Part 2

Spatial distribution of the North Sea fish assemblages with special reference to the coastal and estuarine waters of the Netherlands

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CONTENTS

1 Introduction

In the past, various human activities have affected the coastal and estuarine waters of the Netherlands: fisheries, (micro-)pollution, eutrophication, hydraulic works, recreation, shipping and military activities. In order to protect the natural values of the marine ecosystem, the Dutch government developed a Nature Policy plan (Anonymous, 1989) in which the North Sea was considered to be a nature area. The Waddensea and estuaries were considered to be vital components for a proper functioning of the North Sea. Within the North Sea the government considers the designation of areas, protected from human activities, in the Dutch sector of the North Sea as a contribution to the conservation and, where possible, rehabilitation of a natural diversity of ecologically valuable areas with their specific communities and characteristic species (Anonymous, 1989). For this purpose more detailed information is needed to identify areas with an important function in the life cycle of these species.

A good indicator of the effect of antropogenic activities on the ecosystem may be the found in the fish component of the aquatic ecosystem representing the higher trophic levels. The biology of fish has been studied intensively because of its economic importance for commercial fisheries. RIVO-DLO has collected a substantial database of species composition and abundance of the demersal fish in the North Sea coastal zone and the estuaries through routine fish survey programs since 1970 (van Leeuwen, 1993; van Leeuwen et al., 1994). Moreover, data on North Sea fish were already collected at the turn of the century when the impact of antropogenic activities was considerably less than at present (Rijnsdorp et al., 1996).

In this report, the spatial distribution of fish assemblages in the coastal and offshore waters of the southern North Sea will be analysed using multivariate statistics (principal components analysis and clustering analyses). By selecting data collected in a 5-year period (1990-1994) we hoped to find a classification that is representative for the present period. A classification scheme provides a convenient method for organising a large dataset so that the retrieval of information may be made more efficiently (Everitt, 1993). In biology classification is difficult because of continuing variation in time and space. Verdonschot (1990) summarises the use of classification in aquatic systems as follows:

1) it is necessary for understanding, describing and explaining the enormous diversity of the mixed species communities (du Rietz ex Verdonschot, 1990);

2) it is of practical value, especially with respect of water management for utilitarian requirements, in predicting the effect of projected water management policies and in the assessment of water quality and pollution.

Clustering methods represent a well defined group of mathematic techniques to produce a classification. Because a large number of different clustering methods is available, it is important to realise that each of these methods are biased towards finding clusters possessing certain characteristics related to size, shape or dispersion (SAS Institute inc., 1989). In this study two different clustering methods are compared: 1) a hierarchical method to cluster the species according to the sampling sites and 2) a disjunct method to cluster the sampling sites according to their species distribution.

This study is part of the BEON habitat project, a national programme co-ordinated by BEON, to identify and map the ecotopes (habitats) of the coastal and offshore waters of the southern North Sea. Ecotopes are defined as areas which are characterized by a specific set of abiotic conditions that determine the living conditions for all organisms, and thus determines the assemblages or communities (Leewis & Dankers, 1995). The objective of this study is to explore a method which is suitable to identify fish assemblages, to analyse their species composition and and to relate these to the geographic location, depth and distance to the coast. As such, this report may provide basic data to identify ecotopes when integrated with other environmental variables.

1.1 Fish assemblages in the North Sea

In a review of the North Sea fish, Daan et al. (1990) showed that three main fish assemblages could be distinguished in the North Sea: a shelf edge association, a central North Sea association, a south-eastern North Sea association. In the deeper waters beyond the edge of the continental shelf, other species assemblages may be distinguished (Bergstad, 1990).

These analysies however were restricted to offshore areas and did not include estuaries or shallow coastal waters. Estuarine and coastal waters are characterized by a fish fauna comprising resident species, non-spawning species, nursery type species and seasonally visiting species (Zijlstra, 1978; Hovenkamp and van der Veer, 1993; van Leeuwen et al, 1994; van der Veer and Rijnsdorp, 1995).

In an analysis of demersal young fish survey data collected along the British coasts of the North Sea, English Channel, Bristol Channel and Irish Sea, Riley et al. (1981) distinguished several species clusters reflecting the degree of exposure of the coast and the nature of the sediment: estuary, sheltered beach, boulder beach, open beach.

Hostens and Hamerlynck (1994) analysed the mobile epifauna (fish, crustaceans, echinodermata) of the Oosterschelde and concluded that the epibenthic fauna differed from that of the Voordelta and Westerschelde, whereas within the Oosterschelde four areas could be distinguished.

In the Elbe estuary salinity was the main driving factor in structuring the fish community (Thiel et al., 1995). Marine fish species decreased with decreasing salinity, while fresh water species were absent at salinities >15o/oo.

1.2 Study area

The area studied in this paper comprises of nine tidal basins (#638-Westerschelde, #634-Oosterschelde, #610-Marsdiep, #612-Eierlandse gat, #616-Vliestroom, #616-, #617- , #618- , #619- , #620-Eems-Dollart) and the offshore areas of the southeastern North Sea (Fig.2.1). The environmental factors that may structure the fish assemblages are likely to differ between and/or within the tidal basins and the shallow and deeper offshore areas.

In the Westerschelde, Marsdiep, Vliestroom and Eems-Dollard a salinity gradient occurs from the head of the area to the mounth, due to the run-off of fresh water. In contrast, no significant salinity gradient occurs in the Oosterschelde and areas #612, #617, #618 and #619. The tidal basins also differ with respect to the seasonal cycle in temperature, the tidal amplitude, the relative surface areas of tidal channels, sub-tidal flats and tidal flats, the degree of exposure and the occurence of hard bottom substrate. Further, within each tidal basin differences in the sediment characteristics occur. In the offshore areas of the open North Sea differences in abiotic conditions occur which are related to depth, the position relative to the major rivers and the degree of exposure to wind stress and tidal currents and differences in sediment.

Given the above differences in abiotic factors among the various areas, and the results of fish assemblage studies, it was decided that as a first step we would distinguish about 10 to 20 fish assemblages in the total study area. In a later stage more detailed analysis can be performed for specific areas and specific purposes.

2 Materials and methods

2.1 The origin of the database

RIVO-DLO annually conducts several different surveys in various regions of the North sea. For this study, data of summer and autumn beam trawl surveys carried out between 1990 and 1994 have been selected comprising the DFS, BTS and SNS survey. The demersal fish survey (DFS) is conducted by three vessels in the Wadden Sea (RV Stern), Scheldt estuary (RV Schollevaar) and in the coastal zone of The Netherlands, Germany and Denmark up to 55o N (RV ISIS). A 3m beam trawl is used in the estuaries whereas a 6m beam trawl is used in the coastal waters. The beam trawl survey (BTS) is carried out by RV ISIS in coastal and offshore waters of the southeastern North Sea using an 8m beam trawl. The solenet survey (SNS) is conducted by RV Tridens in the southeastern North Sea and employed a 6m beam trawl. A map indicating the areas sampled is shown in Figure 2.1. A summary of the surveys, sampling periods and gear characteristics is presented in Table 2.1. The number of samples taken annualy in each area varied between 60 and 100 (Table 2.4). The total number of hauls analysed varied between 300 in the Scheldt estuary (DFS-SCH) and over 500 in the coastal waters a (DFS-ISI) and Wadden Sea (DFS-STE). Fifty-five hauls were marked as invalid and were omitted from the dataset as well as 48 stations sampled in the SNS Tridens survey north of the Horn Rif. In total 2155 sampling stations remained in the dataset to perform the analysis (Table 2.4).

The DFS survey was stratified according to tidal basin and depth zone. The minimum depth sampled was determined by the draught of the vessel (≥ 2 m). In the estuaries, only the tidal channels and the sub-tidal flats were sampled. The BTS survey was stratified according ICES rectangles, where two to four stations were selected and evenly distributed over the surface area of the rectangle. The sampling sites of the SNS survey have fixed positions along a line which is located either parallel or perpendicular to the coast. The survey stations had fixed positions which were adjusted when the physical conditions of the station changed.

The catch or a representative sample of the catch was identified, counted and measured. In the DFS survey, the catch was sorted in a shrimp rotary sieve yielding three size fractions. All species were sorted from these size fractions, and their length distribution were recorded. Large samples were sub sampled (van Leeuwen et al.,1994). In the BTS and SNS survey, the catch was sorted and measured from a conveyer belt (van Leeuwen, 1993, van Leeuwen et al., 1994).

The abiotic measurements recorded differ among the surveys (Table 2.3). In the BTS survey sampling the open North Sea, depth aa well as surface and bottom temperatures are recorded. In the coastal zone survey (SNS) depth and surface temperature are recorded. In the estuarine surveys (DFS), depth, surface temperature and secchi-depth (Wadden Sea only) were recorded. Based on the positions of the stations the distance to the coast was calculated. For the estuarine stations, this distance does not accurately reflect the distance to the entrance of the tidal channel, but can be used to compare stations within a tidal basin.

2.2 Pre-processing of the data.

Generally the fish are identified to species level, but some species have been pooled because of identification difficulties. Thus, the *Rajidae* , *Syngnathidae* and *Callionymidae* were treated at genus level. Also the gobies, except *Gobius niger*, have been pooled with *Pomatoschistus spec.*

For some commercially important fish species plaice *Pleuronectes platessa*, sole *Solea solea*, dab *Limanda limanda*, turbot *Scophtalmus maximus*, brill *S. rhombus*, cod *Gadus morhua* and whiting *Merlangus merlangus*, separate size classes were distinguished. These species exploit the coastal or estuarine areas only during a particular phase in their life cycle (Zijlstra 1978). The separation into size classes is based on Knijn et al. (1993). The catches of cod have been divided into two size classes (group 1: 0-25 cm; group 2:>25 cm). The catches of dab are devided into four size classes (group 1: 0-10 cm; group 2 : 10-15 cm; group 3 : 15-20 cm; group 4 : 20-25 cm and group 5 : >25 cm). The other species mentioned above have been devided into three size classes (group 1: 0-15 cm; group 2: 15-25 cm; group 3: >25 cm). Apart from these size classes also the total catch of these species is treated separately in the summary statistics. The catches of the other species are not separated into size classes, partly because they are caught in smaller numbers, partly because their biology is not as well known.

Although all surveys are aimed at sampling the benthic fish community they differ in fishing gears, towing speed, mesh size and haul duration (Table 2.1). Since the relative efficiency of the different survey gear is not known, the catch rates were standardized to the catch of a 6m beam trawl towed for 30 min. at four miles/hr according to:

Number = ((catch/haul duration)*30)*((1/beam trawl size)*6)*((1/towing speed)*4)

2.3 Statistical analysis

The data have been analysed with the following techniques: summary statistics, principal component analysis and two different clustering techniques. Calculations were made using the SAS-package (SAS Institute Inc., 1989).

The species which occurred in less then 0.5 % of the sampling sites were removed from the data set. In the final analyses 62 species, species groups or length groups were included. Of the seven abundant species separated into size classes, only the catch per size class is used in the principal component analysis and in the clustering analysis instead of the over-all total catch.

2.3.1 Transformation of the data

The dataset consists of a number of abundant species which occur in large quantities and a number of less abundant or rare species which occur in small quantities. In this study we want to combine both abundance and presence of the species to come to a classification of the coastal and estuarine waters of the Netherlands based on the total fish community.

The difference between 1 and 2 individuals found is more illustrating than the difference between 101 and 102 individuals. Unless transformation is applied the higher ranges of abundance lead to an overweight of abundant species due to the effect of dominance (Verdonschot, 1990). To partly overcome this problem and to stabilise the variance transformation is an important step in the analysis. Logarithmic transformation is often used in population studies (Bergstad, 1990; Verdonschot, 1990, Overholtz and Tyler, 1985). In this study the catches (n) are transformed with a natural logarithm: $\log_e (n+1)$; 1 is added to the catch before transformation to avoid problems with transformation of the zero-catches.

2.3.2 Principal Component Analysis (PCA)

Principal component analysis is a multivariate technique to examine relationships among several quantitative variables. The analysis is especially valuable in exploratory data analysis (SAS Institute Inc., 1989). A first objective of the PCA is to seek the standardised linear combination of the original variables which has maximal variance (Mardia et al., 1979). The new principal components are found from the correlation matrix of the original variables. In cases where the first few derived components account for a large portion of the variance of the original variables, they may be used as a low dimensional summary of the data (Everitt, 1993). In this study PCA is used to get a first impression of the dataset and preferably a rough idea of the usefulness of a cluster analysis.

2.3.3 Cluster analysis

Clustering techniques can be used to summarise a dataset. Further analysis and interpretation of the clusters can reveal whether these clusters present the natural grouping present in the study area. Most clustering techniques are biased toward finding clusters possessing certain characteristics related to size, shape or dispersion (SAS Inst. Inc., 1989). The initial choice of variables (species) and observations (hauls) constitutes a frame of reference within which the clusters will be established; this choice itself is a categorisation of the dataset (Everitt, 1993). The clustering of a dataset containing only rare species might present a different clustering than the analysis of the entire dataset. Also the fact whether the data are transformed or not might influence the clustering classification. In this study two types of clustering will be used:

- a disjoint clustering which places each observation in only one cluster.

- a hierarchical clustering where clusters are organised in a way that one cluster may be entirely contained within another cluster, but no other kinds of overlap between clusters is allowed (SAS Inst. Inc.). These clusters are often presented by tree-diagrams.

<u>Disjoint clustering: the FASTCLUS procedure</u>

FASTCLUS procedure: This procedure combines an effective method for finding initial clusters with a standard iterative algorithm for minimising the sum of squared distances from the cluster means. The result is a procedure for disjoint clustering. The procedure is based on Hartigan's leader algorithm (1975) and MacQueens k-means algorithm (1967).

On forehand a number of clusters has to be chosen. A set of points called seed points is selected as a first guess of the cluster means. Each observation (a single haul) is assigned to the nearest seed in order to form temporary clusters. The seeds are then replaced by the means of the temporary clusters, and the process is repeated until no further changes occur (Anderberg, 1973; SAS Institute Inc., 1989). The FASTCLUS procedure optionally allows to specify a maximum iteration level to fix the maximum number of iterations for recomputing the cluster seeds. In this study 20 iterations or less were sufficient to obtain a relative change in the cluster seeds < 0.05.

The FASTCLUS procedure is sensitive to outlyers. Therefore it can be used as an effective procedure for detecting outlyers because outlyers often appear as clusters with only one member (SAS Institute Inc., 1989). By requesting a large number of clusters e.g. 100 the outlyers appear as clusters with one member and can be removed from the dataset. After this preliminary analysis the actual clustering can be performed. The procedure applied for 100 clusters revealed 17 stations as outlyers. In the principal component analysis and the cluster analysis these 17 stations were removed.

For the clustering of the data the procedure is applied to form separate classifications with 10 and 20 clusters. These classifications with a fixed number of clusters are meant as a first impression of a possible habitat characterisation. The number of clusters is based on assumptions and earlier studies (see 1.2). By selection of two clustering classifications the robustness of the clusters might be illustrated: whether a cluster in the 10-cluster classification is subdivided or still exists in the 20-cluster classification can become clear.

The output of the procedure contains information about the individual clusters, the variables used to form the clusters (the separate species) and general statistics of the clustering classification. The following list gives a selection of the presented statistics:

a-information about the clusters:

a1-the number of observations in a cluster,

a2-the maximum distance from the cluster seed to any observation in the cluster,

a3-the nearest cluster,

a4-the centroid distances between the clusters

b-information about the variables:

b1-R-squared, the R^2 for predicting the variable from the cluster.

b2-The standard deviation (std) of the variable and the std of the within cluster standard deviation.

c-information about the clustering classification:

c1-Over-all R^2: a combination of the statistics of the variables in separate clusters. It provides information on the goodness-of-fit of the cluster analysis.

c2-Approximate expected over-all R^2: the value of R^2 under the assumption that all variables are un-correlated. Comparison with the above mentioned over-all R^2 for the cluster classification enables a rough indication of the acceptability of the presented cluster classification.

Hierarchical clustering : the CLUSTER procedure

In a hierarchical method data are not partitioned into a particular number of classes at a single step. The classification runs from n clusters which all contain one observation to one cluster containing all observations. This is called a agglomerative clustering method. Fusions made are irrevocable; when an algorithm has joined two observations they cannot subsequently be separated (Everitt, 1993). The hierarchical method is interesting to apply on the transposed matrix: in this way the species are clustered on the basis of the sampling sites. This method can reveal cohesion between species based on their presence in sampling stations.

The SAS package provides different methods to define distance between the clusters. The first stage of these methods is to form a dissimilarity matrix of the variables based on the observations. Based on these dissimilarity values, the clusters are joined together according to the chosen algorithm. Bergstad (1990) and Overholtz and Tyler (1985) calculate the dissimilarity matrix with a Bray Curtis index, a non-euclidean distance, and afterwards use group average linking to join observations into clusters. In this study group average linking will be used in combination with Euclidean distance dissimilarity matrix of the species present in the dataset.

Group average linking defines the distance between two clusters as the average distance between pairs of observations, one in each cluster. The method tends to join clusters with small variances and is slightly biased toward finding clusters with the same variance (SAS Inst. Inc., 1989). The average linkage method is not dependant on extreme values for defining clusters (Anderberg, 1973). The distance between cluster K and cluster L, D_{KL} and is defined as:

$D_{KL} = \Sigma_{i \in K} \Sigma_{j \in L} \; d(x_i, x_j) / (N_K N_L)$ and

$d(x,y) = || x - y ||$

in which: D_{KL} = distance between cluster K and cluster L

N_K = number of elements in cluster K

d (x,y) = any distance or dissimilarity measure between observations x and y

$||x||$ = length of the vector x: the square root of the sum of squares of the element of x (the euclidean distance);

The SAS package provides some useful statistics in its output:

-General information about clusters: the observations joined in each cluster, the number of observations in each cluster.

- Pseudo F-statistic: measuring the separation among all the clusters at the current level.

- Pseudo t^2 statistic: measuring the separation between the clusters most recently joined

- Semipartial R-squared: the decrease in the proportion of variance accounted for resulting from the joining two clusters = the between cluster sum of squares/ corrected total sum of squares.

- R-squared: the squared multiple correlation; the proportion of variance accounted for by the clusters.

The values of the statistics mentioned above are helpful to obtain information on the goodness-of-fit of the clusters at all levels. The pseudo F-statistic and the pseudo t^2-statistic provide information on the optimal number of clusters.

2.4 Pooling the data by station and depth band

In the initial analyses the species composition of each station is compared with the composition of the other stations. The duration of a single haul in the estuarine and coastal surveys is relatively short (15 min) and thus the catch compostion at one location can show a considerable variation. The station grid DFS surveys comprises fixed positions and allowing to eliminate the year to year variation in the catch composition at a station by calculating the mean. Because no station codes were available in the data base, 3x3 mile rectangle station codes were calculated from the geographic location of the haul to deminish the year to year variation and the variation between two stations located close together. The grain size of station grid was based on a compromise between the average distances between individual stations in the surveys. Because, within a 3x3 mile rectangle large differences may occur in the depth of the tows, the average catch rate was calculated by species, station code and depth band. In this study one analysis used two different depth bands (0-15 m, >15 m) and one analysis used six depth bands (0-5 m, 5-10m, 10-15m, 15-20m, 20-25m, >25 m). The rectangles containing less than 5 hauls were omitted from the database.

Collapsing the database into records of the mean abundance by species by station code for two depth bands resulted in a data set of 156 rectangles. The data set based on rectangles devided into six depthbands contained 304 rectangles. For this analysis of the DFS survey area 1406 stations were used (the outlyers are omitted) and 49 species occured in > 0.5% of the stations (Appendix V and VI).

3 Results

3.1 Facts and features of the database

Each observation in the database represents the number of fish of a certain fish species caught in a specific haul. The database consists of 206880 observations of 96 species, species groups or length groups in 2155 hauls. Only 37742 observations (18.2%) contained data of fish caught. The other observations represent the zero-catches. Appendix I presents all species present in the database. In total 74 different species or species groups were recorded. Table 3.1 presents the total catch, the minimum and maximum catch and the relative abundance of all species for the different surveys. The relative abundance is the percentage of sampling sites in which a certain species has occurred. Table 3.1 is presented in two blocks and within each block the species are listed in alphabetic order. The lower block contains the species which occur in < 0.5% of the sampling sites.

Table 3.2 shows the number of species or length categories in different classes of abundance. This table clearly shows that there is a large group of rare species (present in <5% of the sampling sites) and a small number of common species. Of the seven common species, sole, dab and plaice are present in > 70 % of the sampling sites, but because of the separation into size classes the total presence of these species is not listed in Table 3.2. In general common species are also numerically abundant.

3.2 Principal Components Analysis

Table 3.3 shows the eigenvalues of the first ten principal components resulting from the PCA. The first two principal components, generally accounting for the largest explained variance explain only a moderate (20.8%) part of the variance in the variables. The first principal component explains 14.7 % of the variance and the second principal component only 6.2 %. A plot of the sampling sites according to the first two principal components suggests two main groups (Fig. 3.1a). The cluster numbers of the 10-cluster classification (FASTCLUS) were used to label the data points of the PCA output showing that the 10 clusters separate along the first and second principal component axis, although the data points of the clusters showed a considerable overlap (Fig.3b). The deep water clusters are concentrated on the right hand of the first principal component and the shallow water clusters are concentrated along the left hand side. The second principal component relates to longitude. Southern hauls have predominantly negative values, whereas northern hauls have predominantly positive values.

3.2.1 Ten-cluster classification according to the FASTCLUS method

Based on the FASTCLUS procedure a 10-cluster classification of individual hauls is obtained according to their species distribution. For this classification the R-squared explained 44%. This is twice the R-squared (22%) under the assumption that the species are uncorrelated. The positions of the hauls of each cluster are plotted in Fig.3.2. The depth distribution within each cluster is presented in Fig.3.3. Fig 3.4 contains the relative frequency distribution of the depth in the clusters. Appendix II contains summary statistics of the clusters, the distances between the clusters, statistics for the variables (= species) and mean values of all species in the new clusters. A description of the surveys present in each cluster and the distribution of the years over the clusters is given in Tables 3.4 and 3.5. Table 3.6 and Fig 3.5 show the species which mainly determined the classification ($R^2 > 0.4$) and the mean values of the log transformed catches of these species within each cluster.

During the cluster analysis the geographic position is not taken into account, but the spatial distribution of the clusters can be inspected after plotted them in a map. The plots in Fig 3.2 show a clear spatial clustering. Although the conversion factor used to compare the catches of each survey with each other is relatively simple and does not account for all gear differences, Table 3.4 reveals that within a cluster several surveys are represented corroborating that the clusters were not distinguished based on the survey (ship and gear combination).

One cluster (cluster-1) appears to represent hauls with generally low catches irrespective of the position (cluster-1). The other nine clusters have a characteristic geographic location of depth distribution.

In the open North sea, two clusters can be distinguished (cluster-5 and cluster-10) characterised by a relatively high abundance of dragonet, scaldfish, solenette and larger plaice and dab, and by a low abundance of gobies and small plaice. One cluster shows a southern distribution (cluster-10) with a characteristic high abundance of lesser weever, the other cluster shows a northern distribution (cluster-5) with a characteristic abundance of grey gurnard. Both clusters comprises of hauls in deeper water (>20m). The geographic distinction is between the 53oN and 54oN.

Cluster-2 and cluster-7 represent the clusters intermediate between the open North Sea clusters and the true coastal and estuarine clusters. They occurred in a band parallel to the coast at a depth between 10 and 30 m and were dominated by gobies, small and larger plaice, dab, as well as scaldfish, solenette, lesser weever, dragonet and sole. Cluster-2 has a more southern distribution and shows an additional high abundance of lesser weever and gobies (Fig.3.2). Cluster-7 has a more northern distribution and has a high abundance of various size classes of dab. The intermediate clusters comprised none of the hauls taken in the Wadden Sea, Eems-Dollard or Schelde estuary (Table 3.4).

Cluster-3, -8 and -9 occurred in shallow water down to 15 m. and were located both in the coastal zone of the North Sea as well as within the Wadden Sea and Eems-Dollard. These clusters were dominated by small plaice and gobies although offshore species such as dragonets and larger plaice were still present.

Cluster-4 and cluster-6 had a very shallow distribution (<10 m) and represented the true estuarine assemblages dominated by gobies and small plaice. Cluster 6 was restricted to the Wadden Sea and the Eems-Dollard and reflected the occurrence of smelt in addition to small plaice and gobies.

The other seven clusters are more or less restricted to the coastal zone and the estuaries. Within the coastal zone different clusters are distinguished based on the latitude as well as on the depth. The deeper coastal water clusters (cluster-2 and cluster-7) are mainly distributed in water between 10-25 m (Fig.3.3) and show an almost similar species composition as the open North Sea clusters (dragonet, scaldfish and solenette) but with an additional high abundance of small plaice (Fig.3.5).

Cluster distribution within the Wadden Sea and Schelde estuary.

The next step in the analysis is to focus on the Wadden Sea and the Schelde estuary. Fig 3.6 shows that all 10 clusters are present in the Wadden Sea and adjacent offshore waters. Fig 3.7 shows the distribution of the relative frequency per depth band. A more detailed map of the location of the clusters within the Wadden Sea is shown in Fig 3.8 to 3.11. In the western Waddensea comprising of areas #610, #612 and #616, and in the Eems-Dollard estuary (area #620) the same mosaic of clusters is apparent as in the maps of the total study area. Table 3.7 presents the number of stations present in each cluster of the subareas. The deeper water clusters (cluster-2, -5, -7 and -10) occur north of the islands. All other clusters are present in the Western part as well as in the Eems-Dollard estuary. Cluster-6 is clearly confined to the shallow water area close to the mainland.

In the Oosterschelde and Westerschelde, three clusters are present of which cluster-9 consists of three stations in the upper North region (fig 3.12 and 3.13). Most of the stations are classified in cluster-1 which was characterised by an overall poor catch rate. Cluster-1 and -3 are distributed over the same depth range and are not clearly restricted to a particular area.

3.2.2 Twenty-cluster classification

The results of the 20-cluster classification (B1 up to B20), which are presented in Fig 3.14. The detailed information of this classification is presented in Appendix III. The overall R-squared (51%) is higher than in the 10 cluster classification. The approximate overall R-squared for the uncorrelated species is also higher (26%). The 20-cluster classification, therefore, explained twice the amount of variance, comparable to the 10-cluster classification. The results of the 20-cluster classification generally supports the 10-cluster classification. In the open water two clusters, B7 and B16, are distinguished, which have rougly the same spatial distribution as the open North Sea cluster-2 and cluster-5. In the Oosterschelde and Westerschelde again three clusters are distinguished, none of which are exclusive for this area. The rest of the clusters is confined to the Waddensea or shallow coastal zone. As in the 10-cluster classification, some clusters are specific for the northern part (B1, B10, B19, B20), others for the southern (B2, B8, B15, B17).

3.2.3 Seven-cluster classification in coastal and estuarine waters

In contrast to the distinct spatial distribution of the offshore fish assemblages, the 10- and the 20-cluster classification did not reveal spatially distinct fish assemblages in the coastal and estuarine waters. The clusters distinguished in these areas showed a substantial overlap. Because the classification was determined by the most abundant species (Table 3.6) which belonged to the nursery-type (plaice) or seasonal visiting group (dab), a third analysis was performed which was restricted to the 15 typical estuarine or coastal fish species which were present in more than 0.5% of the stations in this area and the estuarine and shallow coastal stations of the DFS surveys in areas #401-404 (Dutch coast), #610-620 (Dutch Wadden Sea and Eems-Dollard) and #634 (Westerschelde) and #638 (Oosterschelde). In total 1210 stations are analysed with the Fastclus procedure. The number of clusters was set at seven, which is equal to the number of estuarine clusters distinguished in the 10-cluster classification of the total data set.

Fig 3.15 presents the clusters C1 up to C7 obtained by this analysis. Fig 3.17 presents the distribution of the relative cluster frequency per depth interval. The detailed information of this clustering is presented in appendix IV. Six species dominated the classification ($R^2 >$ 0.3): gobies, pipefish, smelt, eelpout, five bearded rockling and sea snail (listed in descending sequence of the R^2 values). Fig 3.17 presents the mean values (loge (catch+1)) in the new classification.

Cluster C3, C4 and C6 are mostly restricted to the shallow areas, whereas the other clusters are distributed in over a wider depth range (Fig.3.16). Cluster C1, which comprises one-third of all hauls, consists of generally poor catches rates of all species. Cluster C6 mainly differs from C1 by the large amount of gobies present in these stations (Fig.3.17). Cluster C3 and C4 are clusters where on average most species are present in large numbers.

A comparison of this classification with the 10-cluster classification shows that none of the C-clusters corresponds uniquely to a single cluster obtained by the 10-cluster classification (Fig 3.18). Most of the original clusters are split into several new C-clusters. Even cluster-6, which was characterised by the abundance of smelt, is devided into 6 new clusters: C2 to C7.

In this analysis, we get the impression that the clustering is based on the fact whether a station consists of a poor or a good catch. The intermediate stations are mainly selected on the presence or absence of one or two species. Besides the fact that six important species are selected, this classification presents no new information on the possible distribution of habitats in the coastal and estuarine area.

3.2.4 Seven-cluster classification of the stations in the coastal and estuarine waters pooled by 3x3 mile rectangles

The next step in the analysis was to pool the hauls into fixed geographical stations in order to reduce the among haul variance in catch rate. Because there may be a substantial difference in depth within a 3x3 mile rectangle, two data sets were created. The first employed a two depth band stratification, the other a six-depthband stratification. Pooling resulted in a substantial difference in the number of hauls per 3x3 rectangle and depth band (Table 3.9 3.11) and a minimum of 5 hauls was set for including a rectangle-depth zone cell in the analysis. A 7-cluster classification was obtained with FASTCLUS for each of the 2 data sets and the results are presented in Fig 3.19 and Fig 3.20. The distribution of the clusters in relation with depth is given in Table 3.10 and 3.12.

Pooling the hauls in 3x3 mile rectangles clearly affected the result. The map of clusters showed much less overlap as compared to the 10-cluster or 20-cluster classification of individual hauls. In general the results of the two- and six-depth band classification are similar with a cluster in the Schelde estuary (D2, E3), a marine Wadden Sea cluster (D1, E1), a brackish Wadden Sea cluster (D6, E6), a southern coastal cluster (D7, E7), and shallow and deeper coastal clusters along the Wadden Sea and in the German Bight. A detailed comparison of the two- and six-depth band classification revealed a slight difference in the position of the the borders between the clusters, in particular in the three shallow coastal clusters D6, D1 and D7 (two-depth bands) and E5, E1 and E7 (siz depth bands). In the two-depth band classification, the norther cluster extends southwards to the Elbe, whereas the E5 cluster extends to the Texel and Terschelling.

3.2.5 Hierarchical clustering of species

The result of the hierarchical clustering of species according to their presence and abundance is presented in figure 3.21. All species are listed according to their species code (Appendix I). Roughly four groups of species can be distinguished. Group I, II and IV contain abundant species. Most of these species are ialso important for the 10 cluster classification. Group II contains species which are more or less specific for the deep water regions. Group IV contains species which are specific for the shallow areas. Group III contains all other species mainly listed in order of abundance. Within this group no separation can be made in deep water species or coastline species.

The objective of this analysis is to retrieve species groups consisting of rare and abundant species specifically present in certain geographic areas. Clearly the algorithm used is not suitable to obtain this information. Based on this analysis a separation is made between the abundant and the rare species.

4. Discussion

Before discussing the results of the clustering analysis, we will discuss some methodological issues with regard to the basic data (trawl catches) and the statistical methods employed.

The first point to make is that a trawl catch is not a representative sample of the fish fauna, because there is no fishing gear available that is equaly efficient for all fish species. The efficiency of the gear further changes in relation to the type of sea bed (gravel, coarse sand, fine sand, sandy mud). Some types of sea bed are untrawlable (stony areas, mussel beds) and need a specific fishing gear. Other areas are due to the depth only trawlable with small trawls or beach seines (mud flats, shallow areas). Finally, the sampling of the fish fauna in estuarine or coastal areas poses specific problems due to the strength of the tidal currents and because of changes in fish distribution in relation with the tide (Hinz, 1989; Ruth and Berghahn, 1989). Hence, the fish assemblages determined in the present will inevitably be biased by the peculiarities of the survey gear.

The beam trawl used in the present study are efficient in catching demersal fish, in particular flatfish, but pelagic fish, such as herring and sprat, are only caught by exception (Breckling and Neudecker, 1994). The sampling area was further restricted to the sub-tidal areas with a minimum depth of 2 meter. Hence, tidal flats and the surf zone, which are inhabitat by a specific group of demersal fish have been ignored in the present study. Because the beam trawl employed in our study were not equipped to sample hard grounds, fish species associated with wrecks, mussel beds and boulders will have been underestimated.

Prior to the analysis, the catch rates had to be standardized because the data set comprised of surveys conducted with different vessels and different beam trawl gears. Although, comparative fishing experiments have been conducted in the past but have not been analysed, a simple conversion factor had to be applied that corrected the catch rate for differences in the width of the beam trawl used and the towing speed. This correction is a necessarily crude one which ignores the effect of the type of ground rope on the catch efficiency of the gear. There are indications that the SNS gear (sole net) is more efficient than the BTS and DFS gears which used rollers or bobbins on the ground rope, and that the relative efficiency of a particular gear may further differ among different species-groups (Pfisterer, in prep).

The overall catch composition of the beam trawl hauls showed that some species dominated numerically, whereas a large number of other species were caught only occasionally. This skewed distribution, which is a general feature of any ecological sample and is not specific for trawl samples (Ricklefs, 1979), implies that a single haul will always catch only a part of all the fish species present in a particular area. Zero catches may be due to the absence of a species in a particular area, or to the low numerical abundance in relation to the surface area sampled in one haul. The fact that the explained variance by the PCA ($R^2 \approx 20\%$ by the first two principal components) and the clustering analyses (R2 $\approx 45\%$) is so low may be due to the large number of hauls in which certain species were absent.

The statistical methods employed were sensitive to abundant species. Although a log-transformation was used to reduce the influence of the abundant species, the clusters obtained by the disjoint clustering method, were still determined by the relative proportion of the abundant species (plaice, dab, gobies). The hierarchical method also produced groups of rare and groups of abundant species which is probably due to the euclidean distance calculated by the SAS package. A non euclidean distance such as the Bray Curtis dissimilarity measure used by Bergstad (1990) might alleviate this problem.

The results of the PCA showed that the individual trawl hauls could be classified according to an axis reflecting the distance from the coast and/or depth, and an axis reflecting the latitude. This result was corroborated by the 10- and 20-cluster classification which classified the hauls in clusters with a typical depth distribution as well as a typical position longitude.

Comparison of the 10- and 20-cluster classification results showed a general agreement. The open North Sea hauls were grouped in a southern and northern cluster separated at about 53 degrees North (cluster-5 and cluster-10; cluster-B7 and cluster-B16). The northern cluster resembled the central North Sea association described by Daan et al. (1991), although flatfish were relative more numerous in the beam trawl catches analysed in the present paper. The open North Sea clusters occurred mainly in waters below 20 m depth. Inshore of the 20 m depth contour, a number of coastal and estuarine clusters were distinguished which were dominated by small plaice, dab and gobies. The contribution of other species was relatively small. Within the coastal area clusters were distinguished based on the relative proportion of the three dominant species and the occurence of one or more additional less abundant species. Cluster-6 and cluster-B14, which are dominated by small plaice and gobies and the occurrence of smelt, are related to the discharge of fresh water through the sluices of den Oever and Kornwerderzand in the western Wadden Sea and through the Eems and the sluice of Nieuw-Statenzijl in the Eems-Dollard, represents a typical estuarine cluster also observed in the Elbe estuary (Thiel et al., 1994).

In contrast to the results of the analysis of the mobile epifauna including fish, crustaceans and echinormata of Hostens and Hamerlynck (1994), our analysis of the total data set of beam trawl catches, including the Schelde estuary as well as the other coastal and offshore areas, did not indicate a clear difference in the fish assemblages within the Oosterschelde nor between the Oosterschelde, Westerschelde and Voordelta. In our analysis, however, most of the hauls in the Schelde estuary were classified in cluster-1, which represented hauls with a low catch rate of all species. This result may be due to the conversion factor used to standardize the beam trawl catches. A comparison of the 10-cluster classification of the RV Schollevaar hauls showed that the hauls in the Westerschelde were mainly classified in cluster-1, whereas the hauls in the Oosterschelde were classified in either cluster-1, -3 or -9. Cluster-9 was restricted to three hauls in the Hammen and corresponded to the result of Hostens and Hamerlynck (1994).

Comparison of the 10-cluster classification results of a sub-set of hauls of the DFS-survey and based on 15 estuarine species only showed a completely different result (Fig. 3.18). Only the gobies dominated cluster-C5 showed corresponded with cluster-8. Cluster-C1, comprising with an overall low catch of estuarine species are related to the cluster-1, -3, -5, -7 and -10 of the 10-cluster classification. The latter represented offshore and deeper clusters (cluster-5, -7, -10) which are logically characterised by a low catch of estuarine species. Cluster-6, which was dominated by small plaice, gobies and smelt is now partitioned into clusters C3, C4 and C6, based on the relative abundance of gobies, smelt, pipefish, eelpout, rockling and sea snail. This analysis indicates that a classification of the assemblages in coastal and estuarine waters based on resident species only will give a different result compared to the analysis including nursery-type species and seasonally visiting species (10- and 20-cluster classification).

The results of the above analysis showed a high degreee of spatial overlap among the clusters, especially in the coastal areas. This overlap may be due to the fact that the analysis was based on the catch composition of individual hauls of 15-30 min duration from which some species may have been missed because of their low numerical abundance relative to the surface area sampled. In order to explore the effect of the numerically less abundant species on the classification result, we have attempted to group hauls in stations by pooling the hauls in rectangles of 3x3 mile. This analysis should be considered as a crude exploratory step, because the number of data observations in each rectangle was highly unbalanced. The results, however, showed that the clusters obtained showed much less spatial overlap, suggesting that this approach may give a more stable result. The result that the transition between neigbouring D- or E-clusters occur at differnt locations indicate that the differneces between the cacth composition between stations is rather gradual.

The classification explored in the present study revealed that the fish assemblages clearly differed in relation with the depth, the distance from the coast and with latitude. The results of the clustering are affected by assumptions with regard to the transformation applied, the group of species selected, and whether the analysis is based on individual hauls or on the average catch composition of 'fixed' stations. The latter approach seems to be preferable in order to obtain more stable results reflecting the average distribution of fish assemblages in a particular time period.

Because the trawl catches were restricted to the demersal fish and to trawlable bottoms at a depth of >2 m, typical assemblages of the pelagic system and of the shallow areas of the surf zone and tidal flats were missed. In addition, typical estuarine species (resident and spawning type species) had a relatively small influence on the classification of fish assemblages in the coastal waters suggesting that the multivariate analysis should put more weight on the abundance of resident and spawning species. The analysis of the fish assemblages should further include the analysis of the differences in gear efficiency of the beam trawl gears included in the present study, and should take account of the seasonal changes in distribution of fish species. Finally, the multivariate analysis should be complemented by an analysis of the habitat requierements of resident and spawning type species. Relevant aspects of the analysis of the fish assemblages, which have not been dealt with in the present study, include questions about the factors that determine the structure of the fish assemblages (abiotic factors such as salinity, seabed characteristics, exposure; and biotic factors such as food and inter-specific relations).

Conclusion

1) multivariate analysis of trawl catches can be used to classify the demersal fish assemblages.

2) a preliminairy classification showed that several assemblages could be distinguished which were related to the depth and distance from the coast and with the latitude.

3) nursery-type species and seasonal visiting species (plaice, dab) had a major influence on the classification results

4) comparative fishing experiments should be analysed to obtain relative gear efficiencies for the different beam trawls employed in the present study

5) improved classification is expected when individual hauls are pooled into 'fixed' stations over a number of years and when a stronger transformation of the numerical abundance is applied.

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Fig. 2.1: Geographic areas visited yearly during each survey.

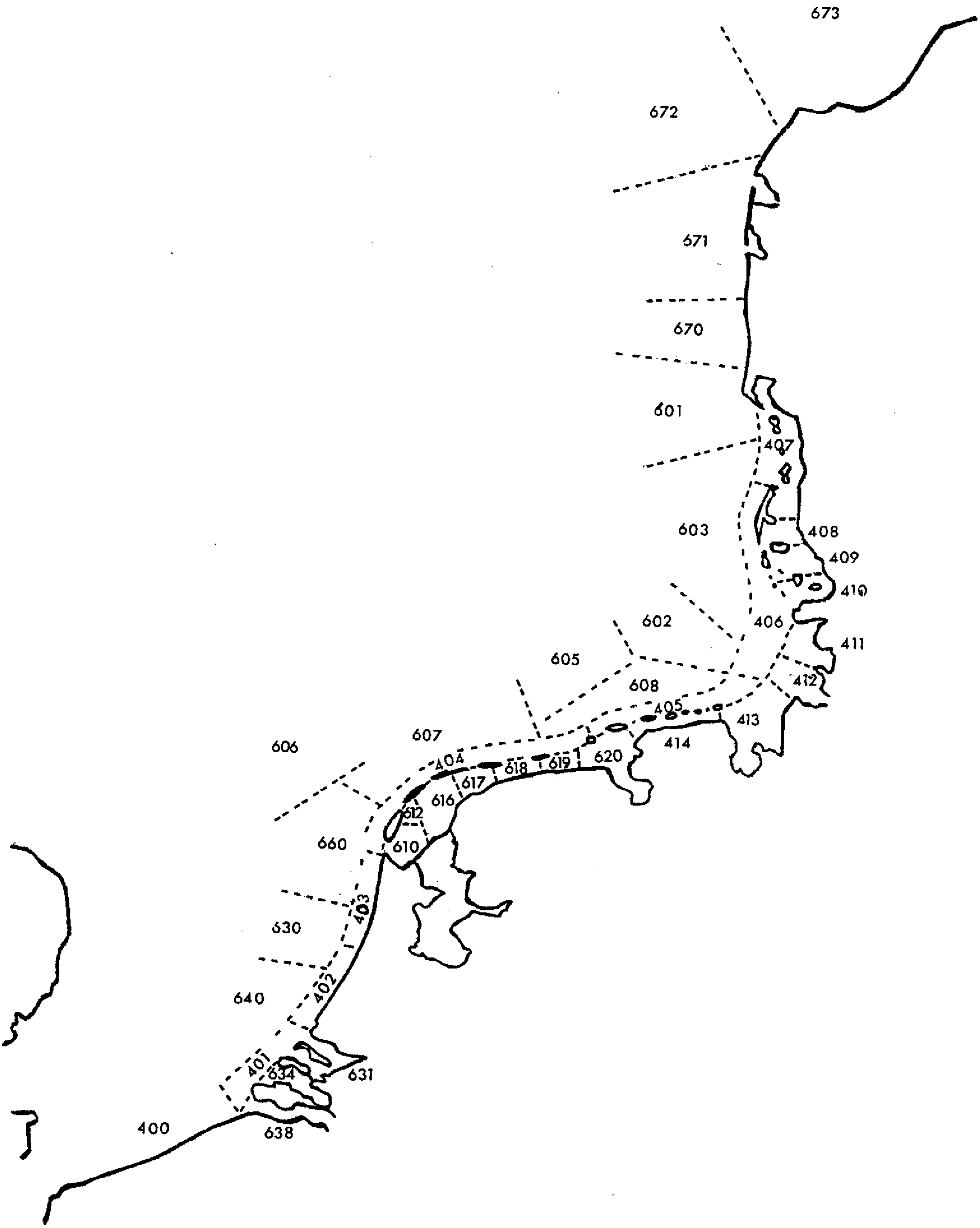


Table 2.1: Specifications of the conducted surveys.

Survey :	DFS	DFS	DFS	BTS	SNS
Vessel :	Stern	Schollevaar	Isis	Isis	Tridens
Code :	DFS,STE	DFS,SCH	DFS,ISI	BTS,ISI	SNS,TRI
Area :	Wadden sea	Scheldt estuary	Coastal zone	Open North Sea	Coastal zone, German Bight
Beam trawl size (m) :	3	3	6	8	6
Ground rope :	bobbins	bobbins	bobbins	chain + rubber discs	chain
Number of tickler chains :	1	1	1	8	4
Mesh size (stretched mesh) :	20	20	20	40	45
Haul duration (min) :	15	15	15	30	15
Towing speed (knots) :	3	3	3	4	4
Month :	Sept.-Oct.	Sept.-Oct.	Sept.-Oct.	Aug.-Sept	Sept.-Oct.

Table 2.2: Total amount of samples taken in the research areas by DFS and SNS surveys in the period 1990-1994.

AREA	DFS,ISI	DFS,SCH	DFS,STE	SNS,TRI	TOTAL
401	106	.	.	.	106
402	78	.	.	.	78
403	53	.	.	.	53
404	137	.	.	.	137
405	74	.	.	.	74
406	99	.	.	.	99
407	29	.	.	.	29
601	.	.	.	30	30
602	.	.	.	20	20
603	.	.	.	23	23
605	.	.	.	19	19
606	.	.	.	19	19
607	.	.	.	43	43
608	.	.	.	24	24
610	.	.	114	.	114
612	.	.	11	.	11
616	.	.	129	.	129
617	.	.	64	.	64
618	.	.	48	.	48
619	.	.	33	.	33
620	.	.	128	.	128
630	.	.	.	27	27
634	.	166	.	.	166
638	.	148	.	.	148
640	.	.	.	20	20
660	.	.	.	33	33
TOTAL	576	314	527	258	1675

Table 2.3: Abiotic variables used in the analysis.

Variable	description	numeric/character
Gear type/vessel	5 different types	character
Position	Northing Easting	numeric
Secchi-depth (m)		numeric
Surface salinity		numeric
Surface temperature		numeric
Bottom salinity		numeric
Bottom temperature		numeric
Distance tot the coas	(nautical miles)	numeric
Wind force	0-12	numeric
Wind direction	12 directions	character
Month	Aug./Sept/Oct.	character
Year	1990-1994	character

Table 2.4: Distribution of the number of hauls sampled over the years and the surveys.

Year/survey	DFS,STE	DFS,SCH	DFS,ISI	SNS,TRI	BTS,ISI
1990	101	62	117	51	94
1991	110	62	107	46	98
1992	101	64	119	55	97
1993	111	58	118	50	100
1994	104	68	115	56	91
Total number of valid hauls :	527	314	576	258	480

Table 3.2: Number of species present in the different classes of relative abundance.

Relative abundance	Number of species listed in a class
Present in <0.5% of the sampling sites	27
Present in <5% of the sampling sites	17
Present in 5-25% of the sampling sites	22
Present in 25-50% of the sampling sites	16
Present in 50-75% of the sampling sites	7
Present in >75% of the sampling sites	0

Table 3.1: Total catch, minimum and maximum values of the catch per haul and relative abundance of the species present in the dataset, calculated for the individual surveys and the sum of all surveys.

					BTS,ISI	BTS,ISI	DFS,ISI	DFS,ISI	DFS,SCH	DFS,SCH	DFS,STE	DFS,STE	SNS,TRI	SNS,TRI
Scientific name	%abundance	Total catch	MIN	MAX	Total catch	%abundance	Total catch	%abundance	Total catch	%abundance	Total catch	%abundance	Total catch	%abundance
Agonus cataphractus	40.37	123370.6	0	34821.07	87334.63	62.08	15206.68	32.99	1216	11.15	9635.28	38.52	9978	55.81
Alosa fallax	1.11	208.15	0	42.67	8	0.21	.	0.00	.	0.00	198.15	4.17	2	0.39
Ammodytidae sp	13.23	23028.89	0	4992	340.32	6.25	21391.24	26.74	821.33	14.01	416	7.40	60	6.98
Anguila anguila	5.01	815.29	0	42.67	99.96	3.13	112	3.30	490.67	16.24	90.67	3.04	22	2.71
Arnoglossus laterna	35.36	99999.78	0	2755.92	78063.35	83.13	10323.43	27.26	5.33	0.32	10.67	0.38	11592	78.68
Belona belone	1.53	372.31	0	64	249.65	3.54	8	0.52	5.33	0.32	5.33	0.19	104	4.26
Buglossidium luteum	33.36	188415.51	0	24416	98225.98	71.67	71369.52	28.65	.	0.00	.	0.00	18820	81.40
Callionymus sp	47.15	234799.93	0	25315.29	121943.73	90.83	79910.2	59.55	.	0.00	.	0.00	32946	91.86
Ciliata mustela	17.45	13331.21	0	426.67	8	0.42	1974.33	12.85	1424	21.66	9922.87	43.64	4	0.78
Clupea harengus	30.21	117047.74	0	9813.33	918.41	8.33	23232.94	23.09	23909.33	39.81	68897.05	65.65	90	2.71
Cyclopterus lumpus	0.84	107.17	0	26.67	16.5	1.25	10.67	0.52	.	0.00	80	1.71	.	0.00
Dicentrarchus labrax	1.35	3515.67	0	2730.67	8	0.63	8	0.35	3498.67	7.64	.	0.00	.	0.00
Engraulis encrasicolus	0.6	154.67	0	48	.	0.00	.	0.00	154.67	4.14	.	0.00	.	0.00
Eutrigla gurnardus	21.3	39681.33	0	6639.8	36874.67	65.00	218.33	3.30	5.33	0.32	16	0.38	2572	46.45
Gadus morhua (0-25cm.)	16.75	11224.37	0	2934.3	5654.37	24.17	2946.67	16.49	85.33	3.18	1770	17.08	762	19.38
Gadus morhua (>25)	7.56	2845.24	0	1296	2772.57	30.00	26.67	1.22	5.33	0.32	10.67	0.38	30	3.49
Gadus morhua totaal	21.48	14069.6	0	2934.3	8426.94	42.71	2973.33	17.19	90.67	3.18	1786.67	17.27	792	22.48
Gasterosteus aculeatus	0.79	1579.03	0	1102.37	1102.37	0.21	181.33	0.35	224	1.59	37.33	1.14	34	1.16
Gobius sp	41.16	1392334.3	0	98048	21514.32	11.67	731200.6	60.07	10.67	0.32	624078.71	74.76	15530	34.88
Hippoglossoides platessoides	2.09	4013.73	0	1405.1	4005.73	9.17	8	0.17	.	0.00	.	0.00	0	0.00
Hyperoplus lanceolatus	12.53	8282.01	0	1589.33	3503.25	26.04	4350.1	13.19	181.33	5.41	85.33	3.04	162	13.95
Limanda limanda (0-10cm)	64.69	440593.34	0	32160	73341.32	45.00	186013.38	85.59	21888	55.10	148180.63	69.33	11160	55.81
Limanda limanda (10-15cm)	59.77	638551.86	0	46781.63	522252.43	92.92	34643.82	62.15	4261.33	26.75	29044.26	30.17	48350	93.41
Limanda limanda (15-20cm)	55.31	475731.19	0	18431.63	402582.4	94.79	23505.36	59.55	1141.33	13.69	2294.1	18.60	46208	99.06
Limanda limanda(20-25cm)	46.82	93952.13	0	8945.27	75529.63	91.67	8568.77	44.27	85.33	2.87	658.4	12.71	9110	92.25
Limanda limanda (>25cm)	27.19	8394.14	0	970.66	6798.42	84.38	664.39	19.79	0	0.00	133.33	3.61	798	55.81
Limanda limanda totaal	87.38	1657545.33	0	66618.37	1080504.2	99.17	253395.71	97.57	27376	62.74	180337.41	74.19	115932	99.61
Liparis liparis	11.32	9822.52	0	853.33	.	0.00	665	9.20	310.80	7.01	8842.67	31.98	4	0.39
Lophius piscatorius	0.51	30	0	6	30	2.29	.	0.00	.	0.00	.	0.00	0	0.00
Merlangus merlangus (0-15cm)	46.5	161066	0	13824	79125.41	59.58	49508.38	41.15	357.33	11.78	24210.87	58.63	7864	51.55
Merlangus merlangus (15-25cm)	51.04	86295.91	0	2218.67	29331.98	70.00	33476.47	48.09	1045.33	18.47	14668.13	44.40	7774	75.58
Merlangus merlangus (>25cm)	21.9	10464.41	0	564	7694.82	50.21	1044.26	13.54	0	0.00	229.33	4.17	1496	50.78
Merlangus merlangus totaal	64.32	311212.98	0	53396.67	116152.21	82.50	84029.11	61.46	1402.67	22.93	92495	65.84	17134	84.11
Merluccius merluccius	0.93	71.63	0	10.13	71.63	4.17	.	0.00	.	0.00	.	0.00	.	0.00
Microstomus kitt	8.12	9383.23	0	3045.87	8788.37	24.79	54.86	1.39	181.33	4.46	10.67	0.38	348	12.40
Mullus surmuletus	69.79	1657	0	156	903	6.88	.	100.00	.	100.00	.	100.00	754	20.93
Myoxocephalus scorpius	19.68	21252.17	0	5377.69	13738.52	14.38	1637.34	15.97	848	17.83	4044.51	31.83	984	15.12
Osmerus eperlanus	10.16	45912.38	0	12629.33	.	0.00	1325.71	5.03	26.67	1.59	44560	35.10	.	0.00
Pholis gunnellus	4.08	1664.37	0	336	370.13	0.63	122.67	1.74	176	6.37	993.58	10.25	2	0.39
Phrynorhombus norvegicus	0.56	188	0	48	162	1.88	8	0.17	.	0.00	.	0.00	18	0.78
Platichthys flesus	33.69	30194	0	4401.48	9801.18	20.63	2373.72	39.58	2316.19	28.66	15174.92	46.11	528	25.58
Pleuronectes platessa (0-15cm)	68.49	627946.94	0	34192	112896.35	26.88	177341.74	85.24	42554.67	76.75	270560.18	95.26	24594	43.80
Pleuronectes platessa (15-25cm)	69.98	434487.24	0	41794.21	323176.7	86.67	33748.44	76.56	11741.71	54.78	11030.39	44.40	54790	94.96
Pleuronectes platessa (>25cm)	40.32	99170.87	0	16775.15	90087.32	86.25	1192.02	18.23	1756.19	22.29	117.33	2.66	6018	84.50
Pleuronectes platessa totaal	94.85	1162220.05	0	56580.18	526775.37	97.50	212282.21	94.44	56052.57	85.35	281707.9	96.02	85402	100.00
Raja sp	13.6	1915.32	0	648	1915.32	7.29	.	0.00	.	0.00	.	0.00	.	100.00
Rhinonemus cimbrius	4.6	3781.58	0	396	3680.25	17.08	5.33	0.35	.	0.00	.	0.00	96	5.04
Scophtalmus maximus (0-15cm)	0.6	231.17	0	74.67	58.5	1.04	.	0.00	0	0.00	170.67	1.33	2	0.39
Scophtalmus maximus (15-25cm)	7.52	1531.83	0	120	1337.16	23.33	.	0.00	16	0.96	26.67	0.57	152	17.05
Scophtalmus maximus (>25cm)	15.64	1636.04	0	81	1536.04	62.29	.	0.00	0	0.00	16	0.38	84	13.95
Scophtalmus maximus totaal	18.52	4014.03	0	615	3546.7	66.88	.	0.00	16	0.96	213.33	2.09	238	24.81
Scophthalmus rhombus (0-15cm)	1.21	135.82	0	10.67	3	0.42	.	0.00	21.33	1.27	107.49	3.42	4	0.78
Scophthalmus rhombus (15-25cm)	4.18	555.81	0	48	426.48	13.13	.	0.00	32	1.91	69.33	1.90	28	4.26
Scophthalmus rhombus (>25cm)	11.23	1264.03	0	55.79	1176.7	42.50	.	0.00	5.33	0.32	0	0.00	82	14.34
Scophthalmus rhombus totaal	14.11	1955.67	0	57	1606.18	46.25	.	0.00	58.67	3.50	178.82	4.74	114	*17.83
Scomber scomber	1.39	115.67	0	12	63	3.75	16	0.87	.	0.00	10.67	0.19	26	2.33
Scyliorhinus caniculus	1.02	3274.5	0	1536	3274.5	4.58	.	0.00	.	0.00	.	0.00	.	0.00
Solea solea (0-15cm)	41.39	95476.66	0	18090.67	1600.83	9.38	48628.34	60.94	8112	51.27	34389.68	49.15	2746	29.46
Solea solea (15-25cm)	40.74	69714.53	0	8100	58737.39	83.54	2033.15	23.78	2096	32.80	576	4.17	6272	83.33
Solea solea (>25cm)	30.81	26270.29	0	2592	24515.25	94.58	355.05	7.47	245.33	7.01	26.67	1.14	1128	53.88
Solea solea totaal	72.3	191536.15	0	18304	84853.27	95.83	51016.54	68.06	10453.33	62.42	35007.02	50.28	10146	94.96
Sprattus sprattus	16.33	18269.97	0	1594.3	2722.8	8.54	5741.02	16.67	1312	8.28	8262.15	31.69	232	8.53
Syngnathus sp	20.65	92647.5	0	5450.07	223.5	3.13	6400	12.67	1808	21.34	84064	51.04	152	8.14
Trachurus trachurus	16.57	13407.26	0	1248	2614.69	24.79	5492.57	15.10	2122.67	13.38	69.33	1.71	3108	38.76
Trachinus vipera	19.54	67862.50	0	3072	39630.24	35.00	12405.65	20.14	26.67	1.59	176	3.42	15534	44.19
Trigla lucerna	31.32	12972.79	0	288	7045.04	62.29	2731.08	28.65	20.67	1.59	192	4.74	2978	70.16
Trisopterus luscus	27.29	67055.72	0	12312	21084.32	20.21	12218.11	26.22	21461.33	44.27	6572.95	22.77	5724	31.40
Trisopterus minutus	7.84	25157.04	0	11016	22834.33	14.79	836.05	7.29	37.33	1.59	309.33	2.47	1040	14.73
Zoarces viviparis	20.51	19791.53	0	768	1478.12	5.00	2413.93	10.07	3729	23.89	11674.08	49.72	498	8.91
abundance<0.5%														
Aspitrigla cuculus	0.46	274.5	0	72	274.5	2.08	.	0.00	.	0.00	.	0.00	.	0.00
Atherina presbyter	0.29	69.33	0	21.33	.	0.00	.	0.00	69.33	1.91	.	0.00	.	0.00
Coryphaenoides rupestris	0.05	3	0	3	3	0.21	.	0.00	.	0.00	.	0.00	.	0.00
Crenomugil labrosus	0.05	12	0	12	12	0.21	.	0.00	.	0.00	.	0.00	.	0.00
Entelurus aequoreus	0.32	26	0	5.33	6	0.42	.	0.00	16	0.96	.	0.00	4	0.78
Galeorhinus galeus	0.32	111.04	0	48	108.38	1.25	2.67	0.17	.	0.00	.	0.00	.	0.00
Glyptocephalus cynoglossus	0.09	35	0	32	3	0.21	32	0.17	.	0.00	.	0.00	.	0.00
Gobius niger	0.09	167.33	0	162	162	0.21	.	0.00	5.33	0.32	.	0.00	.	0.00
Lampetra fluviatilis	0.42	37.33	0	5.33	.	0.00	10.67	0.69	.	0.00	26.67	0.95	.	0.00
Lepidorh. whiffiagonis	0.05	10.67	0	10.67	.	0.00	10.67	0.17	.	0.00	.	0.00	.	0.00
Lumpenus lampretaeformis	0.19	258.46	0	247.96	258.46	0.83	.	0.00	.	0.00	.	0.00	.	0.00
Microchirus variegatus	0.05	3	0	3	3	0.21	.	0.00	.	0.00	.	0.00	.	0.00
Mola mola	0.05	1.5	0	1.5	1.5	0.21	.	0.00	.	0.00	.	0.00	.	0.00
Molva molva	0.14	1323	0	1296	1323	0.63	.	0.00	.	0.00	.	0.00	.	0.00
Mugilidae sp	0.14	19.33	0	12	12	0.21	.	0.00	.	0.00	5.33	0.19	2	0.39
Mustelus mustelus	0.05	24	0	24	24	0.21	.	0.00	.	0.00	.	0.00	.	0.00
Petromyzon marinus	0.23	16	0	5.33	.	0.00	10.67	0.69	5.33	0.32	.	0.00	.	0.00
Pollachius pollachius	0.05	2	0	2	.	0.00	.	0.00	.	0.00	.	0.00	2	0.39
Pollachius virens	0.05	5.33	0	5.33	.	0.00	.	0.00	.	0.00	5.33	0.19	.	0.00
Raniceps raninus	0.05	2	0	2	.	0.00	.	0.00	.	0.00	.	0.00	2	0.39
Salmo trutta	0.05	1.5	0	1.5	1.5	0.21	.	0.00	.	0.00	.	0.00	.	0.00
Sardina pilchardus	0.05	3	0	3	3	0.21	.	0.00	.	0.00	.	0.00	.	0.00
Solea lascaris	0.42	42.46	0	10.13	37.13	1.46	5.33	0.35	.	0.00	.	0.00	.	0.00
Spondyliosoma cantharus	0.05	341.33	0	341.33	.	0.00	.	0.00	.	0.00	341.33	0.19	.	0.00
Squalus acanthias	0.19	199.17	0	170.67	28.5	0.63	170.67	0.17	.	0.00	.	0.00	.	0.00
Trisopterus esmarki	0.05	2	0	2	0	0.00	.	0.00	.	0.00	.	0.00	2	0.39
Zeus faber	0.05	1.5	0	1.5	1.5	0.21	.	0.00	.	0.00	.	0.00	.	0.00

Table 3.3: Eigenvalues and the proportion of explained variance of the first ten principal components.

	Eigenvalue	Proportion	Cumulative
PRIN1	9.08655	0.146557	0.146557
PRIN2	3.83298	0.061822	0.208379
PRIN3	3.00229	0.048424	0.256803
PRIN4	2.11962	0.034187	0.29099
PRIN5	1.99326	0.032149	0.323139
PRIN6	1.7703	0.028553	0.351692
PRIN7	1.52076	0.024528	0.37622
PRIN8	1.45475	0.023464	0.399684
PRIN9	1.39008	0.022421	0.422105
PRIN10	1.30072	0.020979	0.443084

Fig. 3.1a: Sampling sites plotted according to their first two principal components.

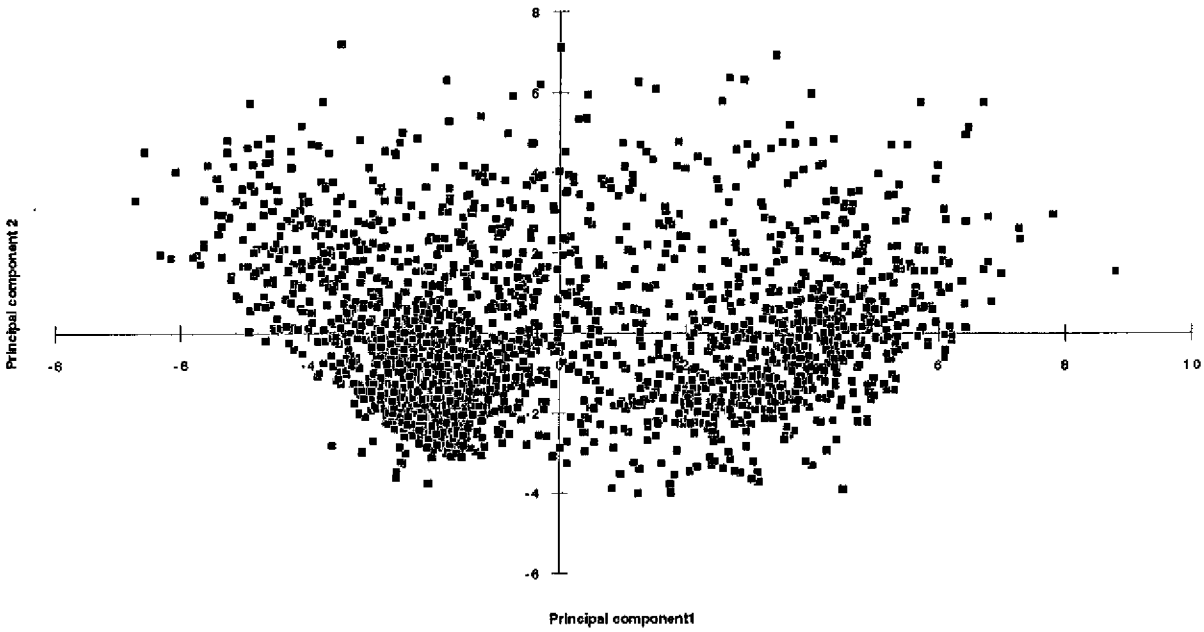
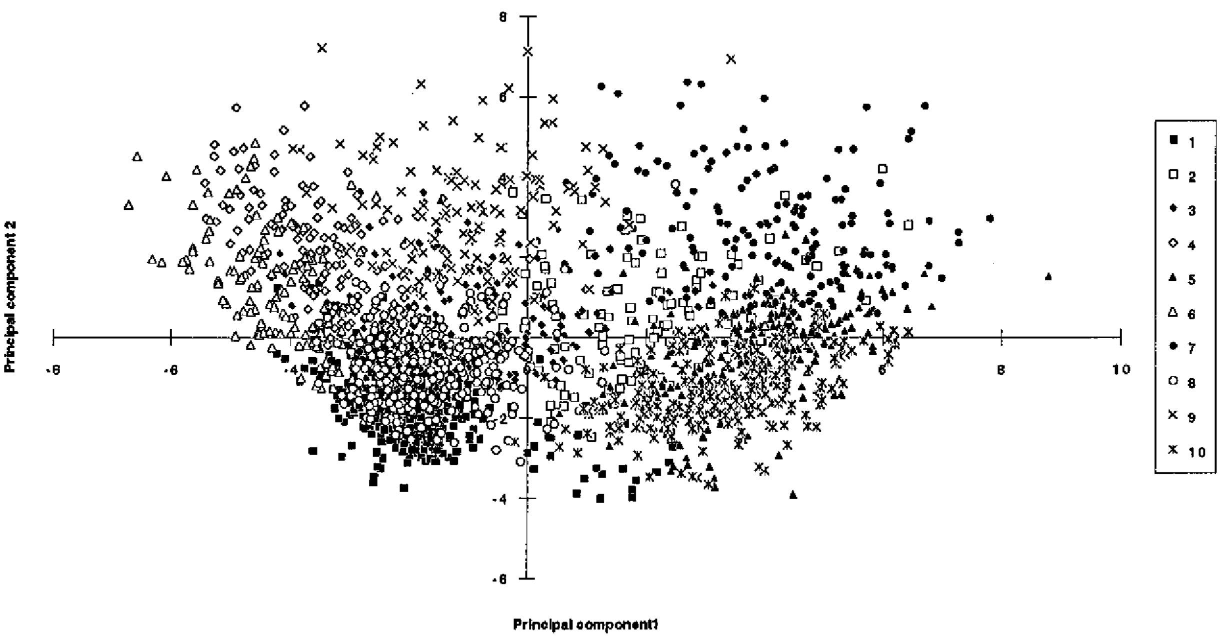


Fig. 3.1b: Sampling sites plotted according to their first two principal components.
Label = cluster number obtained by the 10 cluster classification.



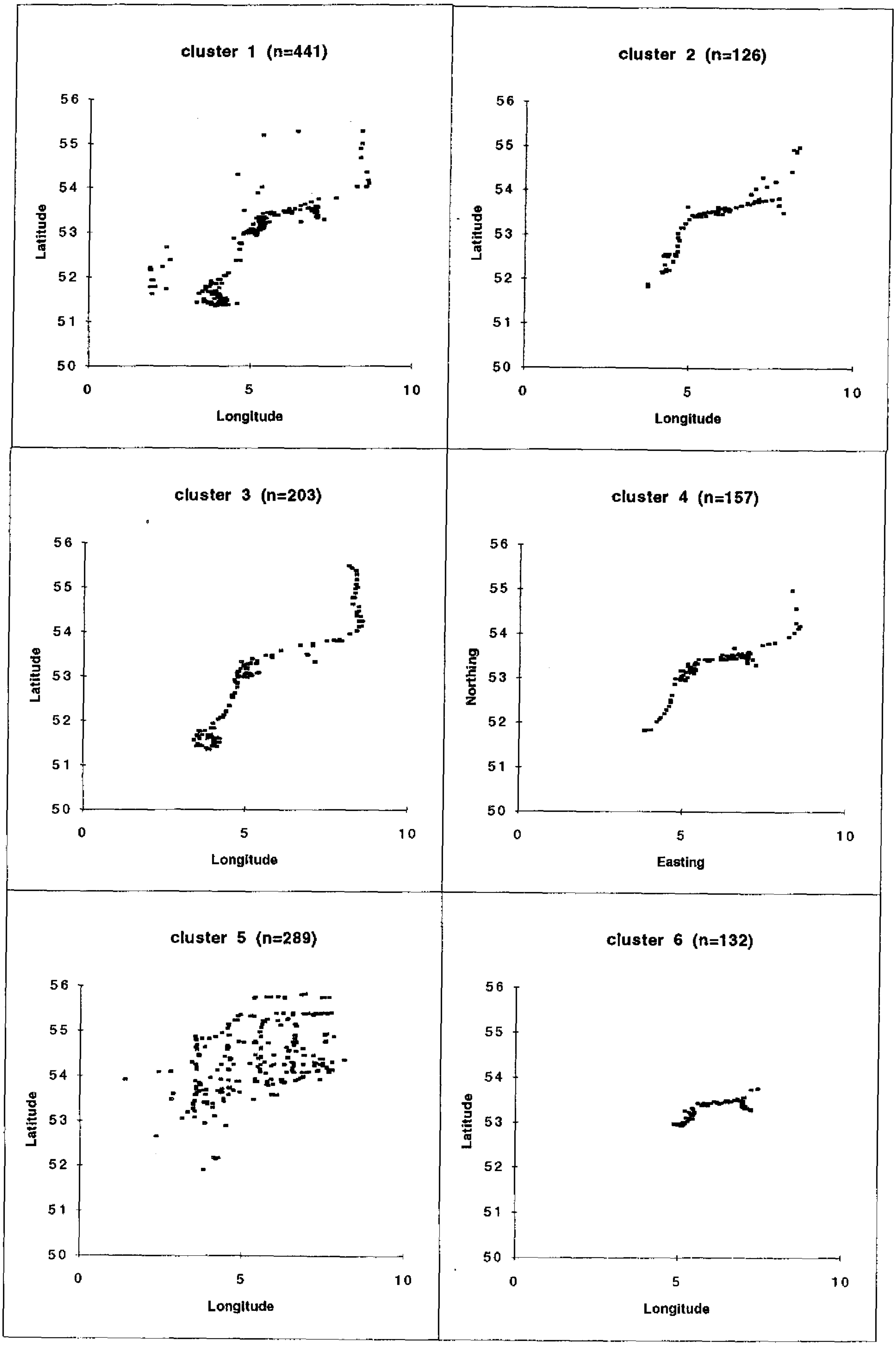


Fig. 3.2: Plots of the 10 cluster classification of the sampling sites according to the species composition (FASTCLUS procedure).

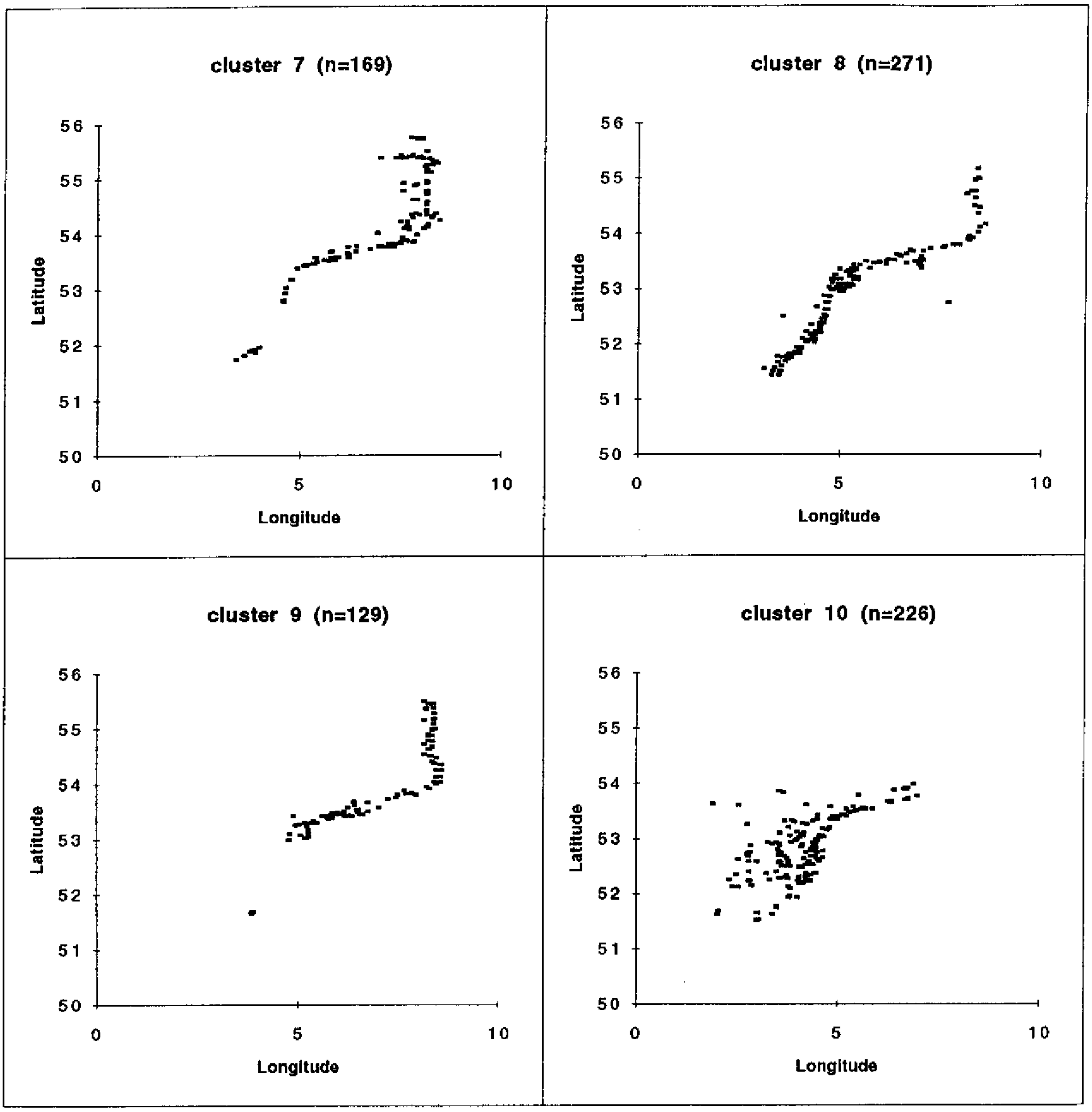

cluster 7 (n=169)
Latitude
Longitude
56
55
54
53
52
51
50
0
5
10
cluster 8 (n=271)
Latitude
Longitude
cluster 9 (n=129)
Latitude
Longitude
cluster 10 (n=226)
Latitude
Longitude

Fig. 3.2:

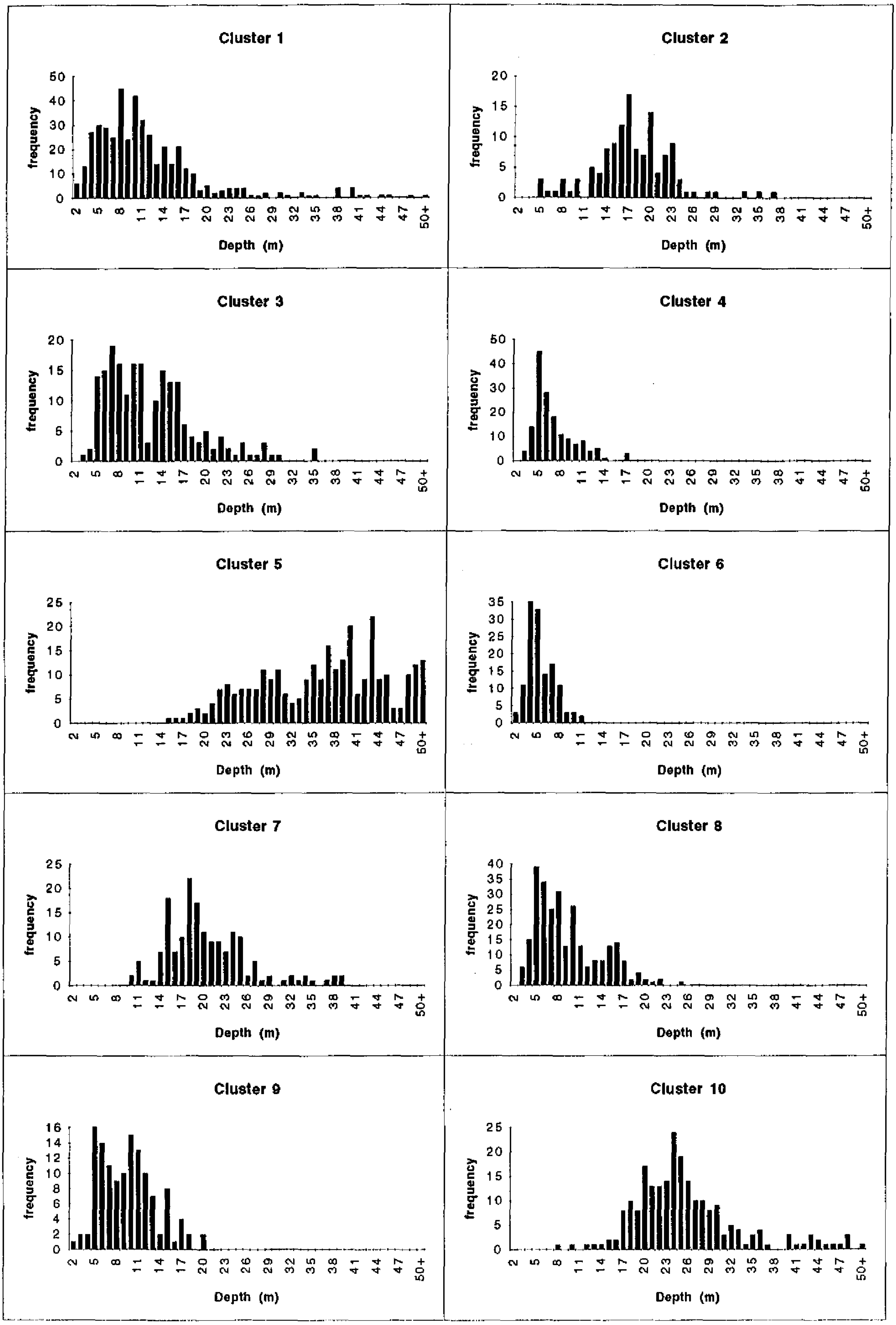


Fig. 3.3: Plots of the frequency distribution of depth for each cluster in the 10 cluster classification.

Fig. 3.4: Distribution of relative cluster frequency per depth interval of 1m. (10 cluster classification).

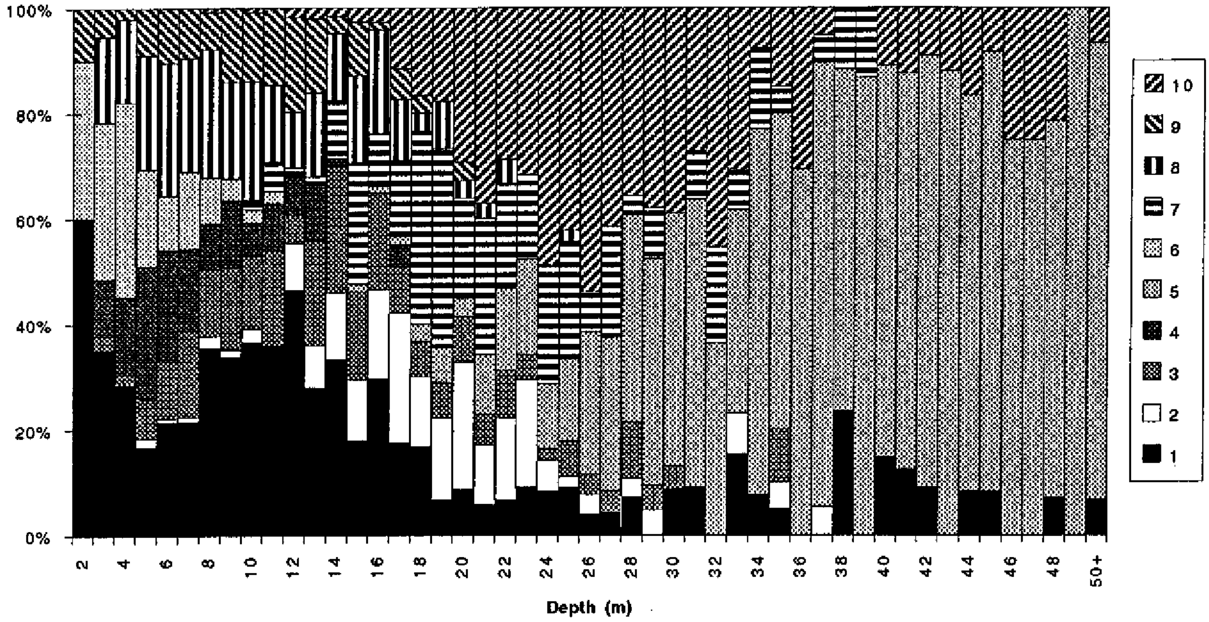


Table 3.4: Distribution of the number of hauls of the surveys in each cluster (10 cluster classification).

Cluster	BTS,ISI	DFS,ISI	DFS,SCH	DFS,STE	SNS,TRI	Total
1	21	48	240	131	1	441
2	14	82	.	.	30	126
3	4	96	70	30	3	203
4	.	38	.	119	.	157
5	228	1	.	.	60	289
6	.	2	.	130	.	132
7	90	8	.	.	71	169
8	2	196	.	67	6	271
9	2	70	3	49	5	129
10	118	27	.	.	79	224
Total	479	568	313	526	255	2141

Table 3.5: Distribution of the number of hauls of the years in each cluster (10 cluster classification).

Cluster	1990	1991	1992	1993	1994	Total
1	66	90	100	96	89	441
2	16	12	33	36	29	126
3	49	51	52	23	28	203
4	13	49	15	25	55	157
5	60	60	57	59	53	289
6	21	13	22	39	37	132
7	40	35	46	26	22	169
8	42	51	50	74	54	271
9	78	15	13	7	16	129
10	38	46	45	50	45	224
Total	423	422	433	435	428	2141

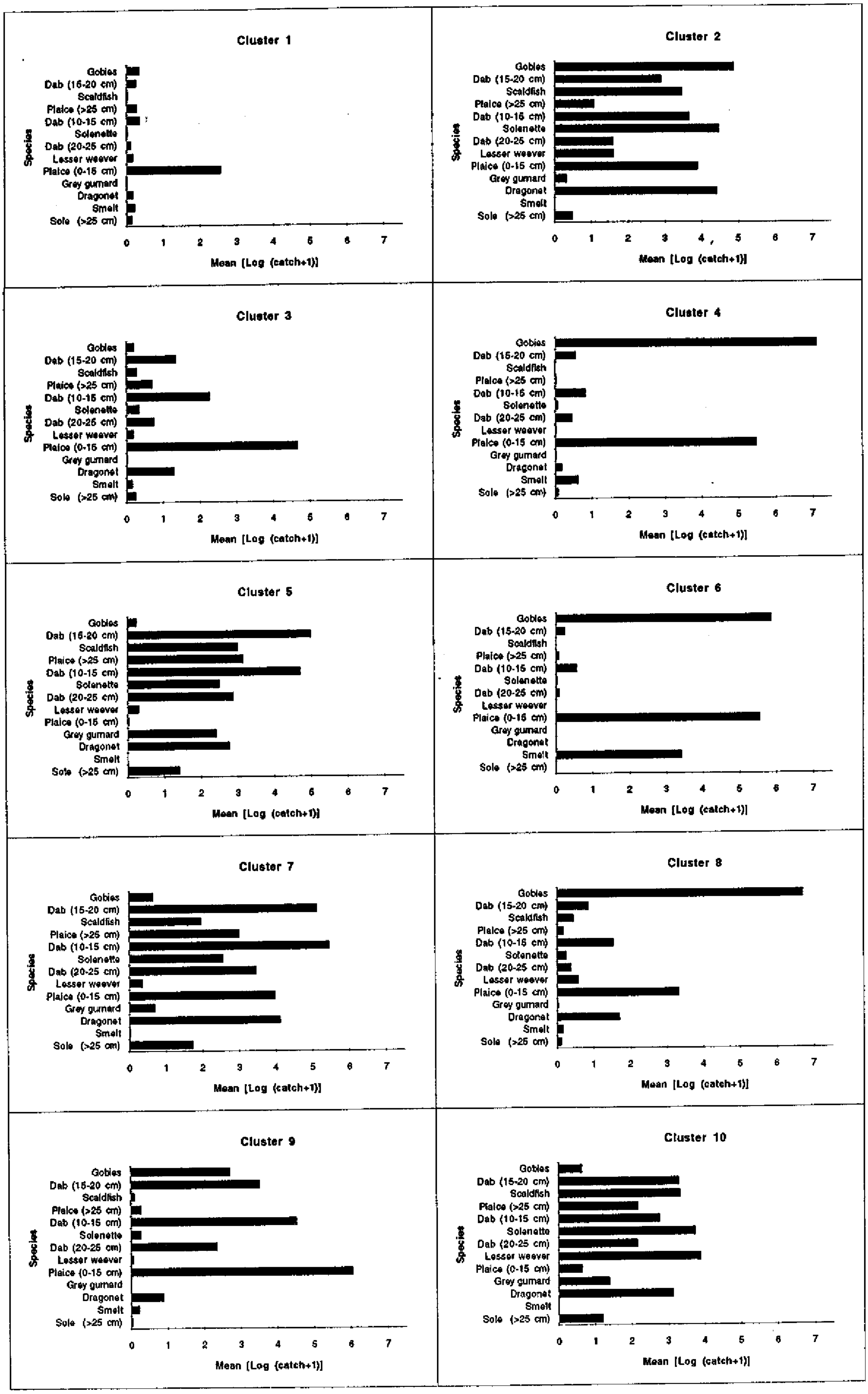


Fig. 3.5: Mean values ($\log_e$ (catch+1)) of the species which mainly account ($R^2 > 0.4$) for the separation of the hauls in the 10 cluster classification according to the species distribution. The species are listed by decreasing R^2 values.

	Cluster	1	2	3	4	5	6	7	8	9	10
R^2	Species										
0.41	Sole (>25 cm)	0.15	0.47	0.24	0.08	1.41	0	1.73	0.1	0.04	1.21
0.47	Smelt	0.23	0	0.16	0.62	0	3.4	0.02	0.15	0.22	0
0.5	Dragonet	0.17	4.41	1.29	0.19	2.77	0	4.12	1.7	0.87	3.14
0.53	Grey gurnard	0.01	0.32	0.03	0.03	2.41	0	0.69	0.02	0	1.38
0.55	Plaice (0-15 cm)	2.56	3.88	4.66	5.47	0.04	5.55	3.97	3.32	6.05	0.64
0.55	Lesser weever	0.17	1.6	0.19	0.03	0.29	0	0.36	0.58	0.06	3.88
0.56	Dab (20-25 cm)	0.12	1.58	0.74	0.45	2.88	0.09	3.47	0.37	2.36	2.16
0.59	Solenette	0.02	4.46	0.34	0.06	2.49	0.02	2.56	0.25	0.28	3.74
0.59	Dab (10-15 cm)	0.36	3.64	2.26	0.82	4.69	0.56	5.45	1.53	4.52	2.75
0.62	Plaice (>25 cm)	0.27	1.06	0.69	0.02	3.14	0.08	3.01	0.17	0.27	2.17
0.63	Scaldfish	0.04	3.45	0.27	0	3	0	1.96	0.43	0.09	3.33
0.7	Dab (15-20 cm)	0.25	2.89	1.34	0.56	4.99	0.24	5.12	0.85	3.52	3.29
0.76	Gobies	0.35	4.86	0.2	7.1	0.24	5.86	0.65	6.7	2.71	0.64

Table 3.6: Mean values ($\log_e$ (catch+1)) per cluster of the species which mainly account ($R^2 > 0.4$) for the separation of the hauls in the 10 cluster classification according to the species distribution.

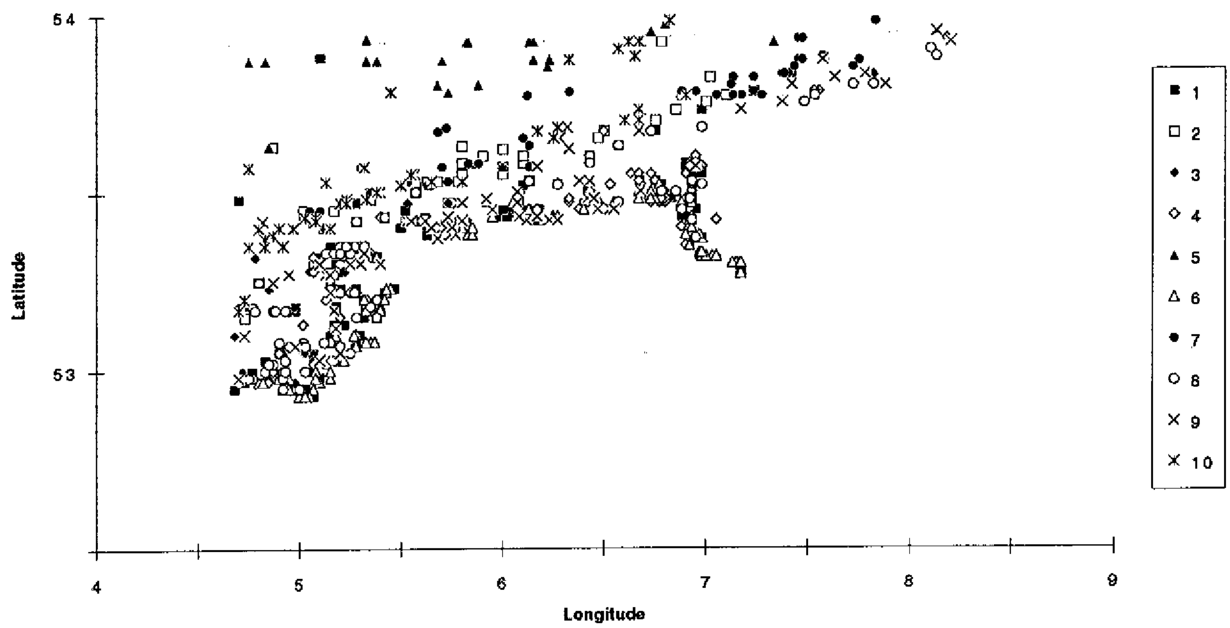


Fig 3.6: Sampling sites in the Waddensea area according to the 10 cluster classification.

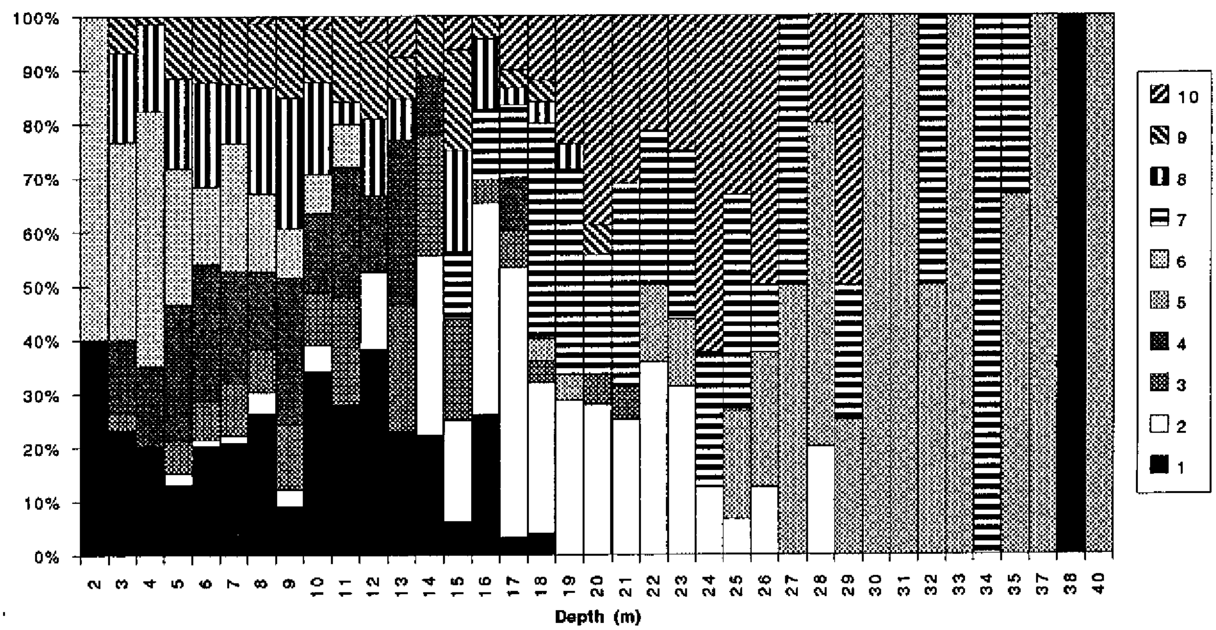


Fig. 3.7: Distribution of relative cluster frequency per depth interval of 1m. (10 cluster classification) in the Waddensea area.

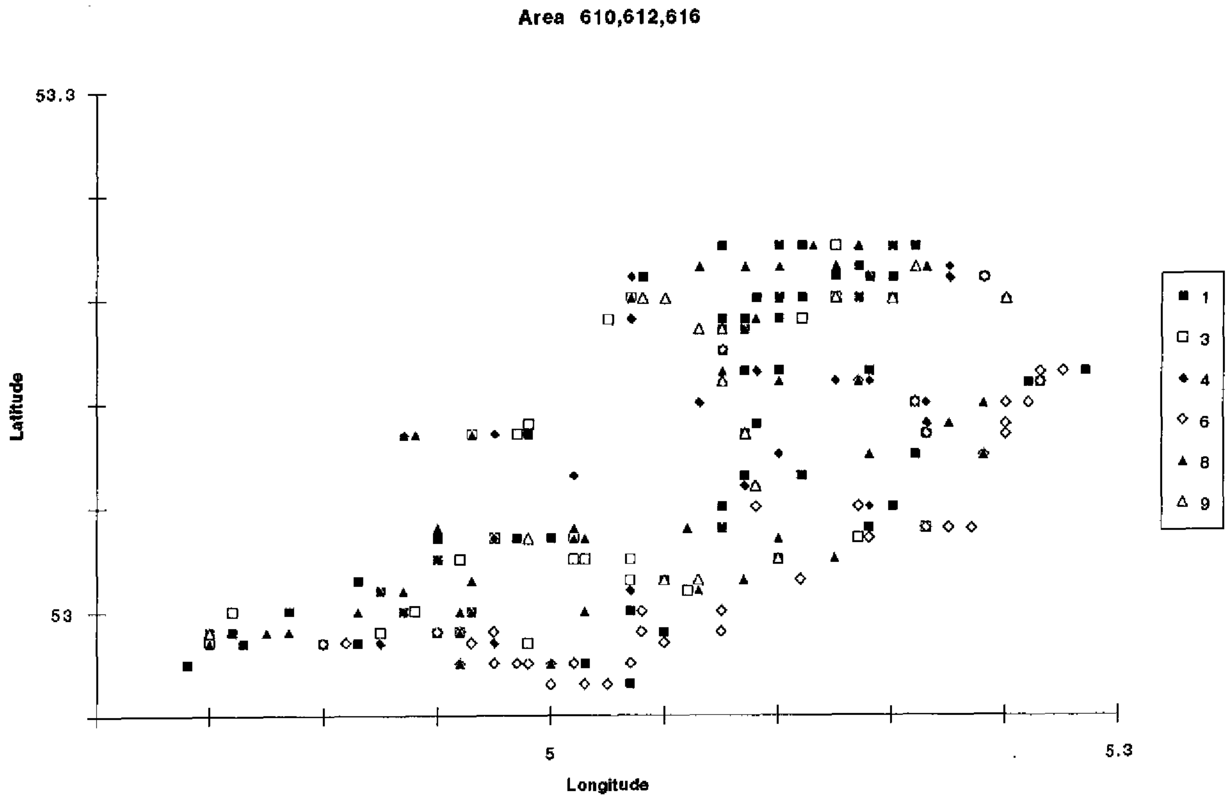


Fig 3.8: Sampling sites in the areas 610, 612 and 616 according to the 10 cluster classification.

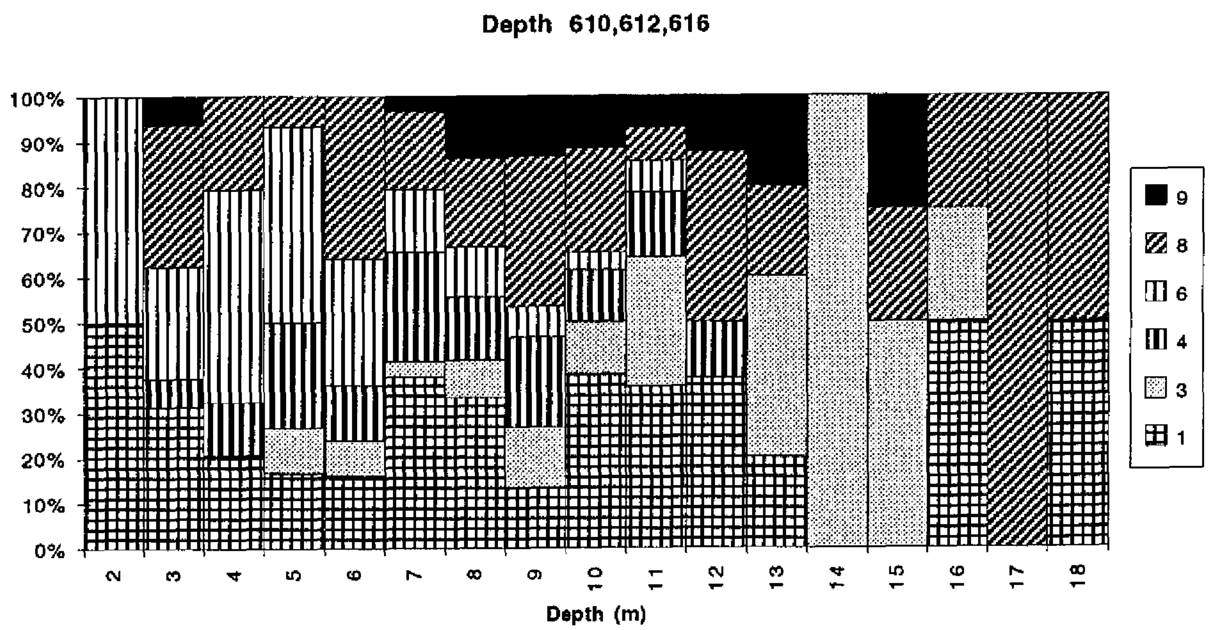


Fig. 3.9: Distribution of relative cluster frequency per depth interval of 1m (10 cluster classification) in the areas 610, 612 and 616.

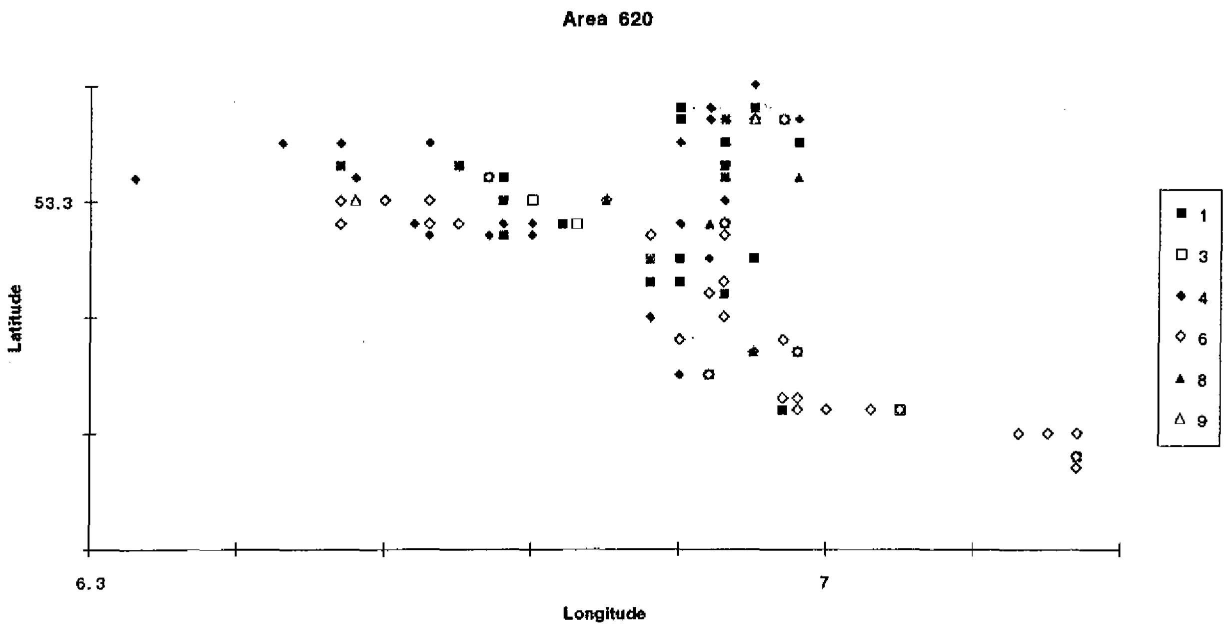


Fig 3.10: Sampling sites in area 620 according to the 10 cluster classification.

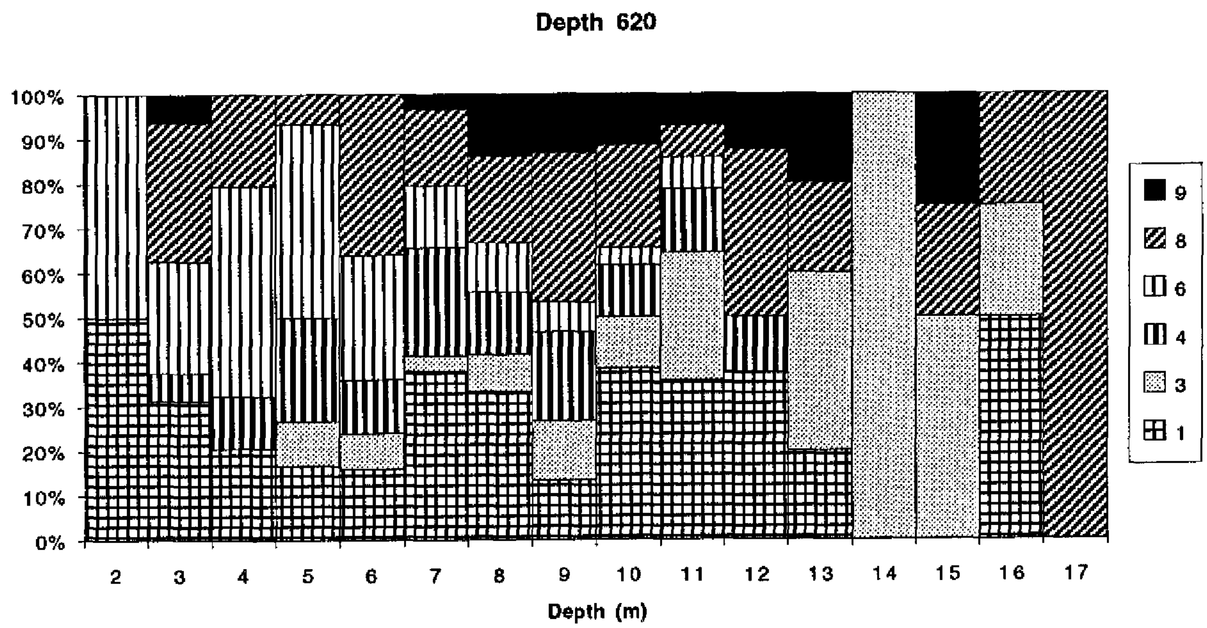


Fig. 3.11: Distribution of relative cluster frequency per depth interval of 1m (10 cluster classification) in area 620.

Area 634, 638

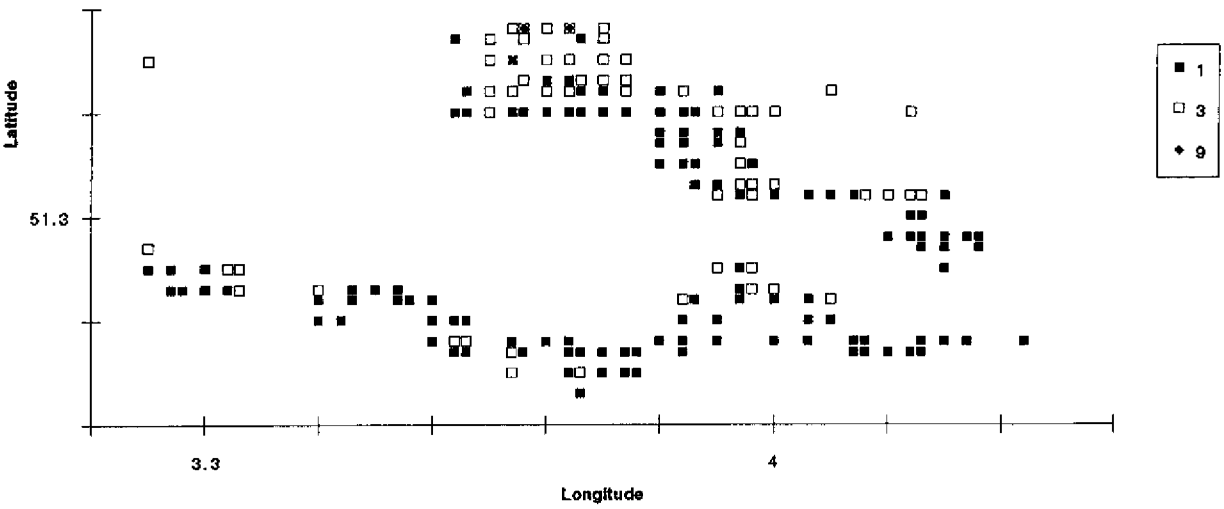


Fig 3.12: Sampling sites in area 634 and 638 (Easter and Wester Scheldt) according to the 10 cluster classification.

depth 634,638

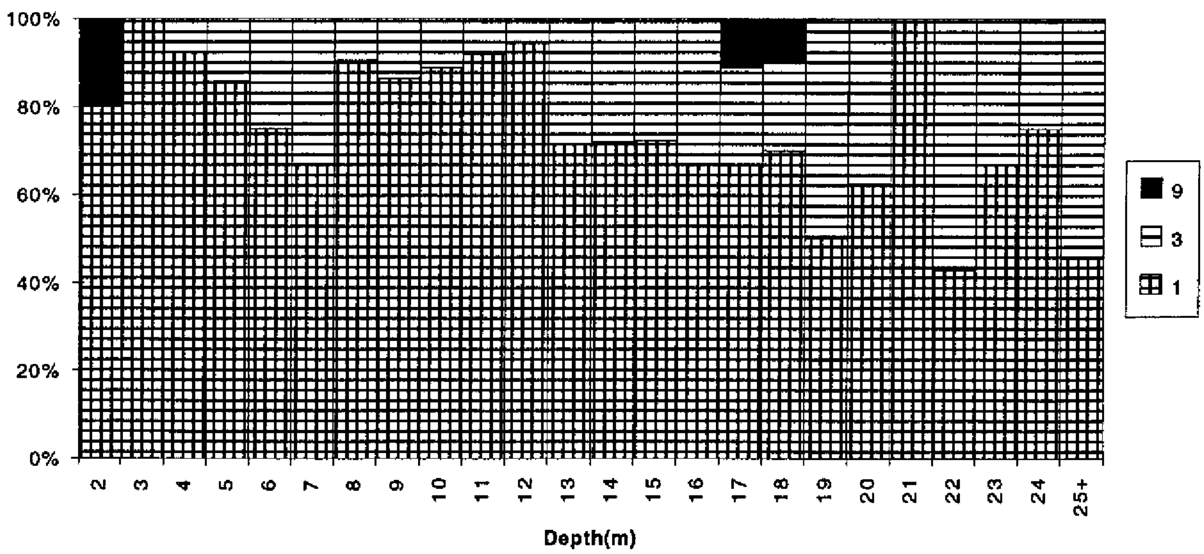


Fig. 3.13: Distribution of relative cluster frequency per depth interval of 1m (10 cluster classification) in area 634 and 638 (Easter and Wester Scheldt).

Cluster	Waddensea	Area 610	Area 612	Area 616	Area 620	Area 634	Area 638
1	143	28	2	39	34	110	130
2	81						
3	56	15	3	7	3	52	18
4	131	9	3	24	37		
5	29						
6	132	26		26	43		
7	62						
8	110	30	3	22	9		
9	73	6		10	2	3	
10	57						
Total:	874	114	11	128	128	165	148

Table 3.7: Number of stations present in each cluster in the Waddensea area and the sub-areas 610 - 638 based on the 10 cluster classification.

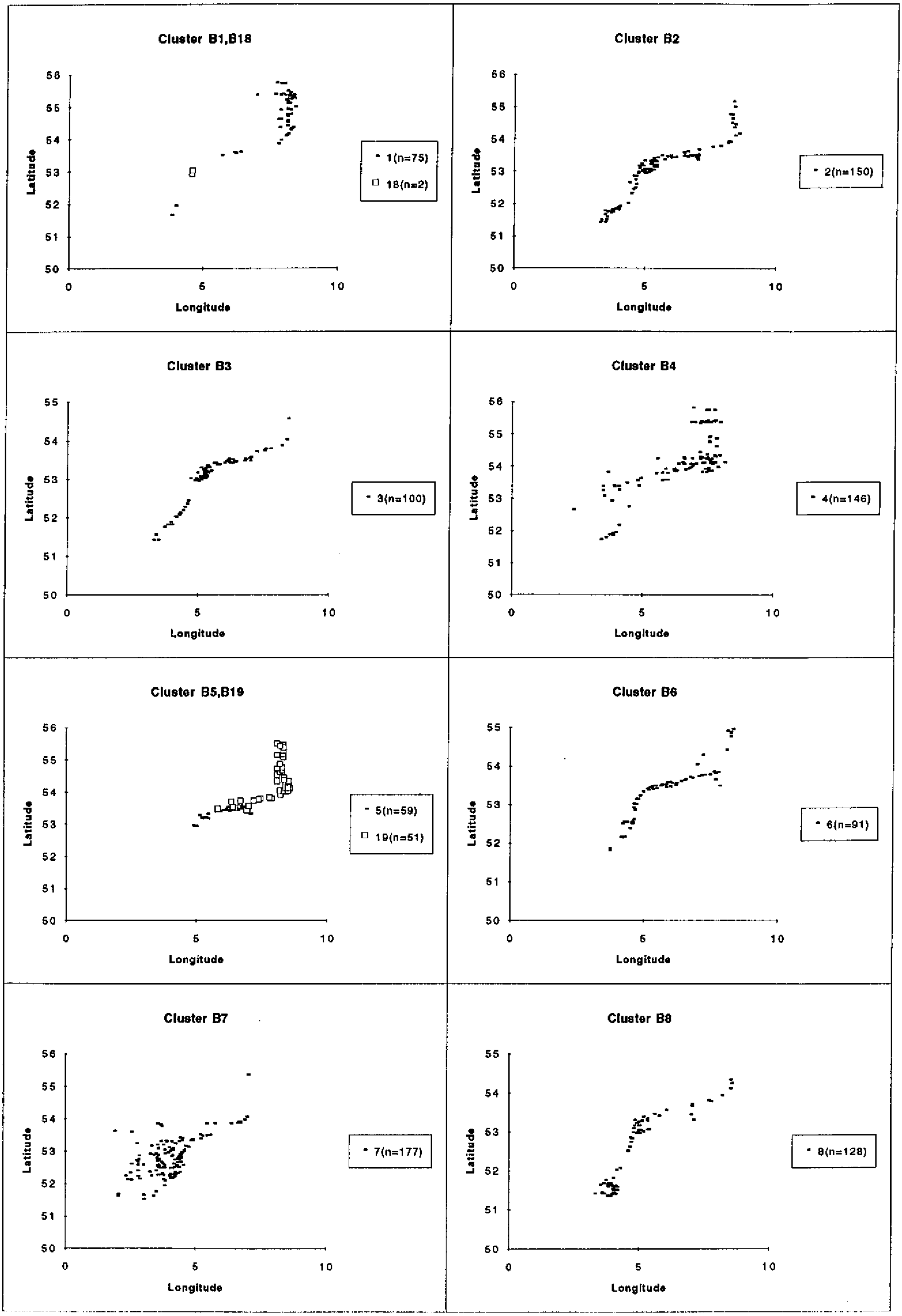


Fig. 3.14: Plots of the 20 cluster classification of the sampling sites according to the species composition (FASTCLUS procedure).

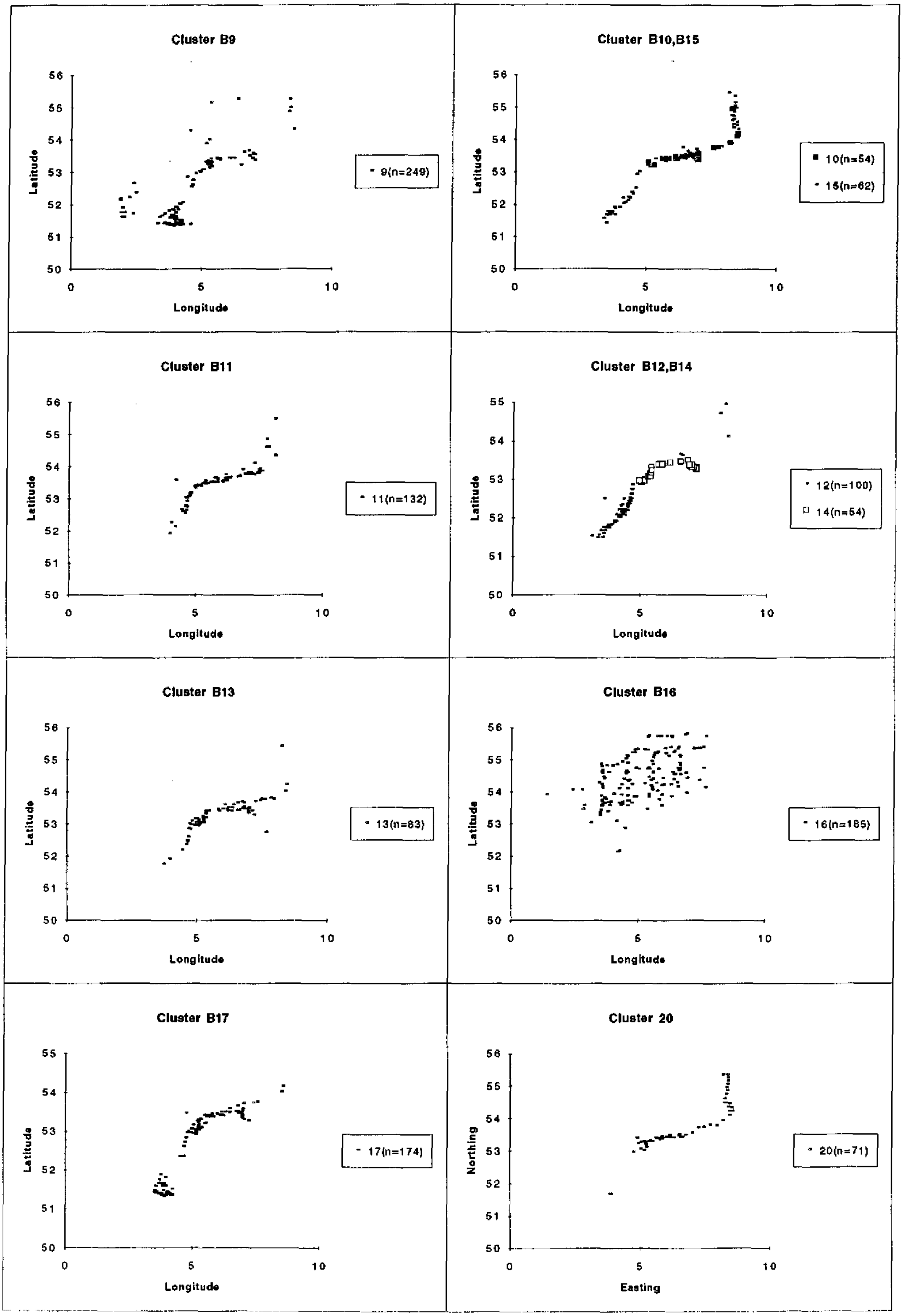

Cluster B9
Latitude
Longitude
9(n=249)
Cluster B10,B15
10(n=54)
15(n=62)
Cluster B11
11(n=132)
Cluster B12,B14
12(n=100)
14(n=54)
Cluster B13
13(n=83)
Cluster B16
16(n=185)
Cluster B17
17(n=174)
Cluster 20
Northing
Easting
20(n=71)

Fig. 3.14:

Table 3.8: Resident coastal zone and estuarine species selected for the 7 cluster classification (FASTCLUS procedure).

NUDC-code	Spcode	Scientific name	English name	Dutch name
8603010205	lamflu	*Lampetra fluviatilis*	Lampern	Rivierprik
8741010102	angang	*Anguila anguila*	Eel	Aal
8747010109	alofal	*Alosa fallax*	Twaite shad	Fint
8747020104	engeng	*Engraulis encrasicolus*	Anchovy	Ansjovis
8755030301	osmepe	*Osmerus eperlanus*	Smelt	Spiering
8791032401	cilmus	*Ciliata mustela*	Five-bearded rockling	Vijfdradige meun
8793012001	zoaviv	*Zoarces viviparis*	Eelpout	Puitaal
8818010101	gasacu	*Gasterosteus aculeatus*	Three spined stickleback	Dried. stekelbaars
8820020119	syngsp	*Syngnathus sp*	pipefish	zeenaald
8820022101	entaeq	*Entelurus aequoreus*	Snake pipefish	Adderzeenaald
8831022207	myosco	*Myoxocephalus scorpius*	Bullrout	Zeedonderpad
8831090828	liplip	*Liparis liparis*	Sea-snail	Slakdolf
8842130209	phogun	*Pholis gunnellus*	Butterfish	Botervis
8847011300	gobisp	*Gobius sp*	Gobies	Grondels
8847041402	plafle	*Platichthys flesus*	Flounder	Bot
Abundance <0.5%				
8805021001	athpre	*Atherina presbyter*	Sand-smelt	Koornaarnvis
8836010000	mugisp	*Mugilidae sp*	Mullets	Harders
8847011316	gobnig	*Gobius niger*	Black goby	Zwarte grondel

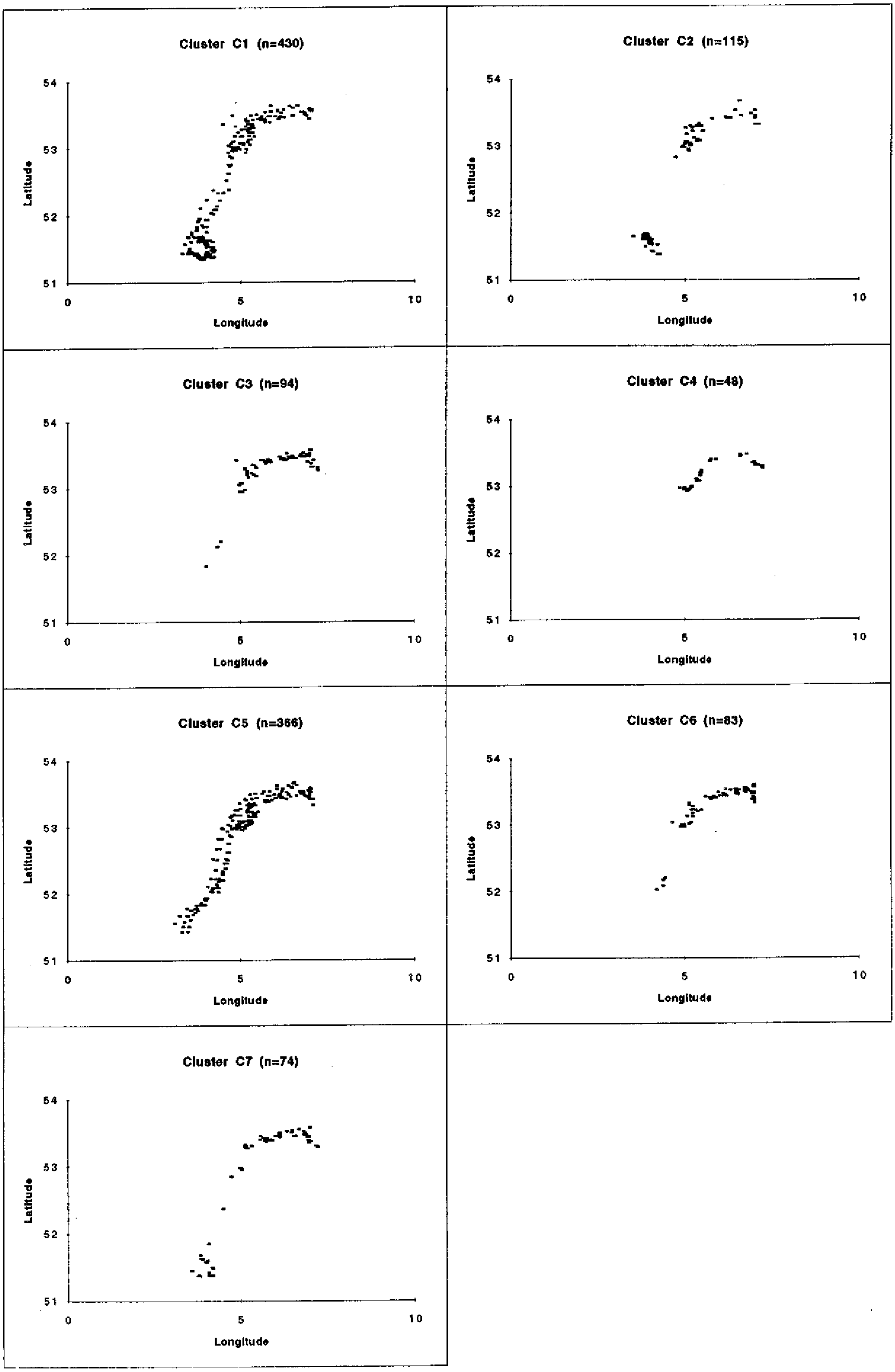


Fig. 3.15: Plots of the 7 cluster classification of the sampling sites according to the species composition of the resident coastal zone and estuaries (FASTCLUS procedure).

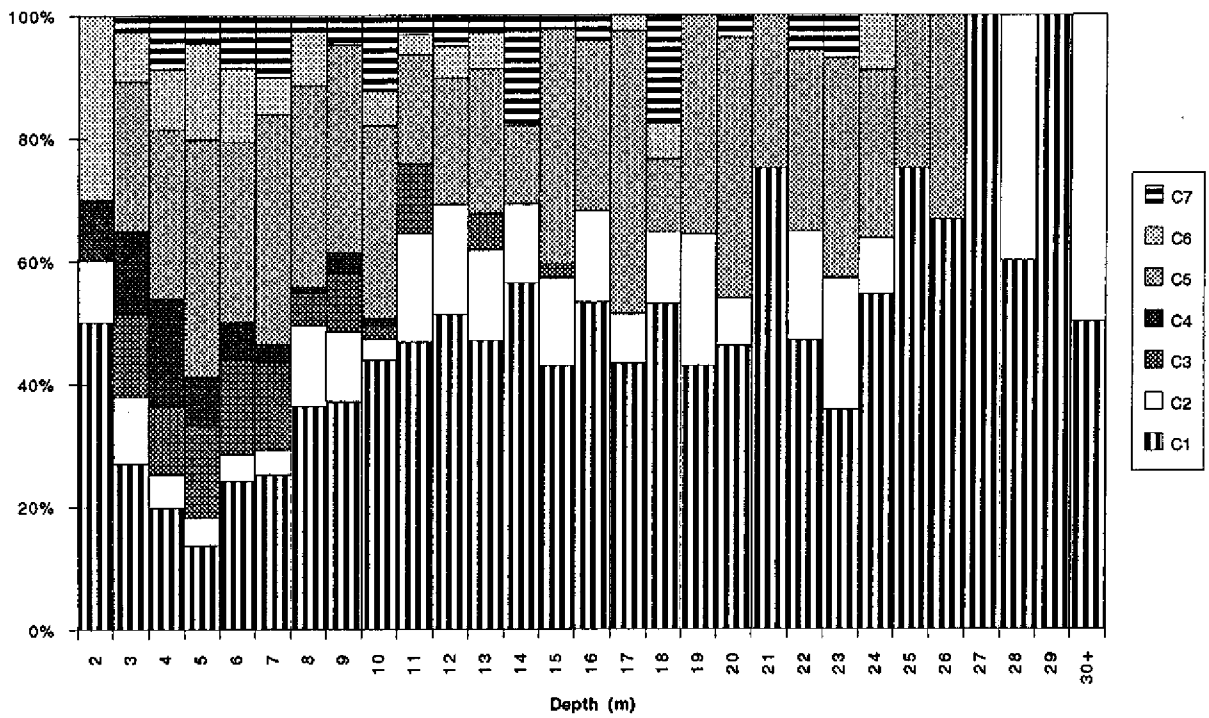


Fig. 3.16: Distribution of relative cluster frequency per depth interval of 1m. (7 cluster classification).

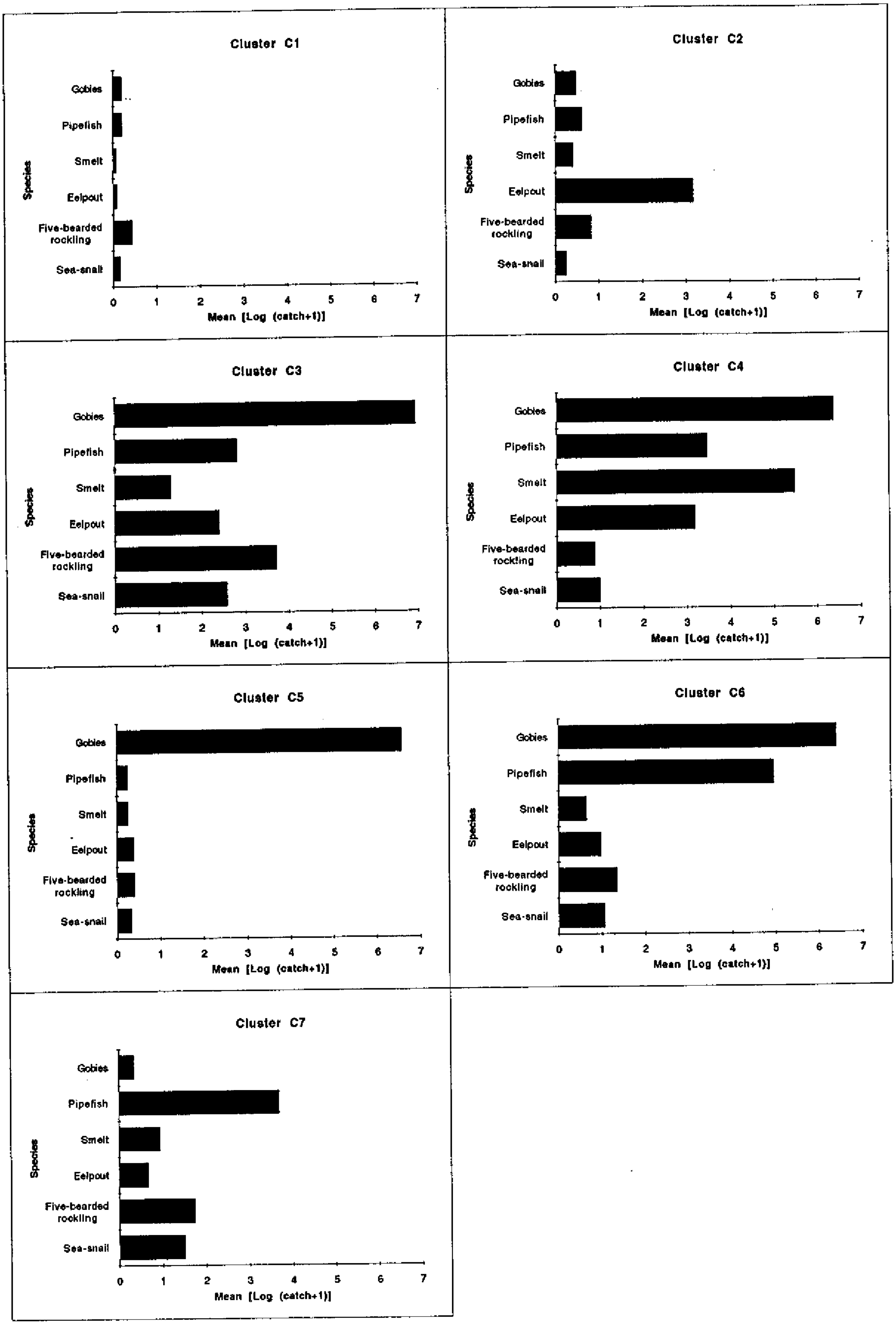
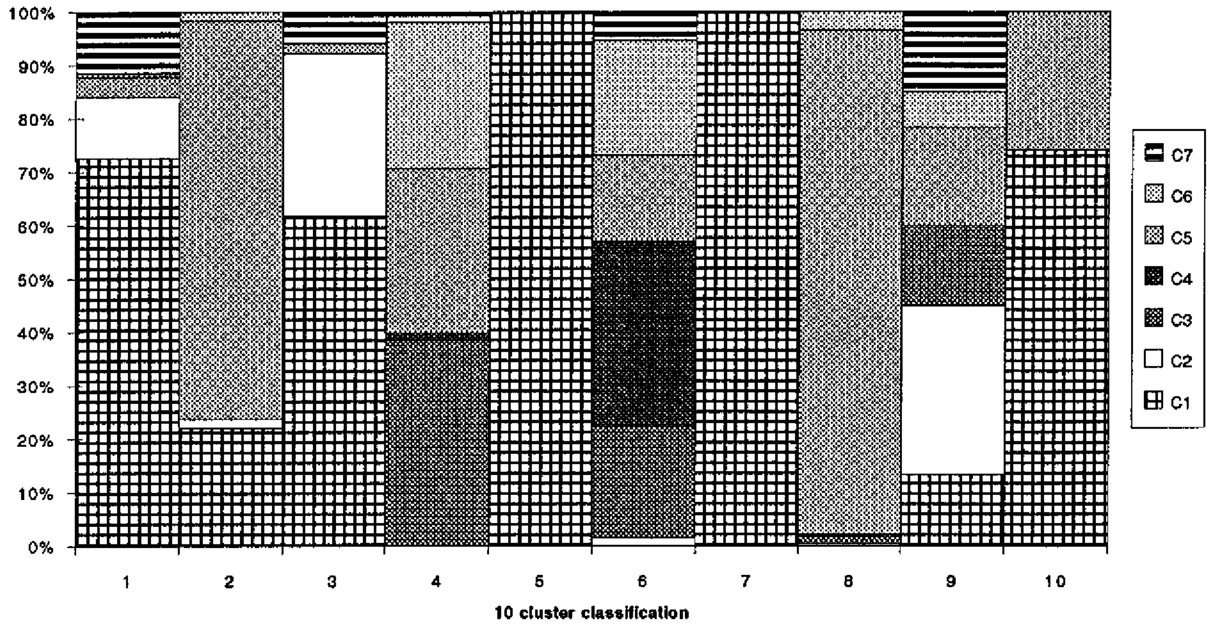


Fig 3.17: Mean values ($\log_e$ (catch+1)) per cluster of the species which mainly account ($R^2 > 0.4$) for the separation of the hauls in the 7 cluster classification according to the species distribution.

Fig 3.18: Comparison of the 10 cluster classification and the 7 cluster classification based on the allocation of the hauls in each cluster.



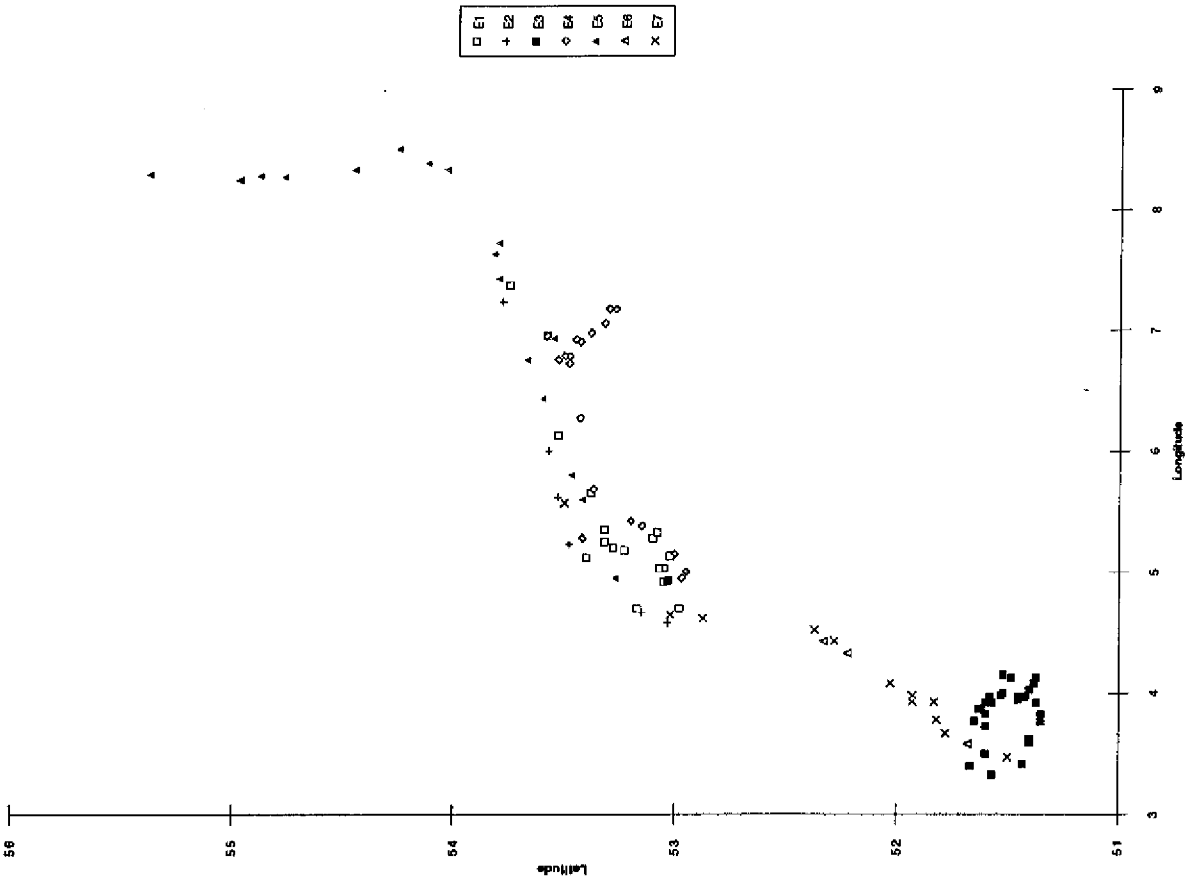


Fig 3.19: The clusters of the 7 cluster classification. The hauls are pooled into 3x3 mile rectangles and into two depthbands (intervals of 15m).

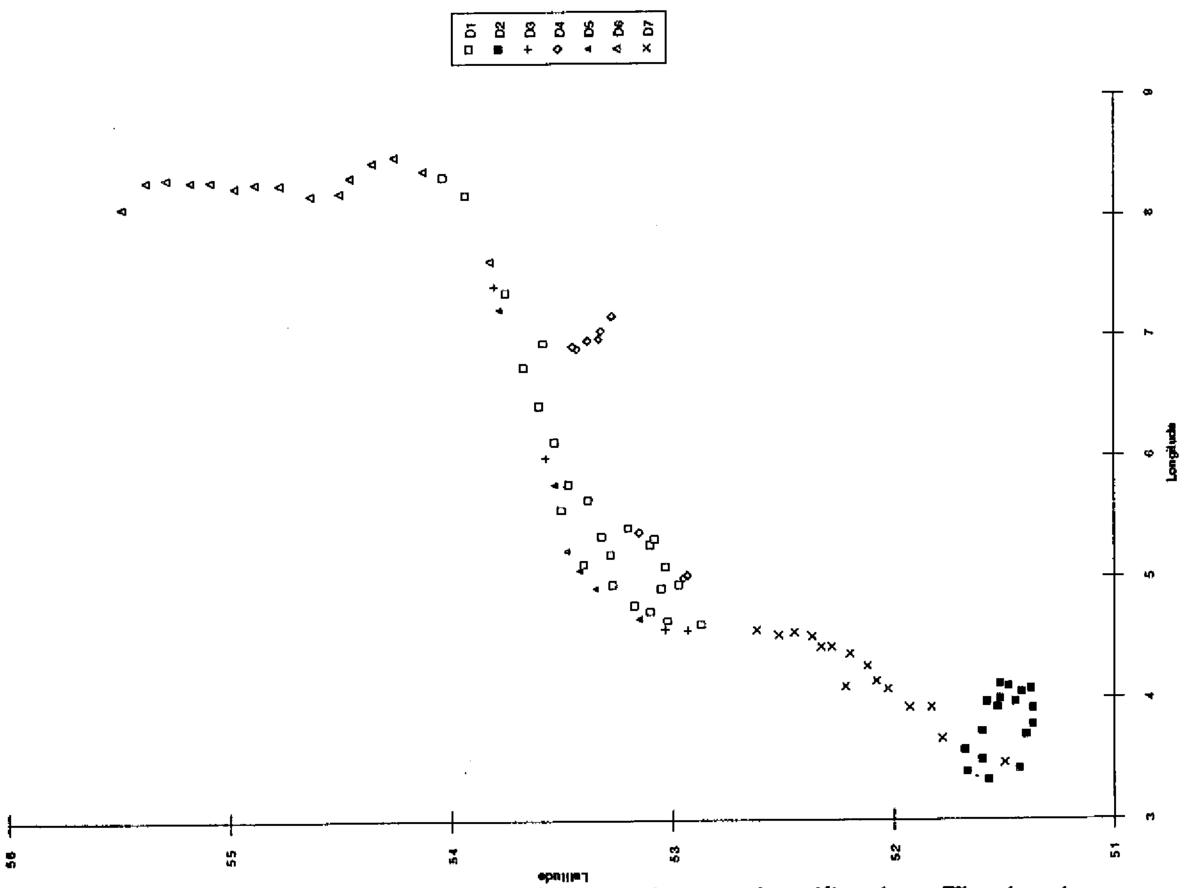


Fig 3.20: The clusters of the 7 cluster classification. The hauls are pooled into 3x3 mile rectangles and into six depthbands (intervals of 5m).

Table 3.9: Distribution of the 3x3 mile rectangles in the clusters. The hauls are pooled into 3x3 mile rectangles and into two depthbands (intervals of 15m).

Number of hauls				Cluster				
In 3x3M-block	D1	D2	D3	D4	D5	D6	D7	Totaal
5	3	.	1	2	3	9	3	21
6	.	1	1	.	.	.	2	4
7	.	1	.	.	1	1	1	4
8	.	.	.	1	1	1	3	6
9	3	.	1	.	.	.	2	6
10	.	1	.	2	.	3	.	6
11	3	4	1	.	.	.	1	9
12	2	.	.	1	.	.	.	3
13	.	1	.	.	1	.	.	2
14	2	.	.	.	.	.	.	2
15	1	.	.	.	.	1	.	2
16	2	1	.	.	.	.	1	4
17	.	.	.	1	.	.	1	2
18	.	.	.	.	.	.	1	1
20	1	2	.	.	.	.	.	3
21	.	1	.	.	.	.	.	1
22	.	2	.	.	.	.	.	2
28	1	.	.	.	.	.	.	1
29	1	.	.	.	.	.	.	1
30	1	.	.	.	.	.	.	1
32	1	.	.	.	.	.	.	1
33	1	.	.	.	.	.	.	1
35	.	.	.	1	.	.	.	1
36	.	1	.	.	.	.	.	1
38	.	1	.	.	.	.	.	1
51	1	.	.	.	.	.	.	1
54	.	1	.	.	.	.	.	1
58	1	.	.	.	.	.	.	1
68	.	.	.	1	.	.	.	1
Totaal	24	17	4	9	6	15	15	90

Table 3.10: Distribution of the cluster frequency of the 3x3 mile rectangles per depth interval of 15m.

	Number of	Depth	
Cluster	blocks in cluster	0-15m	>15m
D1	24	24	.
D2	17	10	7
D3	4	.	4
D4	9	9	.
D5	6	.	6
D6	15	15	.
D7	15	13	2

Table 3.11: Distribution of the 3x3 mile rectangles in the clusters. The hauls are pooled into 3x3 mile rectangles and into six depthbands (intervals of 5m).

Number of hauls in 3x3M-block	E1	E2	E3	E4	E5	E6	E7	Totaal
5	1	4	9	5	5	2	5	31
6	2	.	1	.	6	.	2	11
7	1	.	2	1	3	.	1	8
8	3	1	4	3	3	1	1	16
9	.	.	2	.	.	.	2	4
10	1	1	2	1	.	.	.	5
11	3	.	.	.	.	.	1	4
12	.	.	1	1	.	.	.	2
13	.	.	2	2	.	.	.	4
14	1	.	.	1	.	.	.	2
15	.	.	2	.	.	.	.	2
16	1	.	.	.	.	.	.	1
17	.	.	.	1	.	.	.	1
18	1	.	2	.	.	.	.	3
19	.	.	.	1	.	.	.	1
21	1	.	.	.	.	.	.	1
22	1	.	.	.	.	.	.	1
26	1	.	.	1	.	.	.	2
27	1	.	.	.	.	.	.	1
30	.	.	.	1	.	.	.	1
31	.	.	.	1	.	.	.	1
36	.	.	1	.	.	.	.	1
Totaal	18	6	28	19	17	3	12	103

Table 3.12: Distribution of the cluster frequency of the 3x3 mile rectangles per depth interval of 5m.

Cluster	Number of blocks in cluster	0-5m	Depth 5-10m	10-15m	15-20m	20-25m	>25m
E1	18	2	14	2	.	.	.
E2	6	.	.	.	3	3	.
E3	28	3	6	11	4	3	1
E4	19	13	4	2	.	.	.
E5	17	1	8	6	2	.	.
E6	3	.	1	.	2	.	.
E7	12	4	6	2	.	.	.

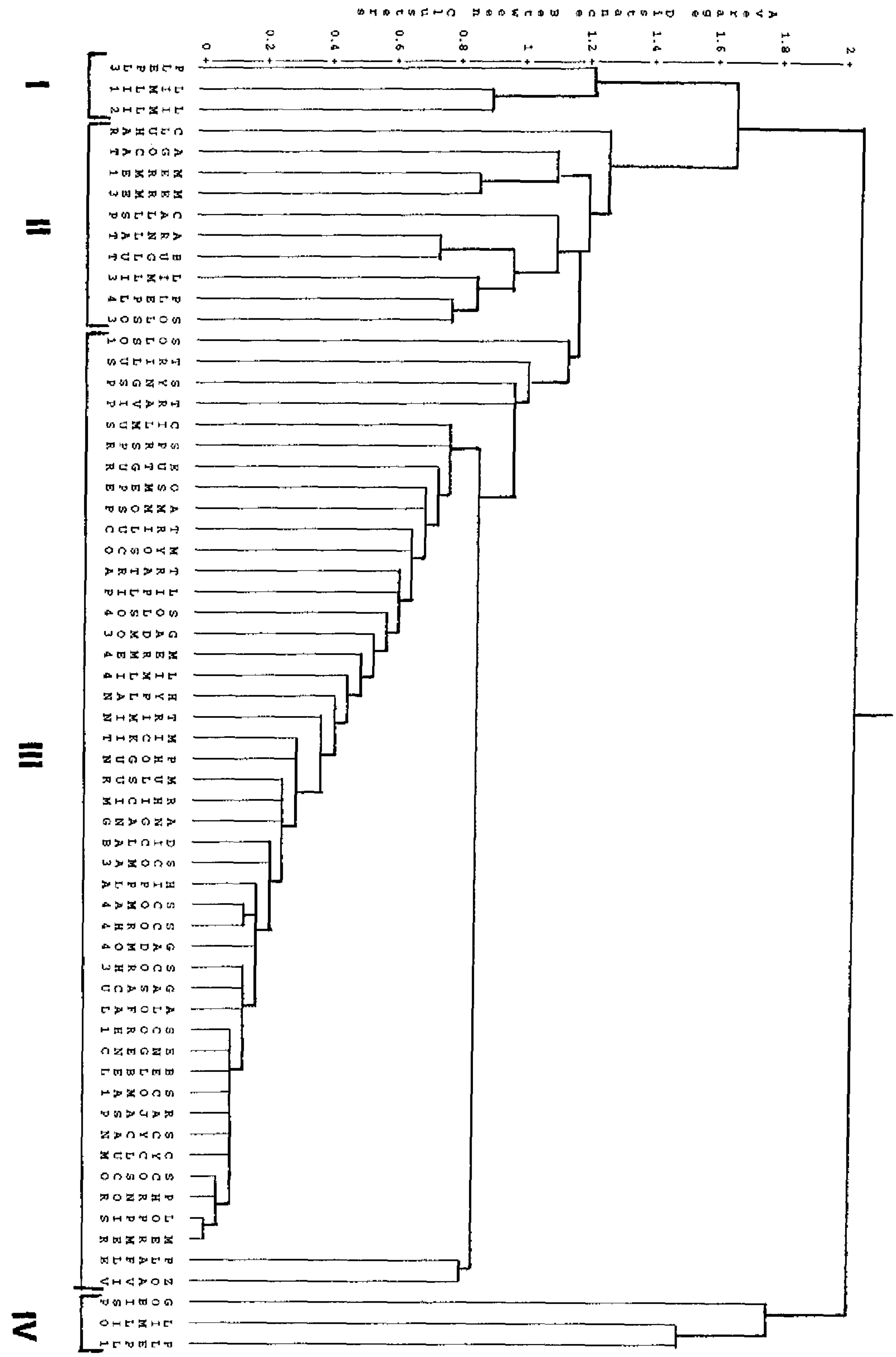


Fig. 3.21: Tree diagram of species as a result of the average linkage method (hierarchical clustering).

Appendix I: Species list of all species present in the dataset.

NUDC-code	Spcode	Scientific name	English name	Dutch name
8603010205	lamflu	*Lampetra fluviatilis*	Lampern	Rivierprik
8603010301	petmar	*Petromyzon marinus*	Lamprey	Zeeprik
8708010306	scycan	*Scyliorhinus caniculus*	Lesser spotted dogfish	Hondshaai
8708020102	galgal	*Galeorhinus galeus*	Tope	Ruwe haai
8708020409	musmus	*Mustelus mustelus*	Smooth hound	Gevlekte gladde haai
8710010201	squaca	*Squalus acanthias*	Spurdog	Doornhaai
8713040100	rajasp	*Raja sp*	Ray	Rog
8741010102	angang	*Anguila anguila*	Eel	Aal
8747010109	alofal	*Alosa fallax*	Twaite shad	Fint
8747010201	cluhar	*Clupea harengus*	Herring	Haring
8747011701	sprspr	*Sprattus sprattus*	Sprat	Sprot
8747012201	sarpil	*Sardina pilchardus*	Pilchard	Sardien
8747020104	engeng	*Engraulis encrasicolus*	Anchovy	Ansjovis
8755010306	saltru	*Salmo trutta*	Sea trout	Zeeforel
8755030301	osmepe	*Osmerus eperlanus*	Smelt	Spiering
8786010103	loppis	*Lophius piscatorius*	Anglerfish	Zeeduivel
8791030402	gadmo3	*Gadus morhua (0-25cm.)*	Cod	Kabeljauw
8791030402	gadmo4	*Gadus morhua (>25)*		
8791030402	gadmo5	*Gadus morhua totaal*		
8791030901	polvir	*Pollachius virens*	Saithe	Koolvis
8791030902	polpol	*Pollachius pollachius*	Pollack	Pollak
8791031501	rhicim	*Rhinonemus cimbrius*	Four-bearded rockling	Vierdradige meun
8791031701	trimin	*Trisopterus minutus*	Poor cod	Dwergbolk
8791031702	trilus	*Trisopterus luscus*	Bib	Steenbolk
8791031703	triesm	*Trisopterus esmarki*	Norway pout	Kever
8791031801	merme1	*Merlangus merlangus (0-15cm)*	Whiting	Wijting
8791031801	merme3	*Merlangus merlangus (15-25cm)*		
8791031801	merme4	*Merlangus merlangus (>25cm)*		
8791031801	merme5	*Merlangus merlangus totaal*		
8791031901	molmol	*Molva molva*	Ling	Leng
8791032301	ranran	*Raniceps raninus*	Tadpole fish	Vorskwab
8791032401	cilmus	*Ciliata mustela*	Five-bearded rockling	Vijfdradige meun
8791040105	mermer	*Merluccius merluccius*	Hake	Heek
8793012001	zoaviv	*Zoarces viviparis*	Eelpout	Puitaal
8794010117	corrup	*Coryphaenoides rupestris*	Roundnose grenadier	Grenadiervis
8803020502	belbel	*Belone belone*	Garfish	Geep
8805021001	athpre	*Atherina presbyter*	Sand-smelt	Koornaarvis
8811030301	zeufab	*Zeus faber*	John Dory	Zonnevis
8818010101	gasacu	*Gasterosteus aculeatus*	Three spined stickleback	Dried. stekelbaars
8820020119	syngsp	*Syngnathus sp*	pipefish	zeenaald
8820022101	entaeq	*Entelurus aequoreus*	Snake pipefish	Adderzeenaald
8826020501	triluc	*Trigla lucerna*	Tub gurnard	Rode poon
8826020601	eutgur	*Eutrigla gurnardus*	Grey gurnard	Grauwe poon
8826020801	aspcuc	*Aspitrigla cuculus*	Red gurnard	Engelse poon
8831022207	myosco	*Myoxocephalus scorpius*	Bullrout	Zeedonderpad
8831080803	agocat	*Agonus cataphractus*	Hooknose	Harnasmannetje
8831090828	liplip	*Liparis liparis*	Sea-snail	Slakdolf
8831091501	cyclum	*Cyclopterus lumpus*	Lumpsucker	Snotolf
8835280103	tratra	*Trachurus trachurus*	Horse mackerel	Horsmakreel
8835431201	spocan	*Spondyliosoma cantharus*	Black sea-bream	Zeekarper
8835450202	mulsur	*Mullus surmuletus*	Red mullet	Mul
8835720101	diclab	*Dicentrarchus labrax*	Bass	Zeebaars
8836010000	mugisp	*Mugilidae sp*	Mullets	Harders
8836010704	crelab	*Crenomugil labrosus*	Thick-lipped Mullet	Harder
8840060101	travip	*Trachinus vipera*	Lesser weever	Kleine pieterman
8842120905	lumlam	*Lumpenus lampretaeformis*	Snake blenny	IJslandse bandvis
8842130209	phogun	*Pholis gunnellus*	Butterfish	Botervis
8845010000	ammosp	*Ammodytidae sp*	Sandeels	Zandspiering
8845010301	hyplan	*Hyperoplus lanceolatus*	Greater sandeel	Smelt
8846010106	callsp	*Callionymus sp*	Dragonet	Pitvis
8847011300	gobisp	*Gobius sp*	Gobies	Grondels
8847011316	gobnig	*Gobius niger*	Black goby	Zwarte grondel
8847032201	phrnor	*Phrynorhombus norvegicus*	Norwegian topknot	Dwergbot
8847040904	limli0	*Limanda limanda (0-10cm)*	Dab	Schar
8847040904	limli1	*Limanda limanda (10-15cm)*		
8847040904	limli2	*Limanda limanda (15-20cm)*		
8847040904	limli3	*Limanda limanda(20-25cm)*		
8847040904	limli4	*Limanda limanda (>25cm)*		
8847040904	limli5	*Limanda limanda totaal*		
8847041402	plafle	*Platichthys flesus*	Flounder	Bot
8850030302	scosco	*Scomber scomber*	Mackerel	Makreel
8857030402	scoma1	*Scophtalmus maximus (0-15cm)*	Turbot	Tarbot
8857030402	scoma3	*Scophtalmus maximus (15-25cm)*		
8857030402	scoma4	*Scophtalmus maximus (>25cm)*		
8857030402	scoma5	*Scophtalmus maximus totaal*		
8857030403	scorh1	*Scophthalmus rhombus (0-15cm)*	Brill	Griet
8857030403	scorh3	*Scophthalmus rhombus (15-25cm)*		
8857030403	scorh4	*Scophthalmus rhombus (>25cm)*		
8857030403	scorh5	*Scophthalmus rhombus totaal*		
8857031702	arnlat	*Arnoglossus laterna*	Scaldfish	Schurftvis
8857032302	lepwhi	*Lepidorh. whiffiagonis*	Megrim	Scharretong
8857040502	glycyn	*Glyptocephalus cynoglossus*	Witch	Witje
8857040603	hippla	*Hippoglossoides platessoides*	Long rough dab	Lange schar
8857041202	mickit	*Microstomus kitt*	Lemon sole	Tongschar
8857041502	plepl1	*Pleuronectes platessa (0-15cm)*	Plaice	Schol
8857041502	plepl3	*Pleuronectes platessa (15-25cm)*		
8857041502	plepl4	*Pleuronectes platessa (>25cm)*		
8857041502	plepl5	*Pleuronectes platessa totaal*		
8858010601	solso1	*Solea solea (0-15cm)*	Sole	Tong
8858010601	solso3	*Solea solea (15-25cm)*		
8858010601	solso4	*Solea solea (>25cm)*		
8858010601	solso5	*Solea solea totaal*		
8858010610	sollas	*Solea lascaris*	Sand sole	Franse tong
8858010801	buglut	*Buglossidium luteum*	Solenette	Dwergtong
8858010903	micvar	*Microchirus variegatus*	Thickback sole	Dikrugtong
8861040101	molmoa	*Mola mola*	Sunfish	Maanvis

Appendix II: Cluster summary, statistics of the variables, mean values of the variables in the classification and distances between the clusters. FASTCLUS 10 cluster classification.

Cluster	Number of hauls in cluster	RMS Std Deviation	Maximum distance from seed to observation	Nearest cluster	Distance between cluster centroids
1	441	0.8017	11.9005	3	5.6576
2	126	1.1194	11.846	10	7.4904
3	203	1.0395	12.1332	1	5.6576
4	157	1.0354	12.1963	6	6.089
5	289	0.8042	12.4423	10	5.6047
6	132	1.0363	12.4759	4	6.089
7	169	1.0629	16.307	5	7.0394
8	271	0.9207	12.8632	4	6.3815
9	129	1.1414	12.3682	3	7.5994
10	226	0.8501	10.8823	5	5.6047

Distance Between Cluster Centroids

Nearest Cluster

Cluster	1	2	3	4	5
1	.	7.29666	6.2404	7.12243	8.15334
2	7.29666	.	7.23446	8.07634	10.29165
3	6.2404	7.23446	.	8.76662	8.12208
4	7.12243	8.07634	8.76662	.	7.07169
5	8.15334	10.29165	8.12208	7.07169	.
6	15.06595	14.2257	13.43001	12.24904	8.41392
7	13.37214	11.83887	10.79899	12.18411	9.15923
8	17.98745	16.8182	16.13798	15.24292	12.16549
9	14.59614	13.41258	14.35239	10.90084	9.21807
10	9.73886	11.25652	7.91545	13.15419	11.80938

Cluster	6	7	8	9	10
1	15.06595	13.37214	17.98745	14.59614	9.73886
2	14.2257	11.83887	16.8182	13.41258	11.25652
3	13.43001	10.79899	16.13798	14.35239	7.91545
4	12.24904	12.18411	15.24292	10.90084	13.15419
5	8.41392	9.15923	12.16549	9.21807	11.80938
6	.	8.163	6.39186	7.25199	15.85763
7	8.163	.	8.9754	8.81075	10.83819
8	6.39186	8.9754	.	8.92724	17.14877
9	7.25199	8.81075	8.92724	.	16.10497
10	15.85763	10.83819	17.14877	16.10497	.

	Statistics for variables			
Variable	Total STD	Within STD	R-Squared	RSQ/(1-RSQ)
AGOCAT	1.724652	1.432659	0.312846	0.455278
ALOFAL	0.221774	0.217752	0.039991	0.041657
AMMOSP	1.121358	1.08312	0.070957	0.076376
ANGANG	0.423704	0.417597	0.032704	0.03381
ARNLAT	1.763687	1.074375	0.630478	1.7062
BELBEL	0.184131	0.18323	0.013916	0.014113
CILMUS	1.21987	1.057575	0.251543	0.336083
CLUHAR	1.907884	1.607994	0.292647	0.413721
CYCLUM	0.155285	0.154917	0.008919	0.008999
EUTGUR	1.164436	0.800149	0.529801	1.12676
GADMO3	0.904907	0.833047	0.156077	0.184942
GADMO4	0.293914	0.280304	0.09429	0.104106
GASACU	0.224948	0.224984	0.003882	0.003897
GOBISP	3.148145	1.529401	0.76498	3.254961
HYPLAN	0.721836	0.685851	0.101013	0.112363
LIMLI0	2.361564	1.860275	0.382089	0.618356
LIMLI1	2.32164	1.495826	0.586625	1.419113
LIMLI2	2.239259	1.231299	0.698914	2.321314
LIMLI3	1.60039	1.067076	0.557299	1.25886
LIMLI4	0.740458	0.640066	0.255919	0.34394
LIPLIP	0.996007	0.88537	0.213142	0.270877
MERME1	1.866737	1.464401	0.387191	0.631829
MERME3	1.72623	1.368891	0.373801	0.596937
MERME4	0.845525	0.758564	0.1985	0.247661
MICKIT	0.493577	0.475846	0.074461	0.080451
MULSUR	0.450404	0.432404	0.082207	0.08957
MYOSCO	1.061113	0.967806	0.171628	0.207187
OSMEPE	1.166428	0.853869	0.466373	0.873967
PHOGUN	0.472076	0.463723	0.039132	0.040725
PLAFLE	1.291166	1.123106	0.24656	0.327245
PLEPL1	2.554258	1.713816	0.551698	1.230641
PLEPL3	2.06012	1.579841	0.414384	0.707603
PLEPL4	1.519569	0.940846	0.61826	1.619587
SCOMA1	0.173728	0.173259	0.009572	0.009664
SCOMA3	0.35204	0.323184	0.160761	0.191556
SCOMA4	0.315533	0.280802	0.211354	0.267996
SCORH1	0.196084	0.195594	0.009173	0.009258
SCORH3	0.246688	0.241313	0.047126	0.049457
SCORH4	0.27706	0.253051	0.169309	0.203817
SCOSCO	0.135069	0.134949	0.005975	0.006011
SOLSO1	1.71822	1.52186	0.218798	0.280079
SOLSO3	1.377649	1.070264	0.398998	0.663889
SOLSO4	0.958439	0.738623	0.408591	0.690877
SPRSPR	1.213152	1.154735	0.097793	0.108393
SYNGSP	1.61861	1.312163	0.345571	0.52805
TRATRA	1.006317	0.95391	0.10522	0.117594
TRAVIP	1.552361	1.046753	0.547233	1.208644
TRILUC	1.048478	0.874072	0.307935	0.444951
TRILUS	1.591059	1.529673	0.07956	0.086437
TRIMIN	0.662519	0.659331	0.013763	0.013955
ZOAVIV	1.298957	1.132315	0.243313	0.321551
BUGLUT	1.996453	1.275415	0.593598	1.460615
CALLSP	2.079876	1.478777	0.496613	0.986543
DICLAB	0.342866	0.339391	0.024281	0.024886
HIPPLA	0.338309	0.320551	0.105996	0.118563
PHRNOR	0.10998	0.109485	0.013146	0.013321
RHICIM	0.436702	0.394752	0.186327	0.228996
ENGENC	0.187559	0.185859	0.022175	0.022678
LOPPIS	0.033296	0.0329704	0.023571	0.02414
MERMER	0.059627	0.0581966	0.05141	0.054196
RAJASP	0.171995	0.170875	0.017135	0.017434
SCYCAN	0.163381	0.162909	0.009943	0.010043
OVER-ALL	**1.263598**	**0.943782**	**0.444483**	**0.800126**
Pseudo F Statistic = 189.63				
Approximate Over-All R-Squared = 0.216				
Cubic clustering criterion = 211.525				

Cluster means											
Cluster	AGOCAT	ALOFAL	AMMOSP	ANGANG	ARNLAT	BELBEL	CILMUS	CLUHAR	CYCLUM	EUTGUR	GADMO3
1	0.27207	0.02231	0.38032	0.1861	0.04137	0.00589	0.47261	1.79463	0.00419	0.0136	0.09963
2	1.59972	0	0.66719	0.04315	3.44966	0.01744	0.03694	0.37682	0	0.32307	0.18297
3	0.94393	0	0.64402	0.23162	0.26964	0.01334	0.58584	0.70676	0.04879	0.03122	0.30501
4	2.31102	0.0274	0.17489	0.06399	0	0	2.18089	2.45826	0.0329	0.0274	1.08268
5	1.33108	0.0038	0.00767	0.02174	3.00279	0.02191	0.00574	0.07305	0.00581	2.40554	0.35725
6	1.00259	0.18887	0.07056	0.11187	0	0	1.40953	3.80385	0.01398	0	0.27325
7	3.50062	0	0.09691	0.03255	1.95705	0.02517	0.00331	0.0749	0	0.69461	0.48797
8	0.49773	0.00681	0.8281	0.05484	0.43407	0.00959	0.39211	1.05007	0.01842	0.02311	0.11526
9	2.72321	0.04387	0.8615	0.04876	0.08557	0.02438	1.1164	1.17146	0	0	1.2913
10	0.72699	0.00405	0.17603	0.00777	3.32865	0.07803	0	0.084	0.00636	1.37851	0.01727

Cluster	GADMO4	GASACU	GOBISP	HYPLAN	LIMLI0	LIMLI1	LIMLI2	LIMLI3	LIMLI4	LIPLIP	MERME1
1	0.03342	0.01898	0.34613	0.12788	1.17172	0.36077	0.24177	0.12248	0.02921	0.28084	0.55024
2	0.02418	0.01744	4.86062	0.38651	4.40253	3.63803	2.88631	1.58031	0.67065	0.01031	0.80888
3	0.03754	0.03502	0.19689	0.22795	4.24491	2.26116	1.33975	0.74321	0.16057	0.22599	0.88873
4	0.02351	0	7.09873	0.07054	5.07007	0.81619	0.55943	0.44581	0.10819	1.38556	3.31598
5	0.286	0	0.23905	0.04318	1.40046	4.68846	4.99262	2.88211	0.71686	0.00557	1.90172
6	0	0.04658	5.86428	0.02797	1.85698	0.56423	0.24184	0.08891	0.03781	1.51563	1.47484
7	0.07218	0.04089	0.65438	0.23566	2.39472	5.45475	5.12135	3.46733	1.15695	0	2.05966
8	0.00479	0.01362	6.69732	0.2841	3.57461	1.52771	0.85284	0.36997	0.1292	0.34353	0.63747
9	0.03022	0.01904	2.70825	0.1263	4.71909	4.51821	3.52117	2.36115	0.5292	0.18263	4.76578
10	0.12026	0.00972	0.63978	0.83759	1.2401	2.75305	3.29379	2.16258	0.82372	0	0.62898

Cluster	MERME3	MERME4	MICKIT	MULSUR	MYOSCO	OSMEPE	PHOGUN	PLAFLE	PLEPL1	PLEPL3	PLEPL4
1	0.54225	0.06402	0.07278	0.00208	0.25554	0.22525	0.07416	0.55935	2.56256	0.92233	0.26823
2	1.25903	0.32173	0.07893	0.26677	0.26155	0	0.02822	0.56009	3.87827	3.96794	1.06469
3	1.014	0.23239	0.12406	0	0.8278	0.16414	0.20492	0.93854	4.65895	3.07437	0.69114
4	2.60911	0.18088	0.02575	0	0.98872	0.62137	0.24682	1.6936	5.47119	1.39661	0.01805
5	2.31754	1.19688	0.31953	0.04894	0.03588	0	0	0.07396	0.04178	2.36395	3.13598
6	0.44524	0.01398	0	0	0.99859	3.39513	0.26455	2.44155	5.55413	1.25838	0.08203
7	1.82179	0.46087	0.44408	0.20433	1.27792	0.02222	0.00769	1.26844	3.96686	5.63202	3.00733
8	0.91424	0.19548	0.01161	0.02237	0.16211	0.15055	0.05962	0.55033	3.3245	1.6168	0.16731
9	4.52836	0.31658	0	0.02555	1.07642	0.21807	0.21339	1.38859	6.05035	3.16817	0.26739
10	0.8017	0.72934	0.10017	0.38744	0.02285	0	0	0.09542	0.63889	2.94394	2.17427

Cluster	SCOMA1	SCOMA3	SCOMA4	SCORH1	SCORH3	SCORH4	SCOSCO	SOLSO1	SOLSO3	SOLSO4	SPRSPR
1	0.01394	0.01954	0.01454	0.02539	0.03487	0.01525	0.00557	1.09432	0.4776	0.15173	0.49997
2	0	0.21184	0.20882	0.00505	0.02693	0.08909	0.02791	1.69909	1.57996	0.47077	0.23831
3	0	0.04089	0.00865	0.02728	0.02351	0.01423	0	2.58785	1.01767	0.24282	0.45072
4	0.0659	0	0	0.06268	0	0	0	2.54005	0.12153	0.07507	0.83804
5	0	0.03256	0.26018	0	0.01102	0.13427	0.023	0.05347	1.3029	1.41276	0.11642
6	0	0	0.01861	0.06056	0.05121	0	0	1.59974	0.02797	0	1.6592
7	0.01002	0.53019	0.44855	0.0065	0.21334	0.34193	0.02702	0.70436	3.20638	1.72856	0.19681
8	0	0.02204	0.00682	0.02043	0.02043	0.0039	0.0164	1.51638	0.22954	0.09826	0.66792
9	0.02283	0.03902	0.00914	0.01431	0.01431	0.01075	0.01441	1.24575	0.22518	0.03756	0.58172
10	0.01135	0.13835	0.25462	0.00486	0.07718	0.27588	0.02513	0.24825	1.75906	1.21451	0.0906

Cluster	SYNGSP	TRATRA	TRAVIP	TRILUC	TRILUS	TRIMIN	ZOAVIV	BUGLUT	CALLSP	DICLAB	HIPPLA
1	0.63356	0.28852	0.1727	0.07688	0.98231	0.12151	0.40008	0.02014	0.17326	0.13636	0.00208
2	0.15724	1.48122	1.60383	1.72942	0.64185	0.26747	0.05802	4.45594	4.41105	0	0
3	0.47627	0.30935	0.19119	0.39459	1.95967	0.16102	1.07334	0.34028	1.28581	0.04123	0.01082
4	2.40471	0	0.0274	0.19721	0.85724	0.09762	1.53038	0.05852	0.18943	0	0
5	0.03681	0.38684	0.28537	0.65092	0.4102	0.23554	0	2.48532	2.77334	0	0.32394
6	3.59398	0.04658	0	0.02797	0.23154	0.01398	2.03135	0.02353	0	0	0
7	0.07193	0.44228	0.36182	1.81112	0.72632	0.14237	0.55161	2.56027	4.11634	0.00662	0
8	0.36624	0.2775	0.57522	0.38276	0.85163	0.18453	0.25726	0.25389	1.69571	0.00479	0
9	1.05141	0.06532	0.06268	0.39927	1.20068	0.06098	1.69725	0.28177	0.87173	0.01431	0
10	0.07377	0.65573	3.87994	1.26505	0.41026	0.29858	0	3.73708	3.13663	0	0

Cluster	PHRNOR	RHICIM	ENGENC	LOPPIS	MERMER	RAJASP	SCYCAN
1	0.00208	0.01495	0.06907	0.00127	0	0.02947	0.04226
2	0	0.04212	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0.03811	0.56018	0	0.01519	0.03957	0.05992	0.01166
6	0	0	0	0	0	0	0
7	0.00331	0.03159	0	0	0	0	0.00331
8	0.00811	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0.00248	0	0	0	0.04255	0.01695

Appendix III: Cluster summary, statistics of the variables, mean values of the variables in the classification and distances between the clusters. FASTCLUS 20 cluster classification.

Cluster	Number of hauls in cluster	RMS Std Deviation	Maximum distance from seed to observation	Nearest Cluster	Distance between cluster centroids
1	75	1.0323	11.8523	4	7.8554
2	150	0.7877	11.2514	3	5.3879
3	100	0.9052	10.3583	2	5.3879
4	146	0.8801	10.707	16	5.4381
5	59	0.9576	11.0189	10	5.9072
6	91	1.0942	11.2572	11	6.7546
7	177	0.7728	10.9169	16	5.9936
8	128	0.942	11.2961	15	5.8973
9	249	0.7243	11.2829	17	4.8423
10	54	0.9505	11.7299	5	5.9072
11	132	0.9941	11.1769	4	5.6082
12	100	0.8844	10.4065	2	5.8786
13	83	1.0277	11.7988	3	6.773
14	54	1.0101	10.5245	5	6.8845
15	62	1.0363	10.6387	8	5.8973
16	185	0.7301	12.5209	4	5.4381
17	174	0.7947	10.3383	9	4.8423
18	2	1.0568	5.8837	4	13.7014
19	51	1.0087	10.5036	20	6.332
20	71	1.0791	11.376	19	6.332

Distance Between Cluster Centroids
Nearest cluster

Cluster	1	2	3	4	5	6	7	8	9	10
1	.	13.59296	13.52161	7.85544	15.36227	10.25716	11.65513	10.73825	13.54529	13.39732
2	13.59296	.	5.38787	13.24971	8.7668	9.01178	10.81991	7.63009	6.51627	7.69251
3	13.52161	5.38787	.	14.26807	7.03298	10.03282	12.88186	8.67249	9.33975	6.52687
4	7.85544	13.24971	14.26807	.	16.94312	9.29605	6.67043	11.76364	11.98141	15.05294
5	15.36227	8.7668	7.03298	16.94312	.	12.75753	15.86184	10.81802	12.12539	5.90722
6	10.25716	9.01178	10.03282	9.29605	12.75753	.	8.77349	10.2078	11.73889	11.63156
7	11.65513	10.81991	12.88186	6.67043	15.86184	8.77349	.	10.79423	9.2199	14.21296
8	10.73825	7.63009	8.67249	11.76364	10.81802	10.2078	10.79423	.	6.20371	9.88882
9	13.54529	6.51627	9.33975	11.98141	12.12539	11.73889	9.2199	6.20371	.	10.57793
10	13.39732	7.69251	6.52687	15.05294	5.90722	11.63156	14.21296	9.88882	10.57793	.
11	8.21859	11.48351	12.82492	5.60822	15.47183	6.75458	6.31915	9.51919	10.68828	14.06715
12	12.83044	5.87859	7.13303	12.05985	10.36994	7.17689	10.78258	9.36785	9.47262	9.28952
13	12.44378	7.19782	6.77301	14.76464	7.62921	9.26431	14.32651	8.22089	11.45606	7.23538
14	15.56039	8.11181	7.4143	16.73663	6.88448	13.07421	15.11343	10.55859	10.96673	8.26014
15	9.21038	8.55528	9.73269	9.50747	12.20429	8.45464	8.82186	5.89728	7.48432	10.9053
16	10.25354	11.47981	12.88312	5.43814	15.92505	10.55694	5.99359	10.78521	9.35049	13.68494
17	13.65683	6.8642	6.90458	13.39505	10.12381	11.99939	11.04534	6.04494	4.84226	9.22676
18	14.12563	20.70715	20.83973	13.70144	21.99386	15.41807	16.54298	17.46615	20.16864	20.77114
19	8.38601	9.19329	9.46459	10.58756	11.51327	10.34588	10.71518	7.01095	8.5758	8.12555
20	8.72752	10.73976	9.39424	12.53974	10.52637	10.81035	13.7145	9.19252	12.30784	7.93261

Cluster	11	12	13	14	15	16	17	18	19	20
1	8.21859	12.83044	12.44378	15.56039	9.21038	10.25354	13.65683	14.12563	8.38601	8.72752
2	11.48351	5.87859	7.19782	8.11181	8.55528	11.47981	6.8642	20.70715	9.19329	10.73976
3	12.82492	7.13303	6.77301	7.4143	9.73269	12.88312	6.90458	20.83973	9.46459	9.39424
4	5.60822	12.05985	14.76464	16.73663	9.50747	5.43814	13.39505	13.70144	10.58756	12.53974
5	15.47183	10.36994	7.62921	6.88448	12.20429	15.92505	10.12381	21.99386	11.51327	10.52637
6	6.75458	7.17689	9.26431	13.07421	8.45464	10.55694	11.99939	15.41807	10.34588	10.81035
7	6.31915	10.78258	14.32651	15.11343	8.82186	5.99359	11.04534	16.54298	10.71518	13.7145
8	9.51919	9.36785	8.22089	10.55859	5.89728	10.78521	6.04494	17.46615	7.01095	9.19252
9	10.68828	9.47262	11.45606	10.96673	7.48432	9.35049	4.84226	20.16864	8.5758	12.30784
10	14.06715	9.28952	7.23538	8.26014	10.9053	13.68494	9.22676	20.77114	8.12555	7.93261
11	.	11.1434	13.07378	14.90033	7.79673	7.91775	11.59555	14.30482	9.61269	12.07448
12	11.1434	.	7.34682	11.06458	7.99026	11.16216	10.00636	18.22326	10.43727	10.54572
13	13.07378	7.34682	.	9.39327	9.82072	14.3616	10.51328	18.7707	9.71069	8.19636
14	14.90033	11.06458	9.39327	.	12.31299	15.37363	9.26572	23.20215	11.94456	12.27461
15	7.79673	7.99026	9.82072	12.31299	.	8.86206	7.76648	15.60178	6.69537	9.61606
16	7.91775	11.16216	14.3616	15.37363	8.86206	.	11.11151	16.68764	9.38113	12.05326
17	11.59555	10.00636	10.51328	9.26572	7.76648	11.11151	.	20.68059	8.14023	11.37226
18	14.30482	18.22326	18.7707	23.20215	15.60178	16.68764	20.68059	.	17.16672	17.69775
19	9.61269	10.43727	9.71069	11.94456	6.69537	9.38113	8.14023	17.16672	.	6.332
20	12.07448	10.54572	8.19636	12.27461	9.61606	12.05326	11.37226	17.69775	6.332	.

	Statistics for variables			
Variable	Total STD	Within STD	R-Squared	RSQ/1-RSQ
AGOCAT	1.724652	1.358687	0.38487	0.625673
ALOFAL	0.221774	0.218466	0.038213	0.039731
AMMOSP	1.121358	1.061748	0.111445	0.125422
ANGANG	0.423704	0.416371	0.042881	0.044802
ARNLAT	1.763687	1.037724	0.656876	1.914396
BELBEL	0.184131	0.183646	0.014079	0.01428
CILMUS	1.21987	0.994059	0.341845	0.519399
CLUHAR	1.907884	1.206716	0.603506	1.522106
CYCLUM	0.155285	0.155	0.012506	0.012664
EUTGUR	1.164436	0.775781	0.560076	1.27312
GADMO3	0.904907	0.823474	0.179227	0.218363
GADMO4	0.293914	0.277336	0.117526	0.133178
GASACU	0.224948	0.224987	0.008531	0.008604
GOBISP	3.148145	1.307227	0.829107	4.851628
HYPLAN	0.721836	0.684588	0.108518	0.121728
LIMLI0	2.361564	1.77968	0.437121	0.776582
LIMLI1	2.32164	1.465669	0.604986	1.531554
LIMLI2	2.239259	1.219312	0.706132	2.402892
LIMLI3	1.60039	1.046381	0.5763	1.36016
LIMLI4	0.740458	0.632073	0.277789	0.384636
LIPLIP	0.996007	0.837116	0.299872	0.428311
MERME1	1.866737	1.412327	0.432671	0.762647
MERME3	1.72623	1.343516	0.39963	0.665639
MERME4	0.845525	0.739684	0.241474	0.318346
MICKIT	0.493577	0.472485	0.091767	0.101039
MULSUR	0.450404	0.429436	0.099004	0.109882
MYOSCO	1.061113	0.941879	0.219095	0.280566
OSMEPE	1.166428	0.804015	0.529084	1.123523
PHOGUN	0.472076	0.459861	0.059497	0.063261
PLAFLE	1.291166	1.068257	0.32155	0.473948
PLEPL1	2.554258	1.500333	0.658039	1.924311
PLEPL3	2.06012	1.420705	0.528639	1.121516
PLEPL4	1.519569	0.895802	0.65556	1.903262
SCOMA1	0.173728	0.173465	0.011865	0.012008
SCOMA3	0.35204	0.315026	0.206332	0.259973
SCOMA4	0.315533	0.283597	0.19935	0.248986
SCORH1	0.196084	0.195478	0.014994	0.015222
SCORH3	0.246688	0.238345	0.07478	0.080824
SCORH4	0.27706	0.252263	0.178339	0.217047
SCOSCO	0.135069	0.134866	0.011845	0.011987
SOLSO1	1.71822	1.426188	0.317148	0.464447
SOLSO3	1.377649	1.049466	0.424838	0.73864
SOLSO4	0.958439	0.729498	0.425818	0.741608
SPRSPR	1.213152	1.113802	0.164559	0.196972
SYNGSP	1.61861	1.233644	0.42426	0.736896
TRATRA	1.006317	0.946438	0.123311	0.140656
TRAVIP	1.552361	1.047849	0.548412	1.214409
TRILUC	1.048478	0.85272	0.344421	0.52537
TRILUS	1.591059	1.495511	0.124337	0.141992
TRIMIN	0.662519	0.658702	0.020256	0.020675
ZOAVIV	1.298957	1.082553	0.311603	0.452649
BUGLUT	1.996453	1.192795	0.646211	1.826546
CALLSP	2.079876	1.264259	0.633792	1.730691
DICLAB	0.342866	0.333252	0.063674	0.068004
HIPPLA	0.338309	0.309552	0.170204	0.205116
PHRNOR	0.10998	0.109709	0.013736	0.013927
RHICIM	0.436702	0.381095	0.245209	0.32487
ENGENC	0.187559	0.185731	0.028097	0.028909
LOPPIS	0.033296	0.0327758	0.039591	0.041223
MERMER	0.059627	0.0574536	0.079809	0.086731
RAJASP	0.171995	0.170325	0.028024	0.028832
SCYCAN	0.163381	0.162387	0.02089	0.021335
OVER-ALL	**1.263598**	**0.888344**	**0.510136**	**1.041385**
Pseudo F Statistic = 116.36				
Approximate Over-All R-Squared = 0.264				
Cubic clustering criterion = 244.928				

Cluster means

Cluster	AGOCAT	ALOFAL	AMMOSP	ANGANG	ARNLAT	BELBEL	CILMUS	CLUHAR	CYCLUM	EUTGUR	GADMO3	GADMO4	GASACU	GOBSP	HYPLAN	LIMLI0
1	4.39882	0	0.22663	0	0.61939	0.03971	0	0.09099	0	0.20957	1.0736	0.06927	0.05287	0.93033	0.12697	3.8614
2	0.26922	0.02461	0.94622	0.06711	0.28682	0	0.29927	0.67417	0.03327	0.02576	0.08484	0	0.01231	5.93132	0.35571	1.91904
3	0.6154	0.03692	0.40721	0	0.02457	0.01299	0.74745	5.02635	0	0	0.12908	0.03145	0.03692	6.34273	0.04991	3.67824
4	2.66994	0	0.00383	0.0485	2.70115	0.01519	0.00383	0.0602	0	2.23579	0.45107	0.17186	0	0.68516	0.07287	2.03355
5	2.40752	0.19951	0.12514	0.12514	0	0	3.21524	3.35028	0.03129	0	0.75219	0	0.07292	6.65355	0.03129	4.12669
6	1.76976	0	0.77521	0.02138	3.41359	0.02415	0.027	0.41302	0	0.22803	0.22827	0.02999	0.02415	6.09031	0.43397	4.19003
7	0.71959	0.00621	0.15625	0.00812	3.37504	0.05458	0	0.09464	0.00812	1.6629	0.019	0.12677	0	0.6723	0.82631	1.25677
8	0.58963	0	0.27695	0.31236	0.11165	0	0.70321	0.65458	0.03361	0.02427	0.14102	0.02934	0.01442	0.15578	0.09033	3.9353
9	0.25963	0.00987	0.41413	0.2052	0.08742	0.00527	0.44316	0.37033	0	0.02965	0.07172	0.05177	0.04734	0.14935	0.16116	0.72719
10	3.35666	0.06836	0.05247	0	0	0	2.56612	2.46198	0	0.07968	1.56784	0.03418	0	5.91712	0.10255	3.08202
11	1.45341	0.00694	0.18601	0.03948	3.49344	0.07566	0.00424	0.17697	0	0.51845	0.1059	0.03952	0.03695	0.53933	0.53294	1.84604
12	0.62906	0	0.44057	0.06811	0.75356	0.01299	0.60436	0.54944	0	0.01099	0.11621	0	0	7.28431	0.16993	4.91167
13	1.71123	0.0296	0.44442	0.12104	0.16774	0	0.99614	0.72822	0.06224	0.01565	0.92625	0.03131	0	7.40124	0.1245	6.12982
14	0.57793	0.17534	0	0.13673	0	0	1.10673	3.32065	0	0	0.23903	0	0	5.97784	0.03418	1.22554
15	1.40093	0	1.81519	0.04749	0.66123	0.04368	0.1002	0.27179	0.05073	0.02096	0.41582	0	0.03962	0.10177	0.60657	4.7557
16	0.81516	0	0.00605	0.01646	2.95355	0.02224	0.00594	0.08819	0.00907	2.33569	0.34583	0.362	0	0.07305	0.02455	1.01344
17	0.353	0.02122	0.26098	0.1745	0.02532	0.01061	0.56271	3.98759	0.02473	0.01061	0.13648	0.01608	0.01061	0.15127	0.09211	2.11308
18	5.147	0	1.68829	0	0	0	0	0	0	0	0	0	0	0	0	7.11861
19	2.63277	0	0.77859	0.08321	0.20572	0.03619	0.25272	0.63999	0	0.04308	1.3745	0	0	0.19118	0.29485	3.10268
20	2.53201	0.07971	0.81152	0.07029	0.05694	0	1.97349	1.41992	0	0	0.67738	0.0183	0	3.56917	0.06975	5.19106

Cluster	LIMLI1	LIMLI2	LIMLI3	LIMLI4	LIPLIP	MERME1	MERME3	MERME4	MICKIT	MULSUR	MYOSCO	OSMEPE	PHOGUN	PLAFLE	PLEPL1	PLEPL3
1	6.1222	5.40917	3.95251	1.31011	0	3.62448	2.16662	0.11289	0.39739	0.00746	2.23306	0.01732	0.04193	1.96006	5.44087	5.57639
2	0.62242	0.37075	0.25445	0.09467	0.27974	0.57637	0.61044	0.08768	0.00866	0.02331	0.27771	0.28473	0.12001	0.44438	3.74912	1.36506
3	1.44843	0.76629	0.41886	0.08487	0.35305	1.88845	1.22551	0.10735	0.02197	0	0.44016	0.78132	0.09293	0.77538	4.54888	1.54588
4	5.15617	5.43212	3.33807	1.07667	0	1.7071	2.02661	0.73103	0.53634	0.13964	0.26314	0	0	0.34146	0.54696	4.58438
5	0.57369	0.15643	0.11588	0.03129	2.94554	2.32935	1.32386	0.06257	0	0	0.60875	1.55062	0.47652	1.87078	5.73077	1.05099
6	3.55066	2.88779	1.58063	0.60174	0.01428	0.72705	1.36608	0.36522	0.04914	0.23104	0.36038	0	0.027	0.61448	4.09308	3.92451
7	2.79326	3.47366	2.16742	0.83274	0.00909	0.68188	0.84706	0.75	0.07546	0.42024	0	0	0	0.0409	0.11428	2.32543
8	1.85035	0.83805	0.30006	0.05899	0.24077	0.70316	1.08723	0.22664	0.15368	0	0.80172	0.17941	0.28874	1.05369	5.05567	3.57392
9	0.46094	0.2911	0.15661	0.03086	0.21942	0.34003	0.42885	0.09328	0.13783	0.00368	0.22816	0.06029	0.08881	0.38352	1.81099	1.14414
10	0.43929	0.42434	0.38608	0.02408	1.01004	4.62315	3.69037	0.06836	0.03418	0	0.85967	1.01746	0.06836	2.10224	5.00256	0.492
11	3.90066	3.52758	2.30211	0.85287	0	0.95257	1.02711	0.55885	0.15231	0.3768	0.31218	0	0.00832	0.61434	3.72664	5.30735
12	2.72792	1.40591	0.41546	0.20359	0.5263	0.72946	1.14897	0.34026	0.01846	0.05383	0.03705	0.0825	0	0.53342	1.73393	1.28659
13	1.56138	1.16575	0.80163	0.20465	0.839	1.77437	1.87172	0.42077	0	0	1.19737	0.26557	0.2424	1.55331	6.32423	2.94478
14	0.29507	0.18547	0.09216	0	1.56706	0.98201	0.22155	0	0	0	1.33066	5.21451	0.28394	3.74036	5.82526	1.33396
15	2.92005	2.2761	1.53204	0.38202	0.11068	0.93657	0.61399	0.19762	0	0	0.88583	0.22059	0.0501	0.81897	3.62705	1.66525
16	4.5036	4.85471	2.73368	0.56197	0	1.92651	2.44934	1.44535	0.27558	0.01695	0	0	0	0.05961	0.02461	1.53974
17	0.34453	0.24522	0.09734	0.0409	0.41632	0.71819	0.55836	0.02554	0	0	0.26144	0.49344	0.04811	0.77791	3.86725	0.76766
18	4.46107	5.69243	5.76923	1.09861	0	1.86629	4.80189	3.44133	0	0	0	0	0	0	1.88829	6.58669
19	2.05136	2.66557	1.95855	0.53864	0	4.23209	4.123	0.1912	0.06617	0.02154	0.8636	0.2085	0.05095	1.10693	5.19228	2.21976
20	5.24267	3.31962	2.19448	0.43769	0.37173	5.1286	4.96406	0.28865	0.026	0	1.07722	0.30227	0.32666	1.5942	6.12469	3.13961

Cluster	PLEPL4	SCOMA1	SCOMA3	SCOMA4	SCORH1	SCORH3	SCORH4	SCOSCO	SOLSO1	SOLSO3	SOLSO4	SPRSPR	SYNGSP	TRATRA	TRAVIP	TRILUC
1	2.82438	0.02257	0.51425	0.333	0.01465	0.11473	0.23278	0.03638	0.731	2.21729	1.08701	0.28499	0.0772	0.2425	0.06636	1.02208
2	0.11028	0	0.00732	0	0.02461	0.05329	0	0.00866	1.07498	0.10413	0.03327	0.59451	0.86824	0.25463	0.69676	0.37079
3	0.06148	0	0	0.02457	0.06148	0.06148	0	0	1.09233	0.10443	0.03145	1.64296	1.0669	0.15412	0.09618	0.14358
4	3.70695	0	0.11892	0.38404	0	0.03479	0.25344	0.01333	0.26457	2.83602	2.01521	0.11736	0.04512	0.66962	0.4933	1.56747
5	0	0.07075	0	0	0.03129	0	0	0	2.70378	0.06257	0	2.08947	5.57741	0	0	0.23971
6	0.78077	0	0.15444	0.15988	0.0035	0.01557	0.07626	0.0325	1.65246	1.36649	0.45879	0.2426	0.16307	1.44408	1.80694	1.58859
7	2.31646	0.01449	0.05116	0.24926	0	0.04186	0.23685	0.01172	0.12618	1.54174	1.22896	0.09147	0.05582	0.51698	4.20106	1.07514
8	0.74631	0	0.01442	0	0.04326	0.01442	0	0	3.01301	1.23012	0.19358	0.25313	0.38953	0.08644	0.12169	0.16762
9	0.47483	0	0.03016	0.02799	0.01483	0.01707	0.02906	0	0.96297	0.57709	0.29065	0.11105	0.50071	0.18966	0.22952	0.07467
10	0	0	0	0	0.03418	0	0	0	1.61434	0.03418	0	0.47317	2.55179	0	0.03418	0.13311
11	1.95566	0	0.58549	0.36474	0.01074	0.29014	0.37872	0.04971	0.91756	2.75527	1.12853	0.15358	0.12492	1.01378	1.47615	2.02194
12	0.29789	0	0.04091	0.03241	0	0	0.01616	0.03145	1.6241	0.43751	0.09993	0.4986	0.23532	0.12906	0.51323	0.43598
13	0.17602	0.05212	0.04322	0.01552	0.09632	0.02224	0	0	3.87756	0.27831	0.25765	0.64195	0.79957	0.19301	0.0296	0.33936
14	0.13214	0	0	0	0.06836	0.0455	0	0	1.70431	0.06836	0	1.02223	3.29146	0	0	0
15	0.57519	0	0.04227	0.05938	0	0	0.04309	0	1.98446	0.98577	0.31428	0.49215	0.57732	0.84668	0.52896	1.1646
16	2.9367	0	0.01765	0.23247	0	0.00882	0.09396	0.02542	0	0.79119	1.2723	0.13467	0.02985	0.22895	0.08921	0.27667
17	0.05672	0.03534	0	0	0.03252	0.03182	0	0.01412	1.28403	0.3632	0.0428	1.14739	0.89613	0.4974	0.11981	0.0744
18	4.21701	0	0	0	0	0	0	0	8.52692	4.00512	3.7348	0	0	0	1.88829	0
19	0.19798	0.02154	0.0531	0	0	0	0	0	0.81956	0.14614	0.06363	0.66987	0.46739	0.09185	0.0715	0.72519
20	0.05207	0.052	0.026	0	0.026	0.026	0	0.0183	1.16501	0.19329	0	0.40979	1.43041	0.026	0.08294	0.21978

Cluster	TRILUS	TRIMIN	ZOAVIV	BUGLUT	CALLSP	DICLAB	HIPPLA	PHRNOR	RHICIM	ENGENC	LOPPIS	MERMER	RAJASP	SCYCAN		
1	0.33151	0.09201	1.65817	1.37068	3.47955	0.03207	0	0	0	0	0	0	0	0		
2	0.36539	0.05932	0.30783	0.21417	0.46971	0	0	0	0	0	0	0	0	0		
3	0.4763	0.11977	0.93483	0.03106	0.4102	0	0	0	0	0	0	0	0	0		
4	0.58263	0.17854	0.0347	3.25125	3.8401	0.00383	0.0095	0.03395	0.1594	0	0	0.00218	0.01255	0.01409		
5	0.52306	0.03129	2.06833	0	0	0	0	0	0	0	0	0	0	0		
6	0.74191	0.26004	0.04621	4.49241	4.1128	0	0	0	0.04404	0	0	0	0	0		
7	0.26279	0.31627	0	3.70527	2.90339	0	0	0	0.00632	0	0	0	0.05433	0.01984		
8	2.16016	0.09424	1.36733	0.24864	0.34879	0.05098	0	0	0	0	0	0	0	0		
9	1.3919	0.21266	0.35307	0.03607	0.26119	0.01707	0.00368	0.00368	0.02649	0.04774	0.00225	0	0.0522	0.07465		
10	0.75518	0	0.96329	0.09283	0.22244	0	0	0	0	0	0	0	0	0		
11	0.63342	0.23468	0.00832	4.19709	4.31866	0	0	0	0.00984	0	0	0	0	0		
12	1.40919	0.27974	0.03145	0.42793	3.73667	0.01299	0	0.02197	0	0	0	0	0	0		
13	1.41638	0.22507	1.79758	0.10949	0.33541	0	0	0	0	0	0	0	0	0		
14	0.18222	0	2.80169	0	0	0	0	0	0	0	0	0	0	0		
15	1.18157	0.1581	0.48727	0.47049	4.12459	0.02977	0	0	0	0	0	0	0	0		
16	0.35113	0.25262	0	1.83221	2.25602	0	0.49855	0.03576	0.77513	0	0.02373	0.0601	0.08369	0.01184		
17	0.58733	0.05101	0.41056	0.01061	0.04848	0.32117	0	0	0	0.10675	0	0	0	0		
18	3.37516	0	0	6.24036	7.91365	0	0	0	0	0	0	0	0	0		
19	0.44702	0.07239	0.79625	0.74541	1.33542	0	0.04308	0	0	0	0	0	0	0		
20	1.75479	0.10604	1.89651	0.0399	0.29542	0	0	0	0	0	0	0	0	0		

Appendix IV: Cluster summary, statistics of the variables, mean values of the variables in the classification and distances between the clusters. FASTCLUS 7 cluster classification.

Cluster	Number of hauls in cluster	RMS Std Deviation	Maximum distance from seed to observation	Nearest cluster	Distance between cluster centroids
C1	430	0.5679	5.7859	2	3.4073
C2	115	0.9322	7.3202	1	3.4073
C3	94	1.2967	7.5719	6	4.3386
C4	48	1.3584	9.0741	3	5.4947
C5	366	0.7215	7.9228	6	4.9512
C6	83	1.0501	7.1796	3	4.3386
C7	74	1.1031	8.538	1	4.1312

Distance between cluster centroids

Nearest cluster

Cluster	C1	C2	C3	C4	C5	C6	C7
C1	.	3.40728493	9.029885597	9.95686225	6.3901997	8.01996345	4.13115942
C2	3.4072849	.	8.003136625	8.64132369	6.83469575	7.75694695	4.38643154
C3	9.0298856	8.00313663	.	5.49468307	5.79970064	4.33855438	7.4830956
C4	9.9568623	8.64132369	5.494683068	.	7.53182872	6.1760037	8.48054181
C5	6.3901997	6.83469575	5.799700643	7.53182872	.	4.95120225	7.38802021
C6	8.0199634	7.75694695	4.338554379	6.1760037	4.95120225	.	6.23387738
C7	4.1311594	4.38643154	7.483095598	8.48054181	7.38802021	6.23387738	.

Statistic for variables

Variable	Total STD	Within STD	R-Squared	RSQ/(1-RSQ)
ALOFAL	0.291333	0.286864	0.035251	0.036539
ANGANG	0.534119	0.530198	0.01952	0.019909
CILMUS	1.489315	1.184232	0.370871	0.5895
GASACU	0.238005	0.237991	0.00508	0.005106
GOBISP	3.379559	1.186314	0.877392	7.156072
LAMFLU	0.134765	0.134546	0.008188	0.008256
LIPLIP	1.266214	1.06456	0.296659	0.421785
MYOSCO	1.053009	0.943161	0.201735	0.252717
OSMEPE	1.446336	0.9855	0.53803	1.164641
PHOGUN	0.578939	0.557724	0.076552	0.082897
PLAFLE	1.452257	1.239614	0.275021	0.379349
SYNGSP	1.949029	1.182831	0.633522	1.728673
ZOAVIV	1.488525	1.018386	0.534251	1.14708
ENGENC	0.249098	0.247741	0.015775	0.016027
ENTAEQ	0.0918331	0.0914312	0.013653	0.013842
OVER-ALL	1.351976	0.840459	0.615466	1.60055

Pseudo F Statistic = 320.91

Approximate Over-All R-Squared = 0.51651

Cubic clustering criterion = 30.416

Cluster means

Cluster	ALOFAL	ANGANG	CILMUS	GASACU	GOBISP	LAMFLU	LIPLIP	MYOSCO
C1	0.00859	0.19418	0.43017	0.02741	0.18613	0	0.15811	0.17152
C2	0.0321	0.24177	0.82313	0	0.47351	0	0.25001	1.26448
C3	0.19842	0.13746	3.70673	0.04577	6.93155	0.03927	2.5694	1.28622
C4	0.14608	0.15382	0.87491	0	6.37345	0	0.99256	1.6611
C5	0.01513	0.05442	0.40478	0.00504	6.56257	0.01569	0.32124	0.20668
C6	0.06672	0.01565	1.35118	0.04448	6.39106	0.02224	1.05927	0.6637
C7	0.0332	0.20446	1.74214	0.04989	0.34075	0.02494	1.49693	0.3938

Cluster	OSMEPE	PHOGUN	PLAFLE	SYNGSP	ZOAVIV	ENGENC	ENTAEQ
C1	0.07316	0.04148	0.58613	0.19761	0.08156	0.06654	0
C2	0.40905	0.37065	1.13933	0.60714	3.15819	0	0.0321
C3	1.28105	0.49955	2.69843	2.79809	2.38521	0	0
C4	5.47773	0.44559	3.45133	3.45097	3.17205	0	0
C5	0.24718	0.038	0.57339	0.24443	0.38115	0	0
C6	0.64584	0.19841	0.9253	4.95326	0.9714	0	0
C7	0.92875	0.14632	1.05539	3.68737	0.65915	0.02494	0.02494

Cluster means

Cluster	AGOCAT	ALOFAL	AMMOSP	ANGANG	ARNLAT	CILMUS	CLUHAR	CYCLUM	EUTGUR	GADMO3
D1	0.86754	0.01757	0.70704	0.02436	0.37177	0.64433	1.87237	0.03727	0.00294	0.27154
D2	0.39644	0	0.33558	0.37196	0.03916	0.60114	1.28964	0	0.00679	0.0637
D3	1.78708	0	0.65629	0.05414	1.55587	0.07059	0.24458	0	0.20001	0.20103
D4	0.91795	0.22083	0.03137	0.12754	0.00401	1.3025	2.68663	0.00586	0.00302	0.42371
D5	0.54662	0	0.83621	0	3.52633	0.04395	0.28955	0	0.40237	0.06552
D6	2.80396	0	1.47837	0	0.16314	0.17728	0.12578	0.05926	0	1.44497
D7	0.21897	0	0.40332	0.14863	0.39198	0.949	1.37028	0	0	0.08338

Cluster	GASACU	GOBISP	HYPLAN	LIMLI0	LIMLI1	LIMLI2	LIMLI3	LIMLI4	LIPLIP	MERME1
D1	0.00858	4.15124	0.11862	3.62519	1.58559	0.94864	0.57904	0.15932	0.39712	1.62961
D2	0.03097	0.29866	0.09706	1.76969	0.8464	0.37784	0.11887	0.02492	0.21593	0.28478
D3	0	3.0508	0.14356	4.33215	3.24124	2.19937	1.02827	0.34588	0.04195	1.07467
D4	0.04403	4.68639	0.02312	1.60441	0.52126	0.29758	0.16303	0.06717	1.79711	1.4172
D5	0	3.60007	0.90471	2.9273	2.46732	2.42762	1.45916	0.61995	0	0.70048
D6	0	2.53893	0.39307	3.90781	2.65914	3.24742	2.51115	0.45502	0	3.15267
D7	0	5.84887	0.17442	5.16485	1.96143	1.04581	0.23536	0.12333	0.61693	0.99215

Cluster	MERME3	MERME4	MICKIT	MULSUR	MYOSCO	OSMEPE	PHOGUN	PLAFLE	PLEPL1	PLEPL3
D1	1.48043	0.20135	0.00792	0	0.54453	0.46358	0.16246	0.95209	5.1992	2.33577
D2	0.54406	0.01319	0.14087	0	0.43402	0.02354	0.15253	0.75581	2.53954	1.73208
D3	1.63164	0.41757	0.10818	0	0.35703	0	0.10236	0.69977	3.39244	3.53235
D4	0.84113	0.02514	0	0	0.80384	3.45268	0.32799	2.66016	5.03401	0.648
D5	0.83063	0.3071	0.01666	0	0.10187	0	0	0.19692	2.76665	4.46183
D6	2.58615	0.07287	0	0	1.43524	0.32947	0.11662	1.02593	5.33468	2.14667
D7	1.10718	0.35839	0.00862	0	0.06946	0.03657	0	0.55943	2.13258	1.43161

Cluster	PLEPL4	SCOMA1	SCORH1	SCORH3	SOLSO1	SOLSO3	SOLSO4	SPRSPR	SYNGSP	TRATRA
D1	0.16559	0.01463	0.03158	0.02496	1.84008	0.20564	0.0783	0.80061	1.15255	0.31191
D2	0.64512	0	0.02891	0.02162	1.76899	0.94486	0.21829	0.30231	0.52324	0.25044
D3	1.25126	0	0	0	2.93138	1.6489	0.45533	0.19436	0.31765	0.71909
D4	0.01606	0.01082	0.06336	0.03412	2.02198	0.04418	0	0.99526	2.51938	0.00401
D5	0.68109	0	0	0	1.46911	1.09371	0.24016	0.24044	0.05849	1.37087
D6	0.211	0	0	0	0.92186	0.12039	0.035	0.39996	0.56817	0.39659
D7	0.14744	0	0	0	1.90094	0.33903	0.09447	0.59696	0.35084	0.11502

Cluster	TRAVIP	TRILUC	TRILUS	TRIMIN	ZOAVIV	DICLAB	ENGENC	BUGLUT	CALLSP	
D1	0.40493	0.48512	0.79715	0.1139	0.86903	0	0	0.3397	0.45769	
D2	0.06686	0.07945	1.96652	0.04476	0.65469	0.16141	0.08629	0.01778	0.28554	
D3	0.93439	0.80029	1.36515	0.15561	0.05127	0	0	3.83872	3.9751	
D4	0.01041	0.02979	0.32099	0	1.93148	0	0	0	0	
D5	2.32533	0.9599	0.65928	0.26266	0.04395	0	0	5.49591	3.96685	
D6	0.03281	0.51721	0.17995	0.0205	1.37108	0	0	0.59899	2.19245	
D7	0.34159	0.10032	1.47023	0.23715	0.07728	0.00541	0	0.29408	2.16736	

Appendix V: Cluster summary, statistics of the variables, mean values of the variables in the classification and distances between the clusters. FASTCLUS 7 cluster classification. The hauls are pooled into 3x3 mile rectangles and into two depthbands (0-15m and >15m).

Cluster	Number of hauls in cluster	RMS Std Deviation	Maximum distance from seed to observation	Nearest cluster	Distance between cluster centroids
D1	24	0.5285	5.4403	7	4.7733
D2	17	0.4933	4.4497	1	5.8424
D3	4	0.6641	4.996	5	4.4946
D4	9	0.5918	6.9138	1	5.4128
D5	6	0.6791	5.9885	3	4.4946
D6	15	0.5958	5.0625	1	5.6445
D7	15	0.5208	4.9457	1	4.7733

Distance between cluster centroids
Nearest cluster

Cluster	D1	D2	D3	D4	D5	D6	D7
D1	.	5.84235987	6.99081002	5.41283699	8.87631539	5.64447877	4.77332339
D2	5.8423599	.	8.29328416	7.71987268	9.87193874	8.30593549	7.14712078
D3	6.99081	8.29328416	.	10.580367	4.49460438	6.88670568	6.79974073
D4	5.412837	7.71987268	10.58036695	.	11.9712122	8.91129971	7.85705125
D5	8.8763154	9.87193874	4.49460438	11.9712122	.	9.17550762	8.691511
D6	5.6444788	8.30593549	6.88670568	8.91129971	9.17550762	.	7.76614961
D7	4.7733234	7.14712078	6.79974073	7.85705125	8.691511	7.76614961	.

Statistic for variables

Variable	Total STD	Within STD	R-Squared	RSQ/(1-RSQ)
AGOCAT	1.023717	0.548275	0.7325	2.738313
ALOFAL	0.0974674	0.0747414	0.451607	0.823511
AMMOSP	0.926104	0.848222	0.217676	0.278243
ANGANG	0.209461	0.165539	0.417519	0.716795
ARNLAT	0.956003	0.408263	0.829922	4.879646
CILMUS	0.679119	0.59194	0.291481	0.411394
CLUHAR	1.232684	0.973981	0.417782	0.71757
CYCLUM	0.0734491	0.0720837	0.101766	0.113296
EUTGUR	0.139962	0.0945162	0.574715	1.351366
GADMO3	0.644499	0.438158	0.568972	1.320035
GASACU	0.0450297	0.0437819	0.118387	0.134284
GOBISP	2.122436	1.136318	0.732688	2.740943
HYPLAN	0.423595	0.377115	0.260845	0.352895
LIMLI0	1.584262	1.056773	0.585049	1.409921
LIMLI1	1.098609	0.809356	0.493848	0.975692
LIMLI2	1.17268	0.573348	0.777071	3.485743
LIMLI3	0.95024	0.440947	0.799186	3.979728
LIMLI4	0.256271	0.187657	0.499944	0.999777
LIPLIP	0.666603	0.451408	0.572348	1.338347
MERME1	1.149742	0.72251	0.631722	1.715343
MERME3	0.917649	0.653801	0.526602	1.112387
MERME4	0.243053	0.208131	0.316153	0.462315
MICKIT	0.118959	0.109111	0.215436	0.274593
MULSUR	0	0	.	.
MYOSCO	0.603171	0.426312	0.534134	1.146539
OSMEPE	1.172915	0.640334	0.722049	2.597753
PHOGUN	0.220852	0.208083	0.172135	0.207926
PLAFLE	0.882091	0.661313	0.475827	0.907767
PLEPL1	1.677015	0.984842	0.678377	2.109227
PLEPL3	1.262789	0.924947	0.499666	0.998664
PLEPL4	0.516845	0.434975	0.339463	0.513919
SCOMA1	0.0251975	0.0251621	0.070032	0.075306
SCORH1	0.0669357	0.0659744	0.09401	0.103765
SCORH3	0.0533397	0.0535338	0.060617	0.064529
SOLSO1	0.839284	0.737897	0.279122	0.387196
SOLSO3	0.584703	0.400432	0.562604	1.286258
SOLSO4	0.214955	0.19395	0.240773	0.317128
SPRSPR	0.53508	0.487262	0.226651	0.293078
SYNGSP	0.894622	0.624354	0.545776	1.201557
TRATRA	0.584949	0.50923	0.293225	0.414878
TRAVIP	0.836126	0.635721	0.46089	0.854908
TRILUC	0.51893	0.452089	0.292188	0.412805
TRILUS	0.908527	0.674961	0.485281	0.942807
TRIMIN	0.184433	0.167771	0.2283	0.295841
ZOAVIV	0.892781	0.698932	0.428432	0.749575
DICLAB	0.116995	0.102	0.291145	0.410725
ENGENC	0.0877223	0.0837531	0.149902	0.176334
BUGLUT	1.553265	0.488716	0.907677	9.831537
CALLSP	1.53895	0.896415	0.683584	2.160401
OVER-ALL	**0.856185**	**0.554451**	**0.608907**	**1.556934**

Pseudo F Statistic = 21.54
Approximate Over-All R-Squared = 0.32025
Cubic clustering criterion = 35.483

Appendix VI: Cluster summary, statistics of the variables, mean values of the variables in the classification and distances between the clusters. FASTCLUS 7 cluster classification. The hauls are pooled into 3x3 mile rectangles and into six depthbands (0-5m, 5-10, 10-15, 15-20, 20-25 and >25m.).

Cluster	Number of hauls in cluster	RMS Std Deviation	Maximum distance from seed to observation	Nearest cluster	Distance between cluster centroids
E1	18	0.4763	4.9208	4	3.7753
E2	6	0.674	5.6296	6	7.7755
E3	28	0.5397	5.7973	1	4.9436
E4	19	0.5605	5.9063	1	3.7753
E5	17	0.6913	6.004	1	4.6046
E6	3	0.6088	4.4238	7	5.2463
E7	12	0.5434	4.8834	1	4.4113

Distance between cluster centroids

Nearest cluster

Cluster	E1	E2	E3	E4	E5	E6	E7
E1	.	9.9419456	4.94360602	3.77525158	4.60456267	6.63948948	4.41130362
E2	9.9419456	.	10.34689226	11.8493031	8.56288384	7.77553626	8.8344681
E3	4.943606	10.3468923	.	7.15445864	7.178928	6.29664601	6.66935481
E4	3.7752516	11.8493031	7.15445864	.	6.87697881	8.71957114	5.92217006
E5	4.6045627	8.56288384	7.178928	6.87697881	.	6.5808133	5.98401708
E6	6.6394895	7.77553626	6.29664601	8.71957114	6.5808133	.	5.24630486
E7	4.4113036	8.8344681	6.66935481	5.92217006	5.98401708	5.24630486	.

Statistic for variables

Variable	Total STD	Within STD	R-Squared	RSQ/(1-RSQ)
AGOCAT	0.955812	0.770718	0.388049	0.634119
ALOFAL	0.0765598	0.0692345	0.230312	0.299228
AMMOSP	0.748422	0.626243	0.341033	0.517526
ANGANG	0.238401	0.210882	0.263562	0.357888
ARNLAT	0.860335	0.503596	0.677522	2.100987
CILMUS	0.779872	0.674977	0.294978	0.418396
CLUHAR	1.327347	1.079966	0.376951	0.60501
CYCLUM	0.0495914	0.0460577	0.188174	0.231792
EUTGUR	0.139363	0.103151	0.484392	0.939457
GADMO3	0.541678	0.427101	0.414873	0.709031
GASACU	0.0788444	0.0788687	0.058244	0.061847
GOBISP	2.151367	0.93819	0.821012	4.586969
HYPLAN	0.32947	0.317409	0.12647	0.144781
LIMLI0	1.447025	0.999255	0.551181	1.228067
LIMLI1	1.172956	0.839701	0.517656	1.073211
LIMLI2	0.974595	0.577303	0.66976	2.028104
LIMLI3	0.780258	0.476054	0.649645	1.854249
LIMLI4	0.230333	0.175985	0.450571	0.820071
LIPLIP	0.689929	0.478875	0.546575	1.205434
MERME1	1.090576	0.755336	0.548519	1.214931
MERME3	1.006675	0.786938	0.42486	0.738708
MERME4	0.227593	0.211242	0.1892	0.233349
MICKIT	0.156013	0.150004	0.129928	0.149331
MULSUR	0	0	.	.
MYOSCO	0.537707	0.469019	0.283921	0.396493
OSMEPE	1.05534	0.624378	0.670556	2.035418
PHOGUN	0.244292	0.238544	0.102594	0.114323
PLAFLE	0.763708	0.643018	0.332791	0.498781
PLEPL1	1.594384	1.072815	0.573877	1.34674
PLEPL3	1.214438	0.963324	0.407804	0.688631
PLEPL4	0.528617	0.484432	0.209584	0.265156
SCOMA1	0.0484444	0.0482093	0.067936	0.072887
SCORH1	0.0587028	0.0566909	0.122231	0.139252
SCORH3	0.0994251	0.100406	0.040168	0.041849
SOLSO1	0.79984	0.815564	0.021455	0.021925
SOLSO3	0.555613	0.392017	0.53147	1.134334
SOLSO4	0.167474	0.144876	0.295678	0.419805
SPRSPR	0.598737	0.542962	0.226008	0.292003
SYNGSP	1.026845	0.591967	0.687208	2.197015
TRATRA	0.616615	0.490249	0.405056	0.680829
TRAVIP	0.689203	0.531518	0.440226	0.786437
TRILUC	0.500236	0.361411	0.508726	1.035524
TRILUS	1.078923	0.95352	0.264894	0.360348
TRIMIN	0.198864	0.196306	0.082882	0.090372
ZOAVIV	0.88059	0.735432	0.34354	0.523322
DICLAB	0.35579	0.34689	0.10532	0.117718
ENGENC	0.131116	0.126819	0.119504	0.135723
BUGLUT	1.412482	0.486735	0.888239	7.947644
CALLSP	1.513977	0.826404	0.719575	2.566016
OVER-ALL	**0.83059**	**0.570837**	**0.555449**	**1.249463**

Pseudo F Statistic = 19.99

Approximate Over-All R-Squared = 0.31067

Cubic clustering criterion = 31.236

Cluster means										
Cluster	AGOCAT	ALOFAL	AMMOSP	ANGANG	ARNLAT	CILMUS	CLUHAR	CYCLUM	EUTGUR	GADMO3
E1	0.77274	0.01248	0.26097	0.03451	0.18774	0.70787	2.56283	0.0575	0	0.18159
E2	0.75128	0	0.51308	0	3.10528	0	0.20913	0	0.42262	0.06552
E3	0.47408	0	0.35738	0.31734	0.0416	0.54848	1.43157	0	0.00942	0.03818
E4	1.20178	0.09618	0.10177	0.0794	0.02829	1.53928	2.52138	0.00694	0.03267	0.46659
E5	2.06034	0	1.41104	0.03445	0.48298	0.48449	0.63401	0	0.03045	1.00453
E6	0.68381	0	0	0.22339	0.63315	0.45884	0.11805	0	0	0.08662
E7	0.19802	0	0.41302	0.06494	0.37501	0.52198	1.69722	0	0	0.03935
Cluster	GASACU	GOBISP	HYPLAN	LIMLI0	LIMLI1	LIMLI2	LIMLI3	LIMLI4	LIPLIP	MERME1
E1	0.01312	3.57446	0.08984	3.23715	1.58709	0.88286	0.44764	0.1045	0.51061	1.56542
E2	0	3.2971	0.44642	3.77158	3.14138	2.40035	1.51928	0.68074	0	0.77756
E3	0.04448	0.41468	0.11549	1.75845	0.79098	0.31321	0.10347	0.03139	0.1803	0.25451
E4	0.03481	5.14182	0.03747	2.34369	0.597	0.29454	0.2386	0.05781	1.49902	1.89836
E5	0	3.14534	0.31266	4.35689	2.6681	2.33093	1.80301	0.23652	0.06871	2.39191
E6	0	2.416	0.08662	5.3051	2.58454	1.02418	0.39583	0.25986	0.51911	0.78512
E7	0	6.00425	0.23452	4.11017	1.57845	0.80847	0.34942	0.13019	0.43241	0.60986
Cluster	MERME3	MERME4	MICKIT	MULSUR	MYOSCO	OSMEPE	PHOGUN	PLAFLE	PLEPL1	PLEPL3
E1	1.34477	0.13045	0.00394	0	0.7125	0.49383	0.19441	0.95862	4.85117	1.99206
E2	1.14597	0.24612	0.1707	0	0.17285	0	0	0.34755	2.52526	4.36438
E3	0.59119	0.01178	0.1082	0	0.46072	0.01747	0.14915	0.74407	2.82157	1.71877
E4	1.18736	0.0453	0	0	0.82627	2.3461	0.24292	1.77204	4.94974	0.99979
E5	2.56334	0.24656	0	0	0.83502	0.26463	0.12577	1.18241	5.41256	2.5737
E6	0.74379	0.08662	0	0	0.08662	0	0.07691	0.67903	1.36273	1.42354
E7	0.90794	0.2467	0.02034	0	0.02175	0.0633	0	0.4841	2.99613	1.79507
Cluster	PLEPL4	SCOMA1	SCORH1	SCORH3	SOLSO1	SOLSO3	SOLSO4	SPRSPR	SYNGSP	TRATRA
E1	0.16057	0.02903	0.0455	0.02196	1.60695	0.20138	0.07265	0.77167	1.31607	0.09321
E2	0.90167	0	0	0	1.73653	1.51334	0.40484	0.16648	0.19015	1.67898
E3	0.547	0	0.0119	0.04829	1.73957	0.85006	0.13822	0.35809	0.47563	0.28667
E4	0.02614	0.02297	0.04736	0.03444	1.60995	0.06198	0.00928	0.97874	2.61841	0.05791
E5	0.18533	0	0	0	1.71791	0.24903	0.05492	0.61702	0.53712	0.67696
E6	0.42936	0	0	0	2.10809	0.67608	0.08662	0.10236	0.29629	0
E7	0.23735	0	0	0	1.46928	0.21611	0.03519	0.97231	0.31691	0.38604
Cluster	TRAVIP	TRILUC	TRILUS	TRIMIN	ZOAVIV	DICLAB	ENGENC	BUGLUT	CALLSP	
E1	0.19599	0.212	1.04966	0.13153	1.30299	0	0	0.18503	0.19049	
E2	2.04388	1.07348	0.71971	0.2151	0	0	0	5.77576	4.73108	
E3	0.05562	0.08896	1.85562	0.07107	0.67361	0.26159	0.10138	0.01976	0.24684	
E4	0.04147	0.06308	0.39445	0.01531	1.52045	0	0	0.00809	0.01994	
E5	0.25573	0.9361	0.6433	0.09303	0.67117	0	0	0.65324	1.46282	
E6	0.21459	0.22737	1.52858	0	0.38179	0.07691	0	0.63146	3.8673	
E7	0.34186	0.21154	0.76614	0.16609	0	0.01203	0	0.27919	1.94162	