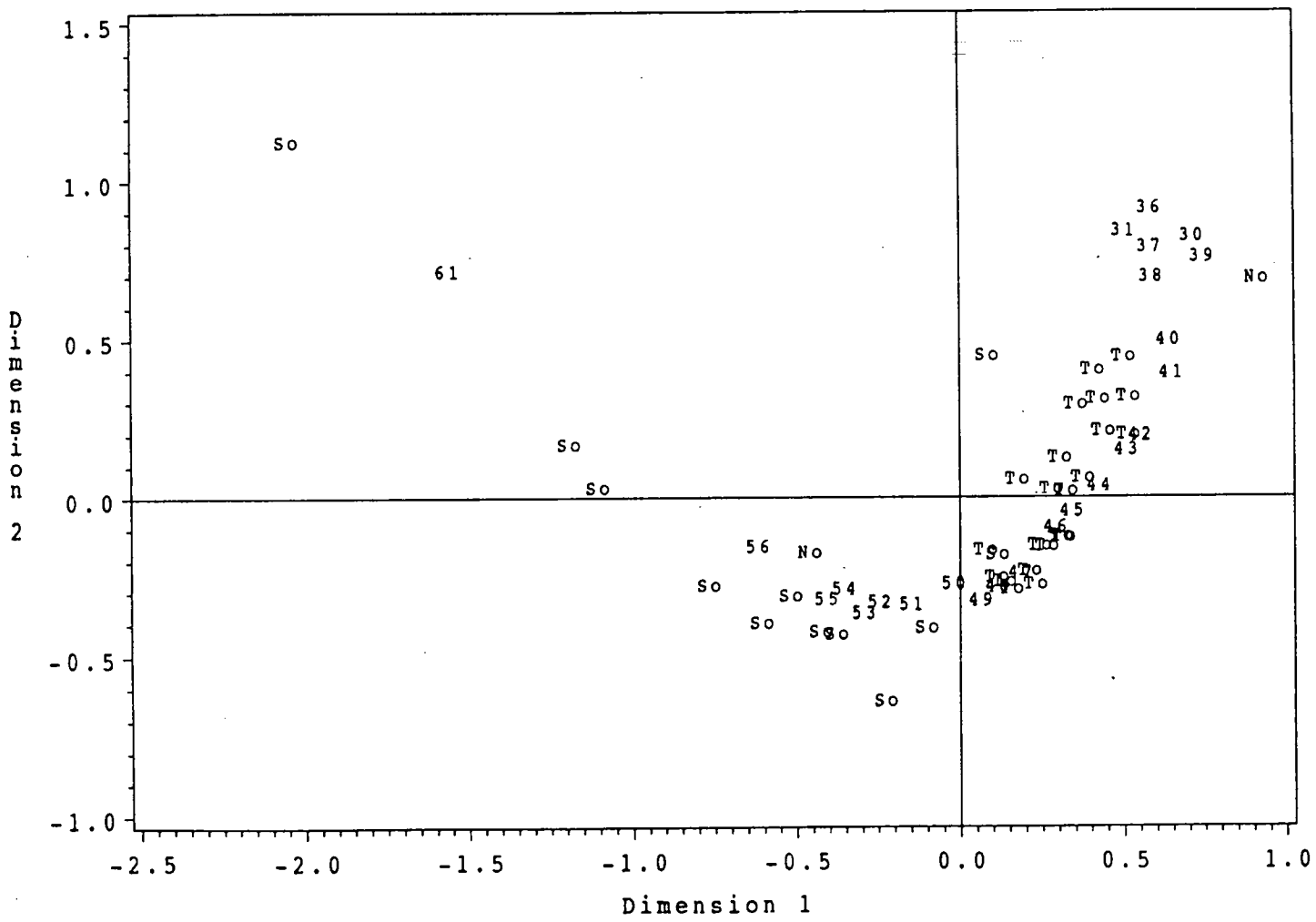


Figure 4. Length frequency samples from catches in October 1991

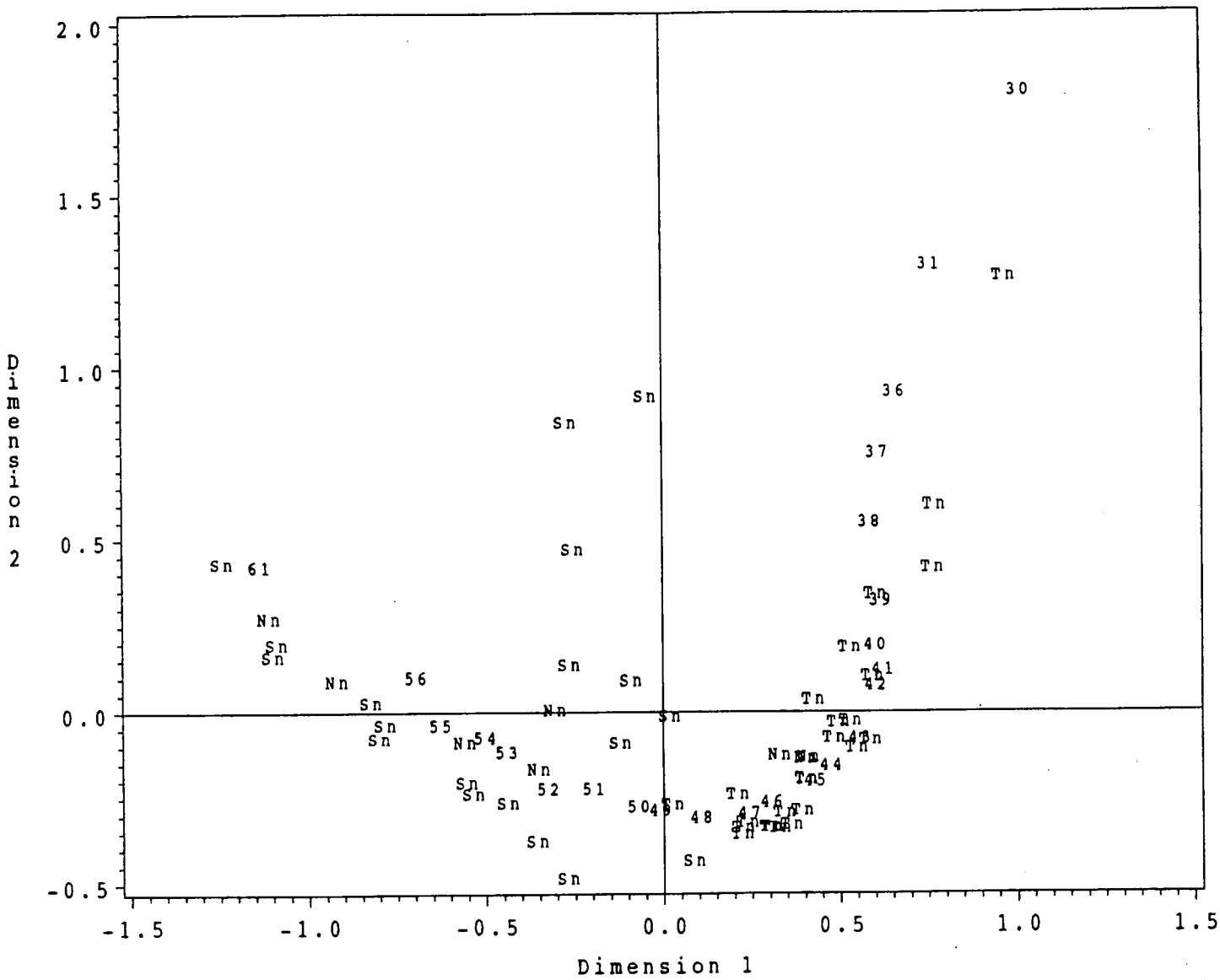
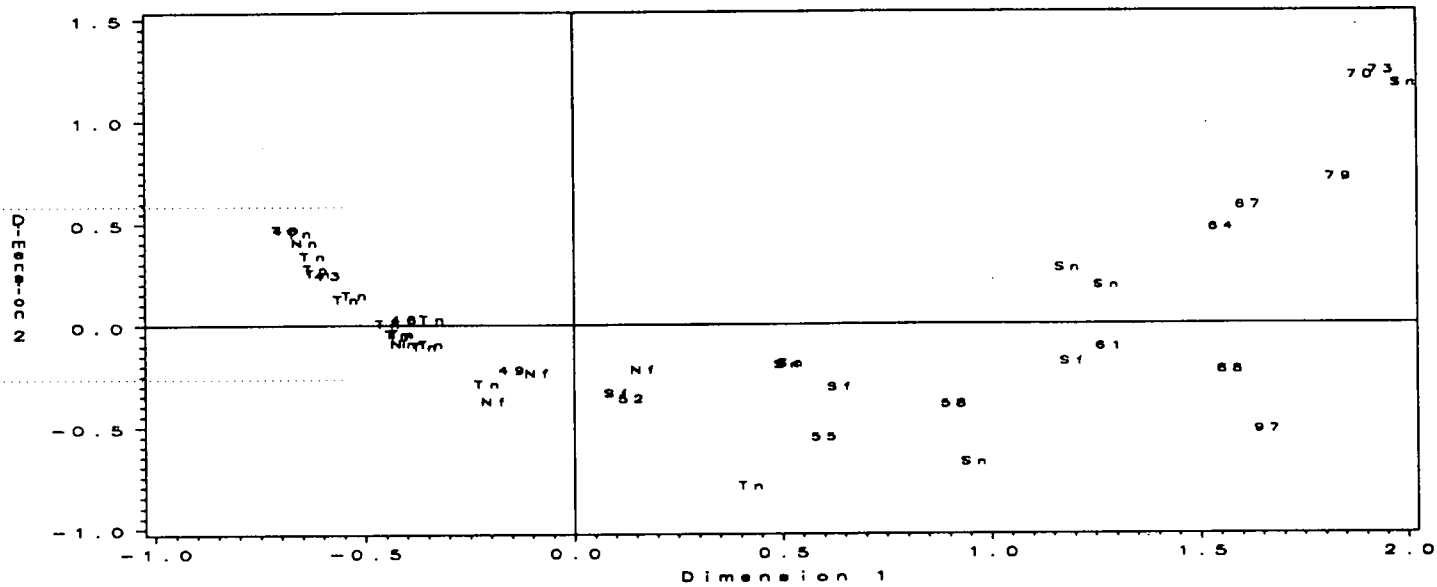


Figure 5. Length frequency samples from catches in November 1992

Nov 1988 and Feb 1989



Nov 1988 and Jan 1989

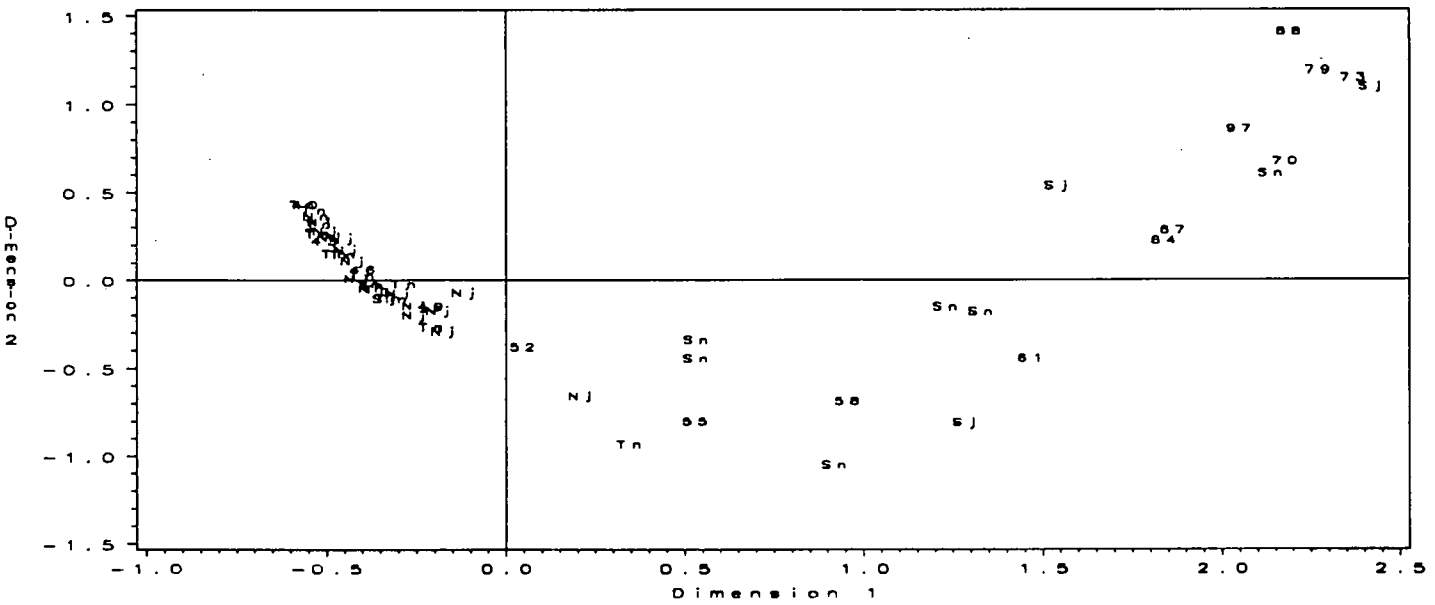


Figure 6. Length frequency samples from catches in Nov 1988, Jan 1989 and Feb 1989
Samples denoted by 'T', 'N', 'S' and 'n' for Nov, 'j' for Jan, 'f' for Feb

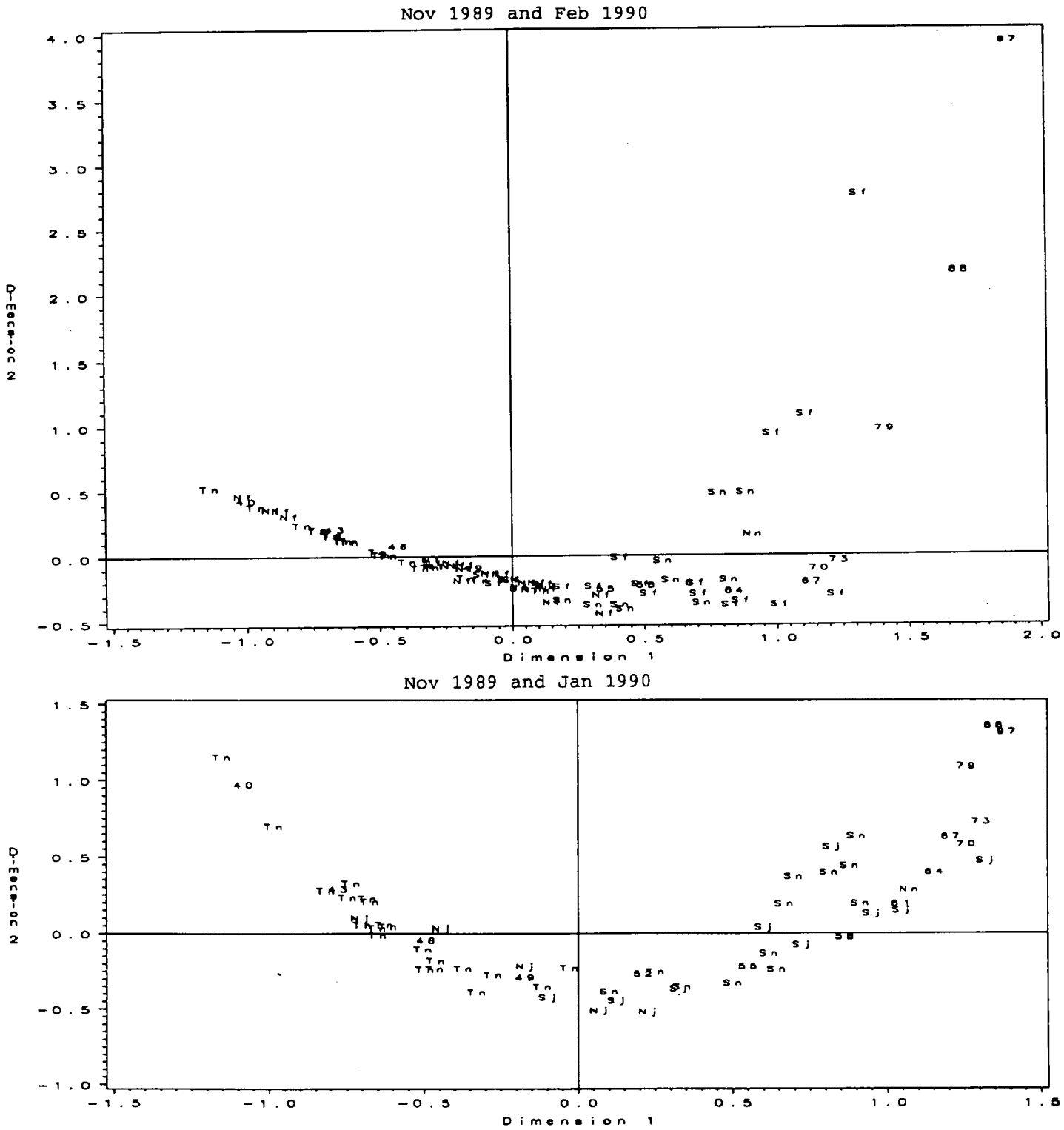
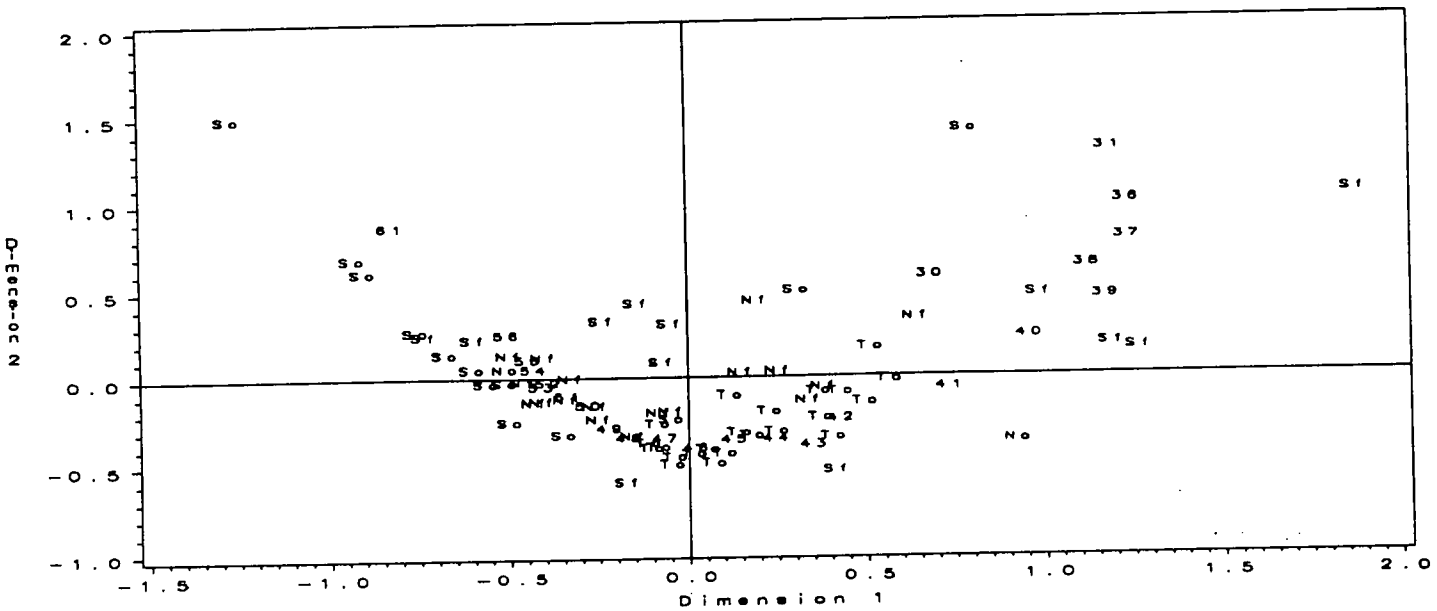


Figure 7. Length frequency samples from catches in Nov 1989, Jan 1989 and Feb 1989
Samples denoted by 'T', 'N', 'S' and 'n' for Nov, 'j' for Jan, 'f' for Feb

Oct 1991 and Feb 1992



Oct 1991 and Jan 1992

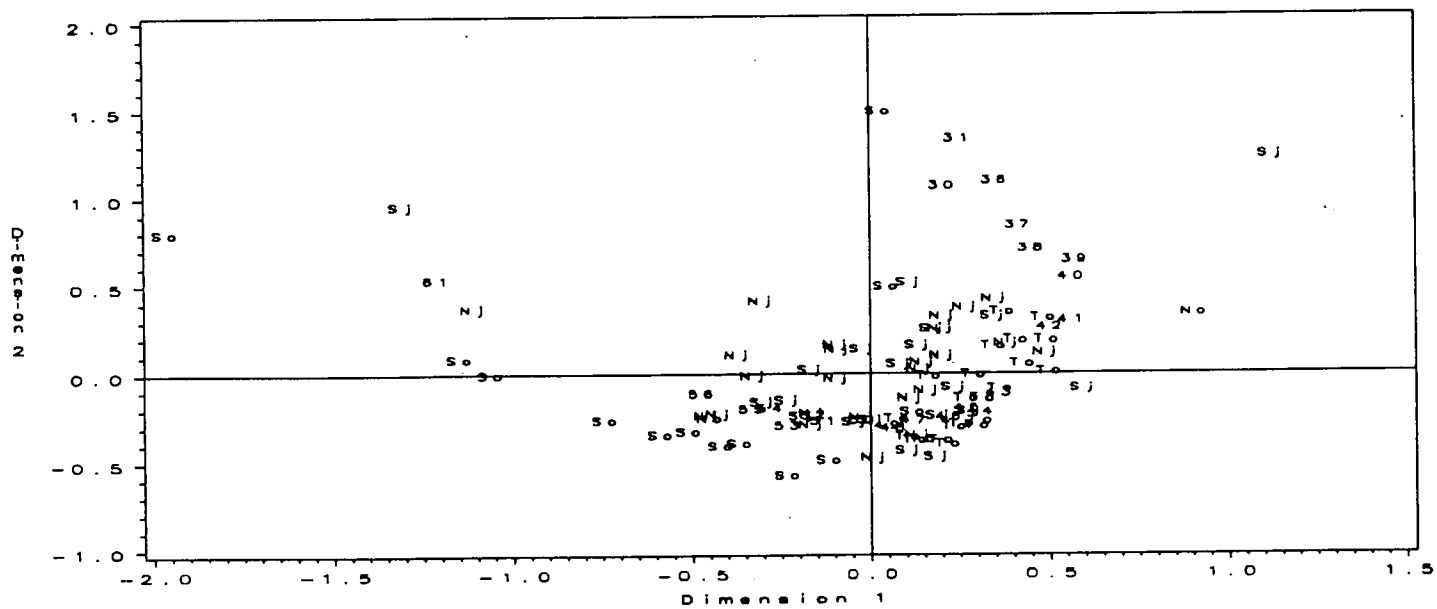


Figure 8. Length frequency samples from catches in Oct 1991, Jan 1992 and Feb 1992
Samples denoted by 'T', 'N', 'S' and 'o' for Oct, 'j' for Jan, 'f' for Feb

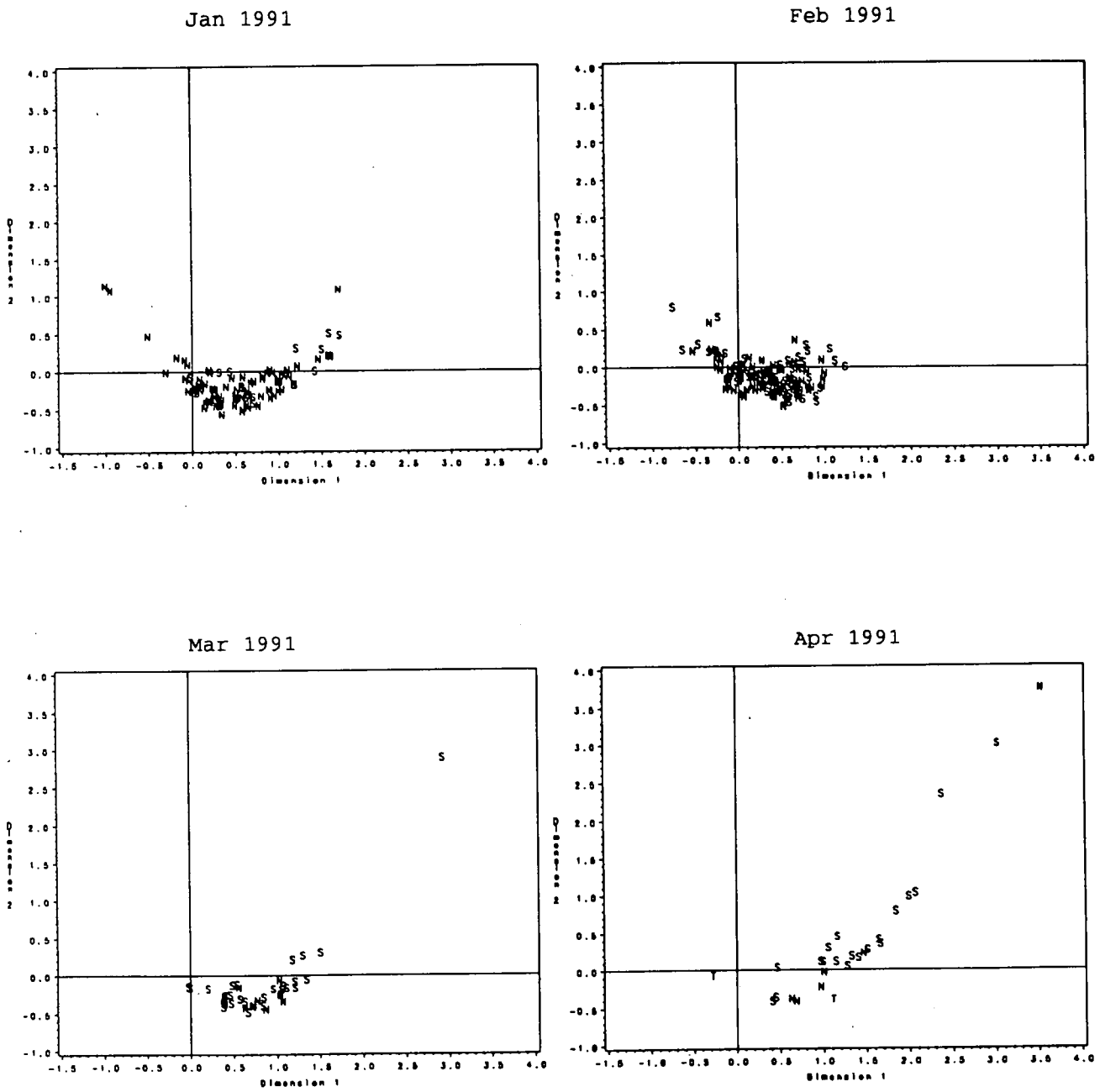
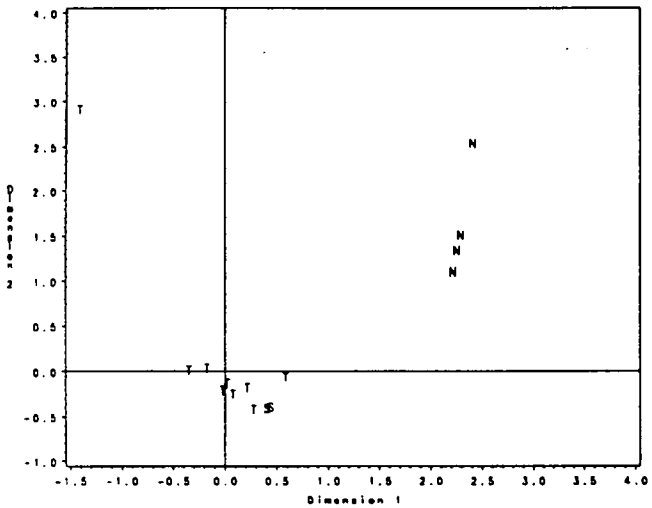
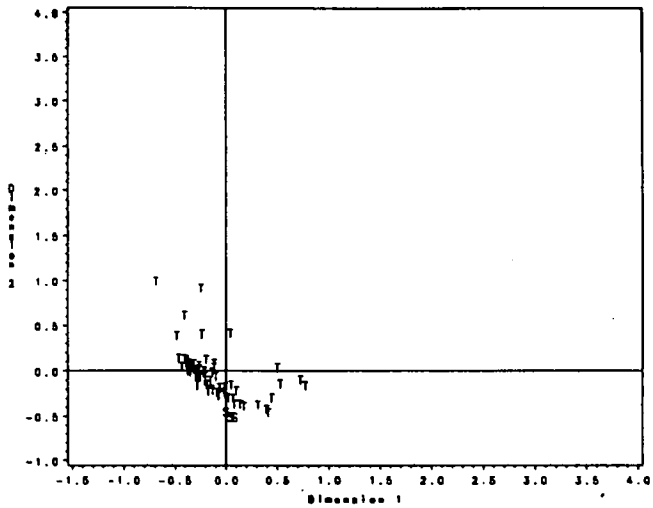


Figure 9. Length frequency samples for 1991 and 1992

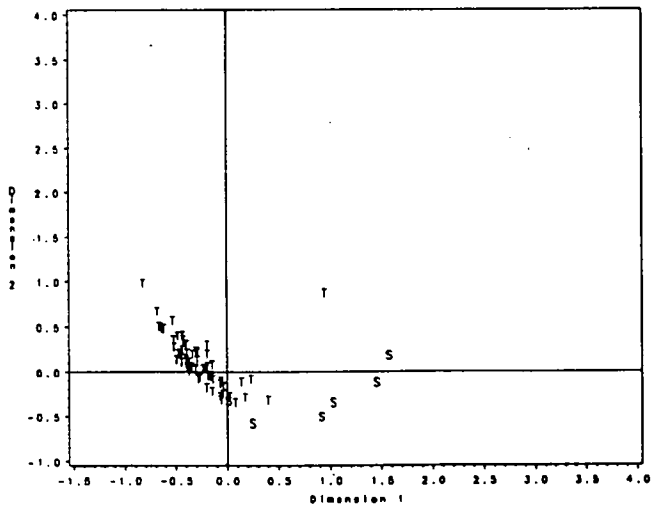
May 1991



Jun 1991



Jul 1991



Aug 1991

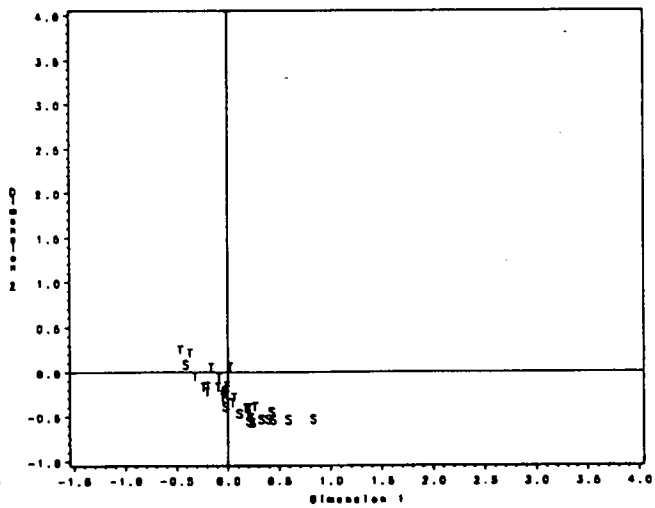


Figure 9. Length frequency samples for 1991 and 1992, cont'd

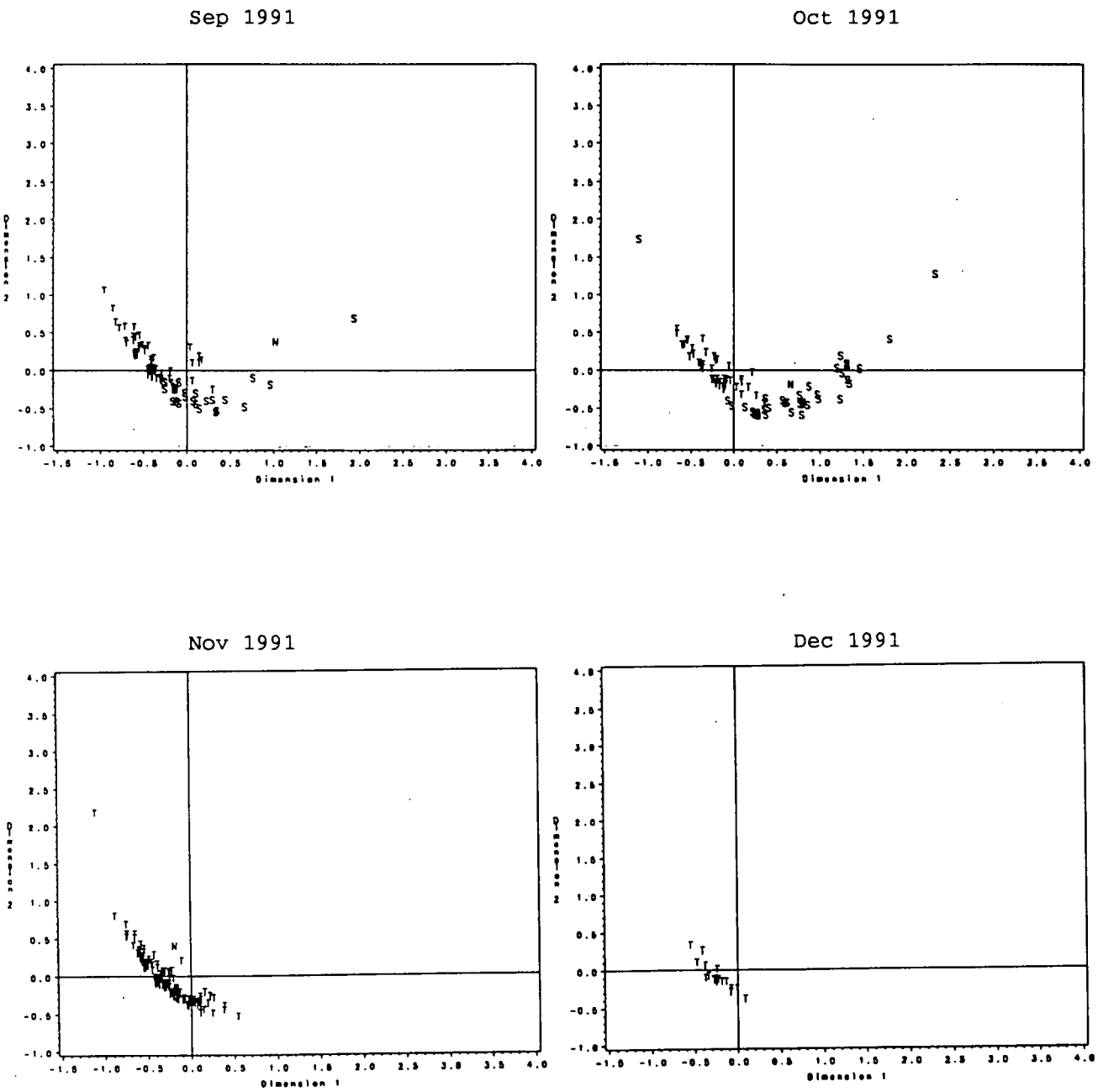


Figure 9. Length frequency samples for 1991 and 1992, cont'd

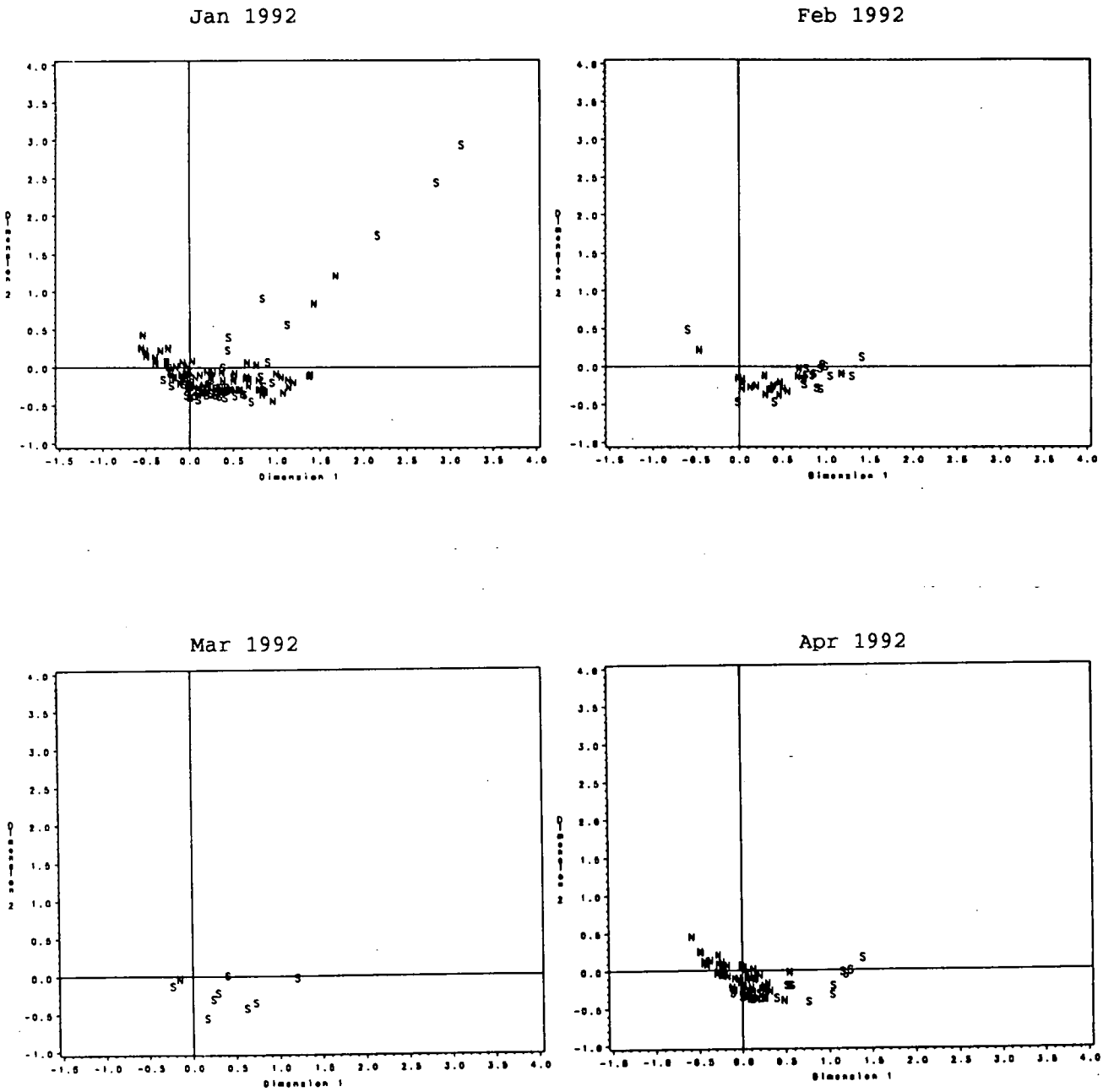


Figure 9. Length frequency samples for 1991 and 1992, cont'd

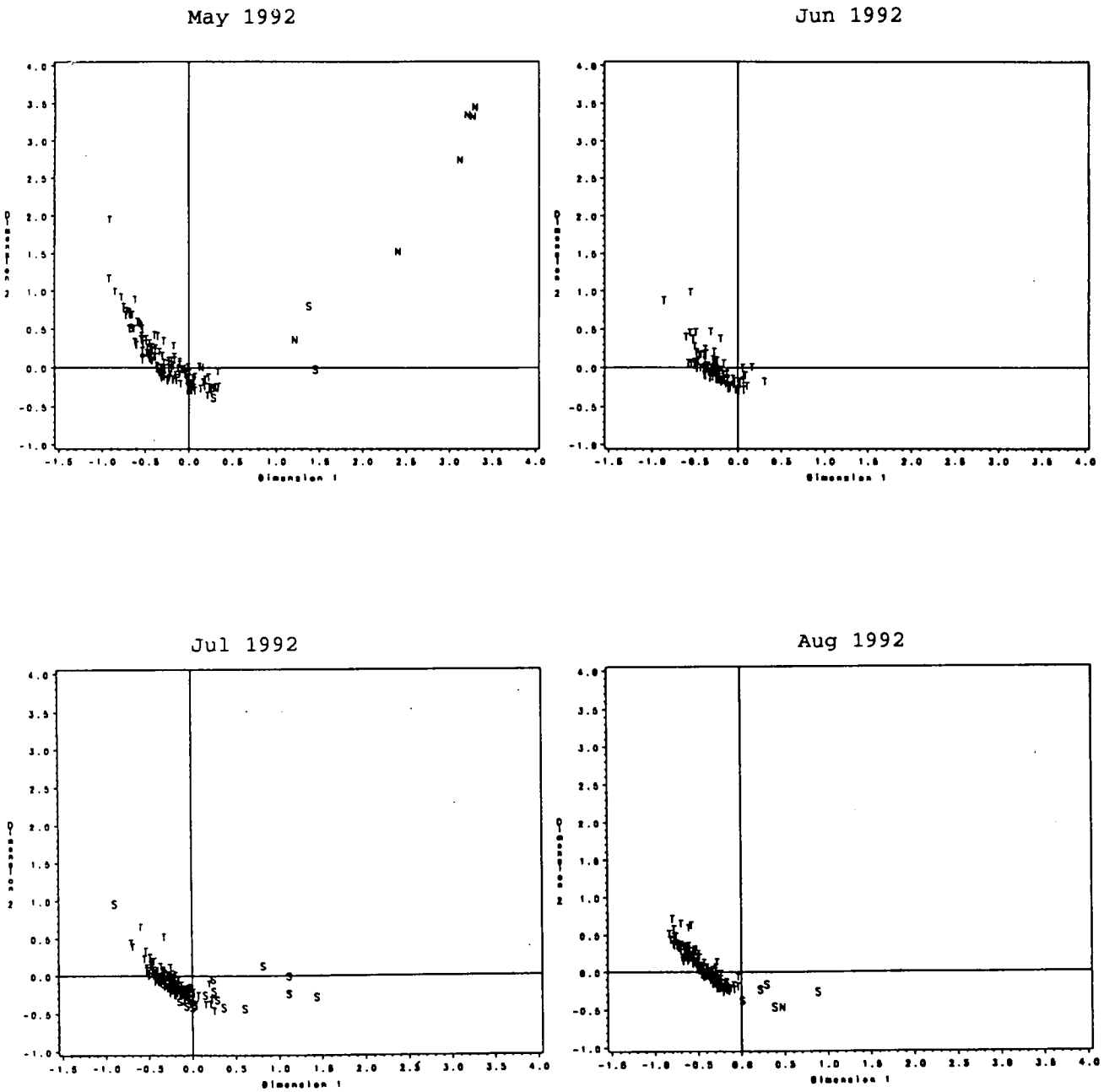


Figure 9. Length frequency samples for 1991 and 1992, cont'd

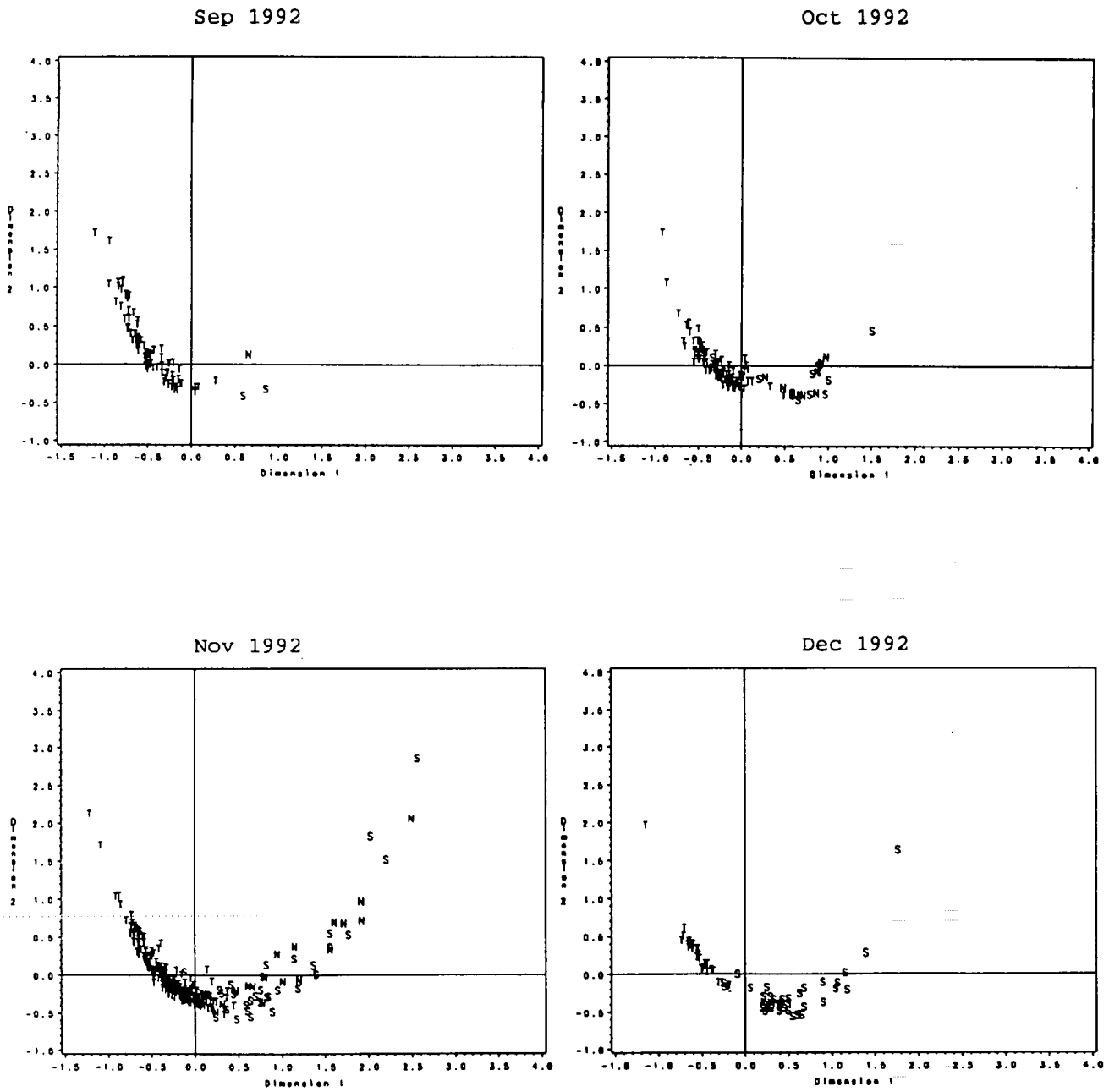


Figure 9. Length frequency samples for 1991 and 1992, cont'd