ICES Marine Habitat Committee
ICES CM 2004/E:05 Ref. ACME, ACE

Report of the Study Group on the North Sea Benthos Project 2000 (SGNSBP)

29 March–1 April 2004
Wilhelmshaven, Germany

International Council for the Exploration of the Sea

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1 OPENING OF MEETING

The Study Group on the North Sea Benthos Project 2000 (SGNSBP) met from 29 March–1 April 2004 at the Senckenberg Institute, Wilhelmshaven, Germany. Dr Rees (Chair) welcomed the participants listed at Annex 1, and recorded apologies from Heye Rumohr (Germany), Sabine Cochrane (Norway), Gerard Duineveld (the Netherlands), Paul Kingston (UK), Jean-Marie Dewarumez and Nicolas Desroy (France). The Study Group had evolved from an earlier subgroup of the ICES Benthos Ecology WG, following the support of ICES at the 2002 ASC. The SG would report to the Marine Habitat Committee (with links to ACME and ACE), as well as to the Benthos Ecology Working Group (BEWG) in order to exploit the opportunity for the reciprocal input of expert advice.

2 APPOINTMENT OF RAPPORTEUR

R. Kilbride was appointed as Rapporteur.

3 TERMS OF REFERENCE OF THE STUDY GROUP

The overall Terms of Reference for SGNSBP are as follows:

a) collect and harmonize data from stations sampled during the 2000 ICES North Sea Benthos Project;
b) augment the NSBP 2000 data with information from other sources (principally from the period 1999–2001) in order to maximise coverage of the North Sea area;
c) propose effective ways for ICES to interact with the NSBP database at the Flanders Marine Institute;
d) prepare a programme of work to resolve problems affecting the compatibility of data sets from different sources;
e) identify patterns in contemporary North Sea benthic assemblages and the causal influences, by reference to supporting environmental data from the NSBP 2000 and other sources;
f) compare the outcome of the NSBP 2000 with that of 1986 and postulate causes for any observed differences, with reference to information on temporal changes in biotic and environmental factors, including human influences;
g) provide a strategic evaluation of the utility of the collaborative exercise for sea-wide quality assessments;
h) make recommendations for the timing and coordination of any future work.

Note: Item a) was modified by the substitution of 2000 for 1986 to account for an inconsistency in the original ToR.

The above Terms of Reference covered the projected activities of the SG for the duration of its existence (predicted to be four years). The content was further reviewed and accepted by the SG as a valid way to proceed.

The Terms of Reference for the present meeting of SGNSBP are as follows:

a) consider the outcome of discussions of an intersessional sub group to:
    i) finalise the benthic macrofaunal data set for the NSBP 2000 and generate outputs from multivariate analyses;
    ii) adjust the 1986 NSBS dataset for compatibility with NSBP 2000 and generate outputs from multivariate analyses;
    iii) make a preliminary statistical comparison of the 1986 and 2000 data, employing ICES rectangles as a basis for station selection;
    iv) make recommendations regarding sub-sets of habitat-specific stations for historical comparisons;
    v) progress the compilation of ancillary environmental data and identify additional needs;
    vi) review regional data assessments prepared by national agencies and others.

b) review the outcome of data compilations and analytical outcomes to date;
c) identify database and analytical issues for further resolution;
d) conduct a preliminary evaluation of findings in relation to hypotheses for natural and anthropogenically-induced changes and make recommendations for follow-up work, particularly in relation to forthcoming publications;
e) make recommendations on the utility of the available data for classification of North Sea habitats based on structural and functional properties of assemblages;
f) evaluate new approaches to data analysis;
g) identify and locate additional biotic/environmental data to aid interpretation of the causes of benthic biological changes;
h) evaluate the scope for contemporaneous and historical comparisons of the status of North Sea epifaunal communities in the context of the NSBP 2000 assessment;
i) determine priorities for assistance from WGSAEM with statistical analyses and develop with WGSAEM a plan for the necessary collaboration.

SGNSBP will report by 16 April 2004 for the attention of the Marine Habitat Committee, ACME and ACE.

4 AGENDA

The draft Agenda at Annex 2 was accepted by the Study Group.

5 REVIEW OF PROGRESS TO MARCH 2004

a) Outcome of previous NSBP2000 Workshops.

SGNSBP felt it would be helpful to include the report of the last intersessional workshop (held in Oostende, November 2003) dealing with preliminary analysis of the data. This is given at Annex 5.

b) Status of database.

Edward Vanden Berghe gave an account of the current status of the database. All outstanding data have now been incorporated. All SG members present felt that the database is now at a stage where it can be used for analysis of species distributions. Edward suggested that the database should be effectively "frozen" at the end of the present meeting to allow for consistency in all subsequent analysis. Nevertheless, all data contributors are requested to have a final look intersessionally for any remaining minor inconsistencies. There are a total of 1401 stations and 1796 samples in the 2000 database. The addition of the 1986 data extends it to 1632 and 2077, respectively.

A summary of the structure and content of the database is given in ICES CM.2002/L:09, presented at the ICES Annual Science Conference. Annex 3 lists the data contributors and summary information relating to their samples.

b) Status of biological information (2000 survey).

Since the last meeting, the taxonomic list has been refined and updated and one additional dataset from the Eastern English Channel has been added to extend the geographical scale of coverage of the data and increase the information content on coarse substratum communities. The biological data is now considered complete and ready for use.

c) Status of environmental information (2000 survey)

Environmental data are very patchy or non-existent. At the last intersessional meeting, a subgroup determined a priority list of environmental variables as a minimum contribution (see Annex 5, Report of meeting in Oostende, November 2003). Data contributors have tended to submit data on sediment type either as visual descriptions or full PSA statistics. There are also currently no biomass data within the database, although there are some available from the German Bight (Rachor) and the western North Sea (Rees/Robertson).

d) Analytical tools.

There are several tools which will be used for multivariate analysis, e.g., PRIMER, TWINSPAN, PC-ORD. These will initially produce groupings of samples based on their similarities to each other which will lead to the assignation of community types within the study area and the species responsible for the differences between these groups. Previous analysis has been based on presence/absence data, but future analysis will be based on 4th root transformed data to reduce the effect of very abundant taxa. It was proposed that Henning Reiss should lead on multivariate analyses of the data at the meeting. Comparisons between the 1986 and 2000 data will be possible with a reduced sample grid from 2000 (i.e., by matching stations from 2000 survey to those from the 1986 survey). It will be carried out on the basis of community types within and between each year.

Steven Degraer was nominated to lead on univariate analyses at the meeting. Rarefaction curves and densities of species were identified as being particularly useful for preliminary assessments.

6 OUTCOME OF ANALYSES

Multivariate analyses

Both PC-ORD and TWINSPAN have shown initial clustering on the basis of coarse vs. fine substratum types. The pattern of clusters from both of these methods are similar to each other (see below for further information) based on fourth root-transformed data. It was suggested that Chi^2 contingency tables between the TWINSPAN and PC-ORD would show whether they were indeed statistically similar. The quality of the clustering was checked by looking at sub-sets of data which we know from previous analysis by institutes represent discrete communities – in particular the Degraer survey of the Belgian coast (well defined trench and sandbank communities) and the Helgoland trench community. These were seen to form unique clusters as expected and so there is good overall agreement between the TWINSPAN and PC-ORD clustering outputs in the division of samples, compared with the expectations of individual data contributors for their areas of interest.

PC-ORD outputs

The cluster analysis within PC-ORD was carried out using Bray-Curtis similarity and group average linkage. Figures A6.1 and A6.2 (Annex 6) show the results based on presence-absence and fourth root transformed abundance data, respectively. Only clusters which included more then five stations were noted as a 'main' cluster in the map. The characteristic species of each main cluster revealed with abundance data were determined with the SIMPER tool within the work package of PRIMER. Similar patterns were found with both transformation types. Approximately five major clusters were distinguished: a) northern North Sea (north of the 50 m contour), b) Oysterground and German Bight, c) continental coastal areas and parts of the Dogger Bank, d) southeastern coast of England (mainly coarse sediment), d) rather heterogeneous assemblages at the coastal areas of France and Belgium and e) English Channel. Several smaller clusters indicating specific communities were also found, e.g., the Amrum Bank or the Helgoland trench.

The northern North Sea cluster as well as the Oysterground and German Bight cluster was mainly characterized by *Amphiura filiformis* and *Spiophanes bombyx*. Discriminating species were *Paramphinome jeffreysii* and *Myriochele oculata* dominating the northern cluster. The continental coastal cluster was mainly characterized by *Tellina fabula*, *Magelona johnstoni* and *Spiophanes bombyx*. The English Channel cluster was characterized by *Pomatoceros triqueter*, *Aonides paucibranchiata*, *Glycera lapidum* and *Scalibregma* spp. The coarse sediment cluster on the southeastern coast of England can be further divided into a clean sand community characterised by *Nephtys caeca* and *Urothoe brevicornis*, and a mixed coarse sediment community with *Sabellaria spinulosa* and *Pholoe* spp. being dominant. The French and Belgium coast clusters were found to be very heterogeneous splitting up into several clusters. A more detailed analysis is in progress.

TWINSPAN outputs

Samples were grouped according to their similarity in species composition using TWINSPAN analysis (Hill, 1979). This program divides the ordinated sampled into two groups and proceeds by dividing each group into two further groups and so on. TWINSPAN also identifies one to several differential species that are particularly diagnostic of each

division in the dendrogram (indicator analysis). This analysis was run twice: firstly solely with presence or absence of species data and secondly taking into account the (logarithmically) transformed abundance of the species (cutlevels used were: 0, 1.5, 2.5, and 3.5).

Figure A6.3 (Annex 6) shows the similarity in species composition between stations, taking densities into account. Figure A6.4 (Annex 6) shows the similarity in species composition between stations based on presence/absence data. The results are very similar.

At the first dichotomy the first four groups (indicator species: *Aonides paucibranchiata*, Nemertea, *Glycera lapidum*, *Pomatoceros triqueter*) are separated from the other five groups (indicator species: *Pomatoceros triqueter*, *Nephtys hombergii*).

At the second dichotomy the first two groups (indicator species: *Typosyllis prolifera*, *Lumbrineris latreilli*, *Exogone naidina*, *Abietinaria abietina*, *Ampharete acutifrons*) are separated from the other two (indicator species: *Laonice bahusiensis*). Indicators separating group 1 and 2 are *Eteone longa* (group 1) and *Prionospio multibranchiata*, *Notomastus latericeus*, *Eunice dubitata*, *Nephasoma minutum* and *Polycirrus* sp. (group 2). Indicator species for group 3 and 4 are *Amphipholis squamata, Pomatoceros triqueter, Lepidonotus squamatus, Gari tellina* (group 3) and *Glycera lapidum* (group 4).

The other five groups are first split based on differences in presence and densities of *Amphiura filiformis, Goniada maculata, Sthenelais limicola, Pholoe baltica, Harpinia antennaria* (groups 5–7) and *Nephtys cirrosa* (groups 8–9). Group 5 is separated from groups 6–7 based on differences in *Paramphinome jeffreysii, Prionospio cirrifera, Spiophanes kroeyeri, Levinsenia gracilis, Anobothrus gracilis, Terebellides stroemi* (group 5) and *Mysella bidentata* (groups 6–7). Indicator species for the division between groups 6 and 7 are *Corbula gibba, Callianassa subterranea, Eudorella truncatula, Nucula nitidosa* (group 6) and *Magelona filiformis, Magelona johnstoni* and *Spiophanes bombyx* (group 7).

Finally indicator species for group 8 are *Nephtys hombergii, Tellina fabula, Abra alba* and *Chaetozone* spp. (no indicator species for group 9).

Univariate analyses

All univariate analyses were conducted using the STATISTICA package. The results of selected analyses are presented below. These include derivations from rarefaction curves, to compensate for different sample sizes between stations. ES(100) = expected number of species in a hypothetical sample of 100 individuals.

Latitudinal gradient

From 51°N to 61°N diversity increased from about ES(100) 0–20 to 30–45. South of 51°N a very variable diversity was found (ES(100) 1 – 43), coinciding with a dataset composed of Hamon grab as well as Van Veen grab samples (Annex 6, Figure A6.5) Since the Hamon grab samples were collected (mainly) in gravel beds (e.g., Channel and English East coast), diversity can be strongly increased by the epifauna of the gravel beds. Combined with the mobile sandy substratum fauna collected with the Van Veen grabs, this fact might explain the wide range of diversity in the area.

No obvious latitudinal gradient in macrobenthic density was found Annex 6, Figure A6.6). Lowest and highest densities (resp. 2 and 26000 ind./m²) were found South of 52°N. North of 52°N macrobenthic densities generally varied between 100 and 10000 ind./m².

Highest densities primarily coincided with high densities of *Lanice conchilega* (Annex 6, Figure A6.7). *Lanice conchilega* was positively correlated with the macrobenthic density. This relationship might be explained by the habitat engineering capacities of *L. conchilega*. It still has to be checked whether this correlation represents a direct causal relationship, since habitat engineers might be specifically linked to habitats rich in macrobenthic fauna. Habitat engineers are here defined as species that increase the habitat complexity by the creation of (semi-) permanent structures above the sediment-water interface.

No correlation between *L. conchilega* density and macrobenthic diversity was found. (Annex 6, Figure A6.7). Because the increasing dominance of *L. conchilega* has the effect of decreasing ES(100), the latter should be recalculated by excluding *L. conchilega* from the dataset.

The strong latitudinal gradient within the macrobenthos does not necessarily indicate a causal relationship between the macrobenthos and latitude. Other environmental variables that are likely to have a causal relationship with the macrobenthic distribution are known to be correlated with latitude. Unfortunately, at this moment information on the major part of these ecologically relevant variables are largely missing. As an example, the latitudinal depth gradient is presented in Figure A6.8 (Annex 6). Nevertheless, latitude can serve as a proxy for an existing ecological gradient throughout the North Sea.

Longitudinal gradient

No longitudinal diversity gradient was detected, when using all data points. However, a latitudinal diversity gradient was found, when selecting a latitudinally-defined subset of data points. In between 53° and 56°N a decreasing diversity was found from West to East (Annex 6, Figure A6.9). Most probably, the strong latitudinal gradient is blurring any longitudinal gradient when using all data points.

No longitudinal gradient was found for the macrobenthic density at this moment. Future analysis will check for the presence of longitudinal density gradients for latitudinally-defined subsets of data points.

Testing of TWINSPAN output using univariate techniques

The average macrobenthic density and diversity per cluster group derived from TWINSPAN analysis ranged from about 300 to 2100 ind./m² and ES(100) of 10 to 32, respectively (Annex 6, Figure A6.10). Groups 1–4 were characterized by a combination of low density and high diversity. High densities and diversity were found in TWIN groups 5–7. TWIN group 9 had both the lowest density and diversity.

Species distributions

Steering group members provided a list of species of interest, and distributions of these species across the survey area were mapped. Several species showed a distribution linked to substratum type (as expected) and a North/South distribution pattern. Distribution maps are shown for *Amphiura filiformis* (Annex 6, Figure A6.11), *Lumbrineris gracilis* (Annex 6, Figure A6.12), *Nephtys hombergii* (Annex 6, Figure A6.13) and *Spiophanes bombyx* (Annex 6, Figure A6.14). Investigations into the distribution of other species will continue, to look for any changes in distribution between the 1986 and 2000 surveys.

Reference

Hill, M.O. 1979. TWINSPAN - a FORTRAN programme for arranging multivariate data in an ordered two-way table by classification of individuals and attributes. Section of Ecology and Systematics, Cornell University, Ithaca, New York.

7 PROGRESS ON OTHER ISSUES

Data on substratum type

Considerable effort was made during the workshop to contact data contributors for outstanding particle size information, either in the form of full analysis or visual descriptions. The description/full analysis for each sample was assessed and assigned to one of eight sediment categories (see Annex 4 for information on categories). This will allow for a standardised assessment of sedimentary characteristics throughout the survey area (see Annex 6, Figure A6.15).

Oceanographic data

Several modellers were contacted for further environmental information (e.g., depth, temperature, tidal currents). These data will be collated intersessionally for use at the next SGNSBP workshop in November 2004.

Anthropogenic influences

It was agreed to produce a synopsis of current information regarding non-fisheries human inputs and activities. This would include an examination of the utility of available data on the distribution of nutrients and contaminants. Information/publications arising from earlier assessments of the relationship between CPR data and human impacts would also be explored.

Meiofauna

Meiofaunal data from the western North Sea are being worked up by CEFAS (UK), and there are limited meiofauna information from the inshore Belgian coastline. There are some meiofaunal community data available from the 1986 survey.

Epifauna

There is no compatible wide-scale data from either the 1986 or 2000 surveys. There may be the possibility to compare the Callaway *et al.* N Sea epifaunal paper with the infaunal work from the current survey.

Fishing effort

Johan Craeymeersch is currently collating accurate fishing effort data. There is the possibility of further progress with this under the EU project MAFCONS.

Feeding types

Good progress had been made by J. Craeymeersch on the compilation of information for the North Sea benthos. It was anticipated that the task would be completed in time for the November 2004 workshop.

ICES Study Group on EcoQOs for opportunistic and sensitive species

Karel Essink summarised the outcome of this meeting, held in Copenhagen in March 2004. Provisional lists of indicator species had been revised, and a number of proposals made for follow up work, including the application of community metrics (e.g., diversity indices) which might reflect the status of indicator groups. In particular, he recommended that the SGNSBP 2000 would be an appropriate group for exploring the validity of proposed indicator species, and the associated metrics. SGNSBP2000 endorsed this proposal, leading to the following recommendation to ICES/OSPAR:

The ICES SGNSBP 2000 recommends to ICES/OSPAR that it employs the NSBP 2000 data to:

- report on the distributions of sub-sets of opportunistic and sensitive species identified by the ICES Study Group on EcoQOs for opportunistic and sensitive species; and
- examine the utility of the recommended metrics.

Future developments/ideas relating to the NSBP2000 initiative

These included the possibility of a coordinated repeat of the 2000 survey (See recommendations), and the scope for extending the present initiative to the east and west, through collaborative links with other sea-wide survey initiatives (See action list), and an evaluation of current status of species occurrences relative to earlier information on biogeographical distributions. This might have the important benefit of identifying shifts in relation to climatic changes (see action list).

Collaboration with WGSAEM

The Study Group had a particular interest in statistical approaches to the comparison of spatial patterns (in this context, between 1986 and 2000 survey data). It was proposed to formulate a series of specific questions at the November 2004 SGNSBP 2000 workshop, for communication to WGSAEM (see recommendations).

8 PUBLICATIONS ARISING FROM RESEARCH

Eike Rachor gave a summary of what he expects to be in the first NSBP SG paper. It will be a descriptive paper of the biodiversity, and will include distribution patterns of species and assemblages, including the occurrence of any "exotic" species. Eike also requested that people make available any additional data (epifauna, underwater video, etc). It is anticipated that this paper will be submitted to the ICES Journal of Marine Science, with a full report of the data (including full species lists) going into an ICES co-operative research report. At the next SG meeting (3–5 November 2004, CEFAS, Burnham-on-Crouch) the plan will be to finalise this paper. The following additional papers (with lead authors) were agreed:

- fishing activities/impacts - J. Craeymeersch
- natural and human impacts (other than fishing) - Ingrid Kroncke
- functional properties – in particular feeding types - Gerard Duineveld
- comparison of epifaunal and infaunal community patterns - Henning Reiss
- benthos/habitat linkages - Steven Degraer
- NSBP 2000 data management – Edward Vanden Berghe

There was discussion on the timescales for future dissemination of data from NSBP 2000. Certain elements of the data can go onto the VLIZ website now, e.g., species lists and station positions, but not species lists by sample.

9 DATE/VENUE FOR NEXT MEETING

Two further meetings were agreed: an intersessional workshop involving a subgroup of Study Group members from 3–5 November 2004 at CEFAS, Burnham-on-Crouch, UK and a larger Study Group meeting (incorporating workshop activity) at the ICES Secretariat, Copenhagen, Denmark from 5–8 April 2005.

10 ACKNOWLEDGEMENTS

Dr Rees thanked Dr Kroncke and Professor Steininger of the Senckenberg Institute for their hospitality and organisation of the workshop.

11 ACTIONS AND RECOMMENDATIONS/ACTION LIST

The ICES Study Group on the North Sea Benthos recommends that it meets intersessionally in November 2004 (analytical subgroup) and then in full session in March 2005 in order to address the Terms of Reference listed at Annex 7. An associated action list is given at Annex 8.

12 ANNEXES

Annex 1 List of Participants

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Annex 2 Agenda

Plenary sessions

1. Welcome/introductions
2. Appointment of Rapporteur
3. Agree Agenda
4. Review of progress to date
    - Database
    - Status of biological information (2000 survey)
    - Status of environmental information (2000 survey)
    - Analytical tools
    - Preliminary outputs (November 2003 workshop: see separate attachment)
5. Plans for publishing outputs
6. Integration of findings from other studies (*e.g.*, fisheries, hydrography, geology)
7. New data sources; feasibility of inclusion
8. Additional idea to maximize the utility of survey data ('brainstorming')
9. Recommendations for future work
10. Action List
11. Date/venue for future meeting(s)
12. Close of meeting

Subgroup sessions

1. Amendments to NSBP 2000 data matrix (remaining taxonomic/other issues)
2. Further analyses of species/abundance matrix
3. Criteria for 1986/2000 comparison
4. Preliminary drafting of text
5. Derived measures: feeding type, biomass/production, carbon flux, other
6. Contributions of benthic ecological and environmental data to habitat mapping
7. Scope for parallel evaluation of epifaunal status (data sources, etc.)
8. Scope for parallel evaluation of meiofaunal status (data sources, etc.)

Annex 3 Summary of data sources in the form submitted for the NSBP 2000 survey

(Note: the mesh size is 1 mm unless otherwise specified).

Contact name	Area	Sampling device	Sample size (m^2)	No. reps	Notes
Degraer	Belgian coastline	Van Veen	0.1	1	Autumn/Spring sampling
Van Dalfsen	Dogger Bank	Van Veen	0.1	5	Aggregated data
Desroy	French coast	Hamon grab	0.25	2	Aggregated data 2 mm mesh
Dewarumez	English Channel French coastline	Hamon grab	0.25	2	Aggregated data 2 mm mesh
Duineveld	Dutch waters	Box core	0.068	1	Sampling over 2 years (’00 and ’01)
Cochrane	Norwegian offshore waters	Van Veen	0.1	5	Aggregated data
Hillewaert	Belgian coast	Van Veen	0.1	3	Autumn and Spring and fixed before sieving
Nehring	German estuaries	Van Veen	0.1	6	Separate
Newell	Eastern English Channel	Hamon grab	0.1 and 0.2	1	Data in m^2
Oug	Norwegian coastal	Day Grab/Van Veen	0.1	4	Separate
Rachor	German Bight/ Dogger Bank	Van Veen	0.1	2 (1–4)	Data in m^2 Aggregated
Rees	Western N Sea	Hamon/Day grab	0.1	3(1–3)	Separate
Robertson	North Sea	NIOZ core	0.25	2(1–3)	Separate
Rumohr	German Bight	Van Veen	0.1	1	Data in m^2
NSBS (1986)	N Sea	Smith-McIntyre / Van Veen	0.1	2	Data in m^2 separate and sieved over 0.5 (N. North Sea) and 1 mm mesh (S. North Sea)

Annex 4 Sediment categories (North Sea Benthos Project 2000)

A – Mud (silt and clay)

B – Mud and Sand

C – Fine sand (fine to medium sand)

D – Coarse sand (medium to coarse sand)

E – Sand and Gravel

F – Gravel

G – Stones

H – Mixed (from mud to gravel/shells)

Annex 5 Report of the SGNSBP2000 meeting in Oostende November 2003

ICES STUDY GROUP ON THE NORTH SEA BENTHOS PROJECT 2000

INTER-SESSIONAL WORKSHOP AT VLIZ, OOSTENDE, 3–5 NOVEMBER 2003

Present: Hubert Rees (Chair), Rebecca Kilbride (Rapporteur), Edward van den Berghe (Host), Eike Rachor, Henning Reiss, Gerard Duineveld, Jan Mees (part), Johan Craeymeersch (part)

Notes from meeting

The meeting commenced on the morning of the 3November with agreement on the Agenda (Appendix 1). Rebecca Kilbride was appointed as Rapporteur. Discussion on the current status of the database and where any gaps exist in the data was first on the agenda. Edward now holds all data in the database. Since the Yerseke meeting in March 2003, new data have been added to the database and it was necessary to review the species list. As for previous changes to the lists, decisions were made in order to improve between-laboratory consistency, which included the resolution of remaining problems relating to synonymies, misspellings and incomplete identifications presumed (in many cases) to be due to the occurrence of juveniles in samples. All changes to the species list were documented.

To make data comparable both within the 2000 survey and in comparison with the 1986 survey, it is likely that 2 samples from each station will be pooled with the exception of Mike Robertson's samples (large 0.25 m^2 boxcorer used so 1 replicate is sufficient) and those from Dutch waters which are not replicated and are of a smaller size (0.06 m^2). Indeed variation in the size of sampling equipment appears to be the main inconsistency in the data set; smaller samples will need to be multiplied up to become comparable with the larger ones in terms of counts, but this cannot compensate for the species/area problem. There was also discussion regarding coverage of the 1986 data-set in comparison to the 2000 data, as the Northern North Sea is better covered in the 1986 survey than the 2000, and the 2000 coverage of the Southern North Sea is greater than in 1986 (see Figure A5.1 for map of 1986 and 2000 sampling coverage).

Once Study group members had completed their alterations to the species list these were incorporated into the database to allow analyses of the NSBP2000 data. For data analysis, all species occurring in only one sample were removed from the list. This reduced the species list to 651 species. Following this, cluster analysis was performed using PRIMER and TWINSPAN to compare the different methods and outputs. Encouragingly, they seem to show similar patterns of sample clustering (Figures A5.2 and A5.3). These will be refined at the next meeting. Also, a subset of common species were selected to compare the 1986 and 2000 data and these plots are shown below in Figures A5.4–A5.8 (but note that the NSBP2000 data are not yet corrected to numbers per m^2). Preliminary examination of these and other taxa revealed distributional similarities in some cases, and significant differences in others. Further in-depth analyses of the 2000 and 1986 data will be carried out at the next Study Group meeting. Much of the second day of the workshop was spent refining these analyses and limited progress was made on drafting of any text. However, it is anticipated that progress will be made on this aspect of the project at the next Study Group meeting.

On the final day, the morning was spent agreeing the need for and sources of environmental data. Hubert and Henning had spent time drawing up a list with priorities attached to these (See Appendix 2). There are still also several missing values for metadata (See action list below for clarification of these), which include peak tidal currents, and water depths for some samples. It was suggested that all water depths are corrected to the Amsterdam level. The action list (Appendix 3) shows specific actions placed on Study Group members for the provision of such environmental data.

A request from David Connor (JNCC and Chair of ICES WGMHM) for a preliminary definition of the status of the North Sea by geo-referenced community type employing 2000 data was discussed. It was felt by the Study Group members present that this request could not be adequately met until after the March 2004 meeting. However, access to the 1986 data, along with a sediment map and references to national reports which incorporate more recent data, could be provided via the VLIZ website.

It was suggested that group members make available any national monitoring reports containing useful information for the NSBP2000. These national reports may also be helpful in making decisions on habitat sub-types to enable comparison between 1986 and 2000 data. However, it was felt that this should be discussed further at the next meeting and that it was not possible to make any progress in the meantime until further analyses have been carried out.

Also, Hubert has negotiated with a consortium of UK aggregate extraction companies for the inclusion of data from the eastern English Channel where a large baseline study has recently been carried out. These data will be added to the NSBP2000 species list and any necessary alterations made; Prof R Newell (UK) will act on behalf of the aggregate companies as the contact point for this data source.

Access to and use of all data sets incorporated into NSBP2000, agreed at the 2002 Ostende meeting, was reviewed and the wording was marginally amended (Appendix 4) to reflect the views of all participants.

Also, comparison of the 1986 and 2000 data in terms of feeding types requires further discussion and work. The 1986 and 2000 lists need to be linked and this is not yet complete. Edward and Johan are working on this and aim to finalise it in time for the March 2004 meeting.

There was discussion regarding authorship and themes/numbers of papers that could arise from the NSBP2000 initiative. Eike was proposed as lead author of an overview paper on North Sea benthic communities arising from present analytical work and he proposed a further paper investigating the status of vulnerable, rare and endangered species. There are also several other themes which are likely to be pursued, and it was decided to make a final decision at the March 2004 meeting.

On the subject of the forthcoming March 2004 meeting at Wilhelmshaven, NSBP Steering Group members are requested to notify Hubert Rees if they would like to invite others to the meeting, and Hubert will speak with Ingrid Kroncke regarding the format of the meeting.

Finally, a reminder that actions to be carried out before the next meeting are shown in Appendix 3. All are requested to ensure that any actions against their names are carried out before the March meeting to enable good progress to be made at this meeting.

Acknowledgements

Grateful thanks to Edward Van Den Berg, Jan Mees and other staff at VLIZ for their efforts in ensuring a productive outcome to the meeting, and for their hospitality.

Appendix 1 Draft agenda

Monday, 3 November

10.00–13.00: for those in attendance

- Set-up
- Initiate review of NSBP 2000 taxon list for resolution of remaining taxonomic inconsistencies
- ICES 1986 NSBS: preliminary identification of comparability problems for resolution

14.00–14.30

- Agree Agenda
- Appoint Rapporteur
- Agree structure/timetable for Workshop report (for circulation prior to the March 2004 SG meeting in Wilhelmshaven)
- Review access to and uses of data sets/authorship (see Appendix 3 of Ostende 2002 Workshop)
- Address ICES WGMHM request (see below for further information)

14.30–15.30

Progress report on project status:

- Status of NSBP biological data/database
- Status of environmental data
- Additional data sources
- Address remaining taxonomic and other inconsistencies for NSBP 2000 data
- In parallel, further address comparability issues with respect to the ICES 1986 NSBS

16.00–17.30

- Finalise NSBP 2000 benthos data set and initiate analyses
- Continue work on preparation of 1986 data
- 'Finalise' environmental data set

Tuesday, 4 November

09.00–10.30

- Conduct further analyses of NSBP 2000 data
- Resolve 1986/2000 discrepancies

11.00–13.00

- Conduct further analyses of NSBP 2000 data
- Conduct intercomparison of 1986 and 2000 survey data
- In parallel, initiate write-up of work: Introduction, Methods, Data quality, etc.

14.00–14.30

- Review progress/resolve problems

14.30–15.30

- Continue analyses/drafting of text

16.00–17.30

Continue analyses/drafting of text

Wednesday, 5 November

09.00–09.30

- Review progress
- Consider habitat sub-types for historical comparisons and make recommendations for follow-up work

09.30–12.00

- Continue analyses/drafting of text

12.00–13.00

- Review analytical and written Workshop output
- Review regional data assessments (national agencies/others) and their relevance to SG NSBP 2000 activity
- Agree future actions
- Agree structure/content of Workshop report
- Review Terms of Reference/membership/invitees for March 2004 SG meeting
- Any other business

14.00–15.00

Complete analyses/refine outputs for reporting purposes

End of workshop

Appendix 2 NSBP 2000 environmental data: needs and sources

1 Sediments

i) Data from NSBS (1986) and NSBP 2000 samples

Variable(s)	1986	2000	Priority need
Particle size analyses/statistics	Yes	Yes for part of survey	1
Sediment descriptions	Yes?	Yes for all stations?	1
Total organic carbon	Yes	Yes for part of surveys	2
Phytopigments	Yes for all stations?	No?	2
Contaminants	Yes	Yes for part of survey	2

ii) Other data sources

Maps, etc., from geological institutes; other sediments properties (e.g., porosity). Priority need: 2/3.

iii) Associated problems for resolution:

a) Harmonisation of methodology (e.g., for psa). NB. G Irion (Germany) analysed the full suite of 1986 sediment samples, so comparability was assured.
b) Cost (?) and time-scale for analyses
c) Availability of samples

2 Water-column (spatial pattern for classifying stations in 1986 and 2000; overview of temporal trends for evaluating any differences)

Variable	Nature of need	Source(s)	Priority
Temperature	Surface/bottom; 'summer'/'winter'	ICES? Maps/model output	1
Depth (a)	At time/location of sampling	Survey metadata: some missing (but available?)	1
Depth (b)	Bathymetric map to underpin benthos maps	ICES? National institutes?	1
Salinity	Surface/bottom; 'summer/'winter'?	ICES? Maps/model output	2
Turbidity	Surface/?bottom; annual average?	ICES? Maps/model output	2
Nutrients		ICES? Maps/model output	1
Plankton/productivity	Identify variables of interest	CPR/website	1
Oxygen/contaminants?			2/3

3 Water movements

Variable	Nature of need	Priority
Tidal currents	Max spring rates at sampling stations	1
Wave action/'exposure'?	Significant wave heights	2/3
NAO Index	For inferences concerning possible changes over time (1986–2000)	1

4 Human activities

Variable	Sources	Priority
Fishing activity	ICES? Other data sources? (see Johan Craeymeersch)	1
Dumping/extraction/oil and gas/pipelines, etc.	OSPAR/national data; identify locations for mapping of scale of activities	1

5 Notes

- The use of contoured plots for several variables of interest may be the simplest and quickest for evaluating spatial patterns, even if not as precise as modelling output matches to individual station positions. However, for evaluating changes between 1986 and 2000, we need to address trends in intervening years as well as snapshots of the data.
- For certain variables (e.g., fishing activity) there may be a need to make comparisons at the scale of ICES rectangles. This will require effort to synthesise the data from benthos stations in a consistent way.
- NB. Requests for information on environmental variables must be precisely formulated to avoid confusion and extra work in filtering out unwanted data.

6 Summary of priority 1 variables

Medium/activity	Variables
Sediments	Psa and/or sediment descriptions
Water-column	Temperature, depths (a and b), nutrients, plankton populations/productivity, NAO Index
Water movements	Tidal currents
Human activities	Fishing activities; location/extent of dumping/extraction/oil and gas activities

Appendix 3 Action list

All data providers to send the following sediment information to Edward by the end of November: raw data on % particle size distributions (as available), median grain size, maximum grain size, % silt/clay and sediment descriptions at the time of sampling. *NB*. The last is essential even if no other information is yet available.

Edward to contact data providers regarding remaining depth data (i.e., station depths at the time of sampling) and this depth data should be standardised to depth from the water surface.

Edward to obtain maps of temperature and salinity possibly using ICES data

Eike to follow up on a N Sea bathymetric map and provide this in electronic format to Edward

There is an Atlas of nutrient information by Brockman. **Eike** to pass contact details to Edward for follow-up.

Plankton and productivity – **Gerard** to look into accessing these data, e.g., via SAHFOS or the ERSEM model.

Ingrid and Henning to identify suitable sources of information on N Sea tidal currents, indices of wave action/exposure (e.g., significant wave heights) and NAO Index

Johan to report progress in compiling information on current fishing activity and changes since 1986 at the March 2004 SG meeting

Hubert to identify suitable maps of the spatial extent of anthropogenic activities such as dredged material disposal, aggregate extraction and oil and gas pipelines and installations

Edward to identify gaps in total organic carbon data and chase data providers for the information

Henning/Hubert to approach Georg Irion regarding assessment of contaminants/TOC/phytopigments in sediments arising from the current re-survey (subject to data availability), and comparisons with 1986 data

Eike to contact Dr Puls (Hamburg) who has a turbidity model of the N Sea (may also hold relevant current and sediment data)

All to contact Edward regarding information on any significant changes/events, e.g., in water-column oxygen, nutrient or contaminant levels in the 2 years preceding the NSBP re-survey (i.e., 1997/8), which might be relevant to the interpretation of the benthos data

Hubert to contact Edward regarding UK sources of digitised environmental data for the North Sea.

Individual data contributors to send to Edward references to published national (or other) reports covering assessments of the samples included in the North Sea Benthos database

Hubert to provide new E English Channel data to Edward, following finalisation of agreements over use/access with a consortium of aggregate extraction companies responsible for the work.

Eike to explore sources of any new Danish data

Procedures for calculating the AWI biotic index (A Borja) to be added to database – **Hubert and Edward** to proceed with this in consultation with Angel Borja

Edward/data providers to resolve remaining issues regarding access to individual versus pooled sample data.

Edward/Hubert/Becky to assess the amount and consistency of information on biomass.

Hubert to contact Paul Kingston regarding an up-dated UKOOA database for the western North Sea.

Edward to exclude any data outside the 1999/2001 window for NSBP analyses.

Henning to forward a summary of the outcome of the Workshop cluster/MDS analyses of NSBP data to Becky asap for inclusion in the Workshop report.

Eike to contact Dr Backhaus regarding the possible availability of near-bottom tidal current data in digitised format.

Edward and Johan to complete the feeding type work for the March meeting linking the 1986 and 2000 species lists

All to notify Hubert of their intention to invite others to the March meeting

Hubert to discuss structure of March meeting with the host, Ingrid.

Appendix 4 Access to, and use of, data sets contributing to the ICES NSBP 2000

The following rules with respect to access to, and use of individual or institutional data sets were agreed at the workshop on the North Sea Benthos Project (NSBP-2000) held in Oostende, Belgium, at 28–29 January 2002, with minor amendments added at the ICES SG NSBP 2000 intersessional workshop at Oostende in November 2003:

- The raw data compilation will only be available for participants in the NSBP-2000 for the purpose of data analysis aimed at the production of common reports/publications. At a later moment it will be decided when public access to the raw data can be allowed. Individual datasets which comprise the data compilation remain the property of the original data collectors and may be made available through other national sources
- All data contributors can be co-authors on any publication based on the integrated dataset. For each publication there will be a group-decision regarding the name of the 'first' author and the order of co-authors.
- The timing of any common report or publication will consider and respect any national requirement with regard to reporting on national data sets.
- Any participant who wants to use data from another data owner can do so only after given consent by the respective data owners.
- The meta-data regarding individual or institutional data sets will be made available to public access via the web. These meta-data will not include any raw data as mentioned under (1) nor species lists.

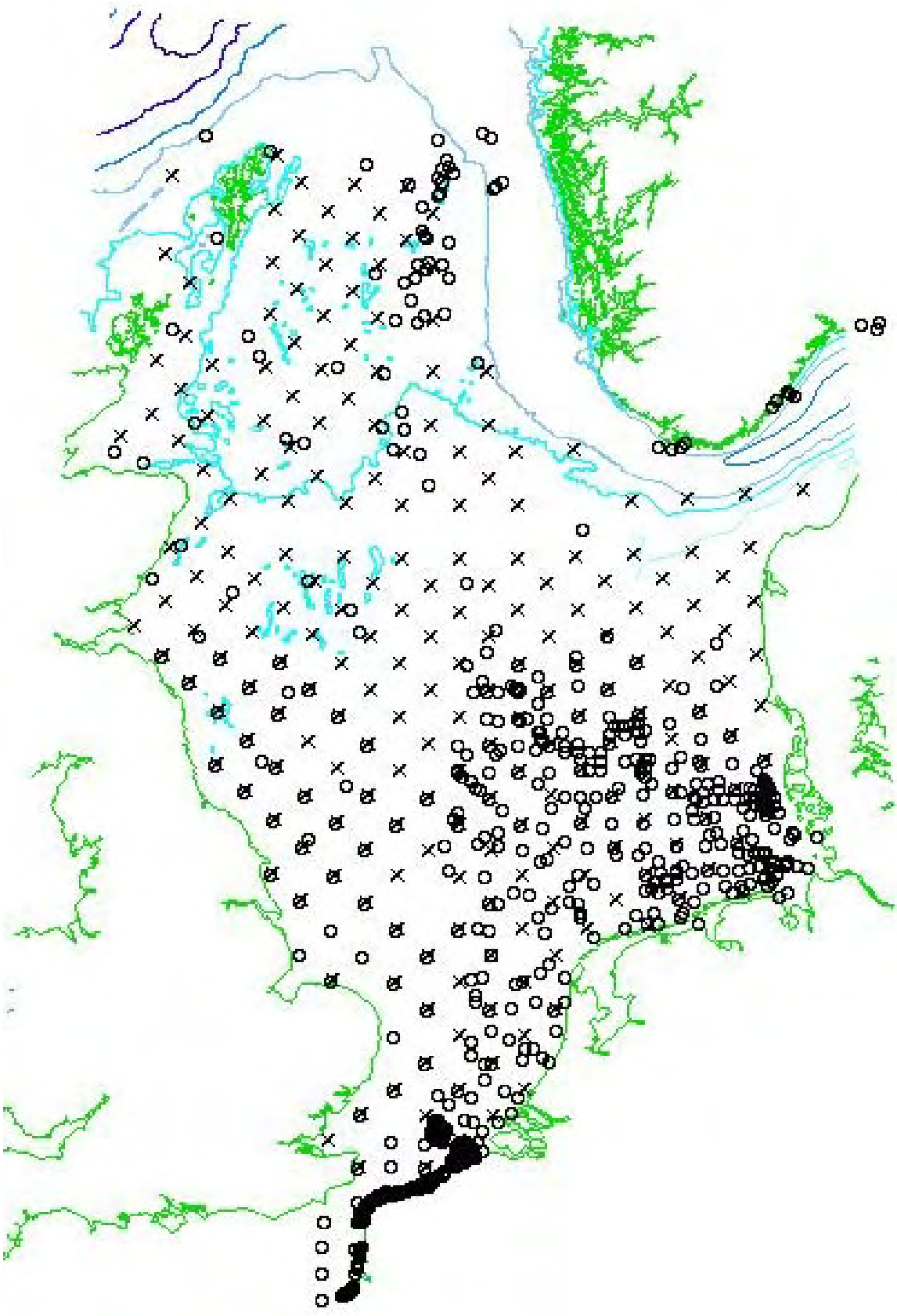

Figure A5.1. Map of stations in the 2000 survey (o) and the 1986 survey (x).

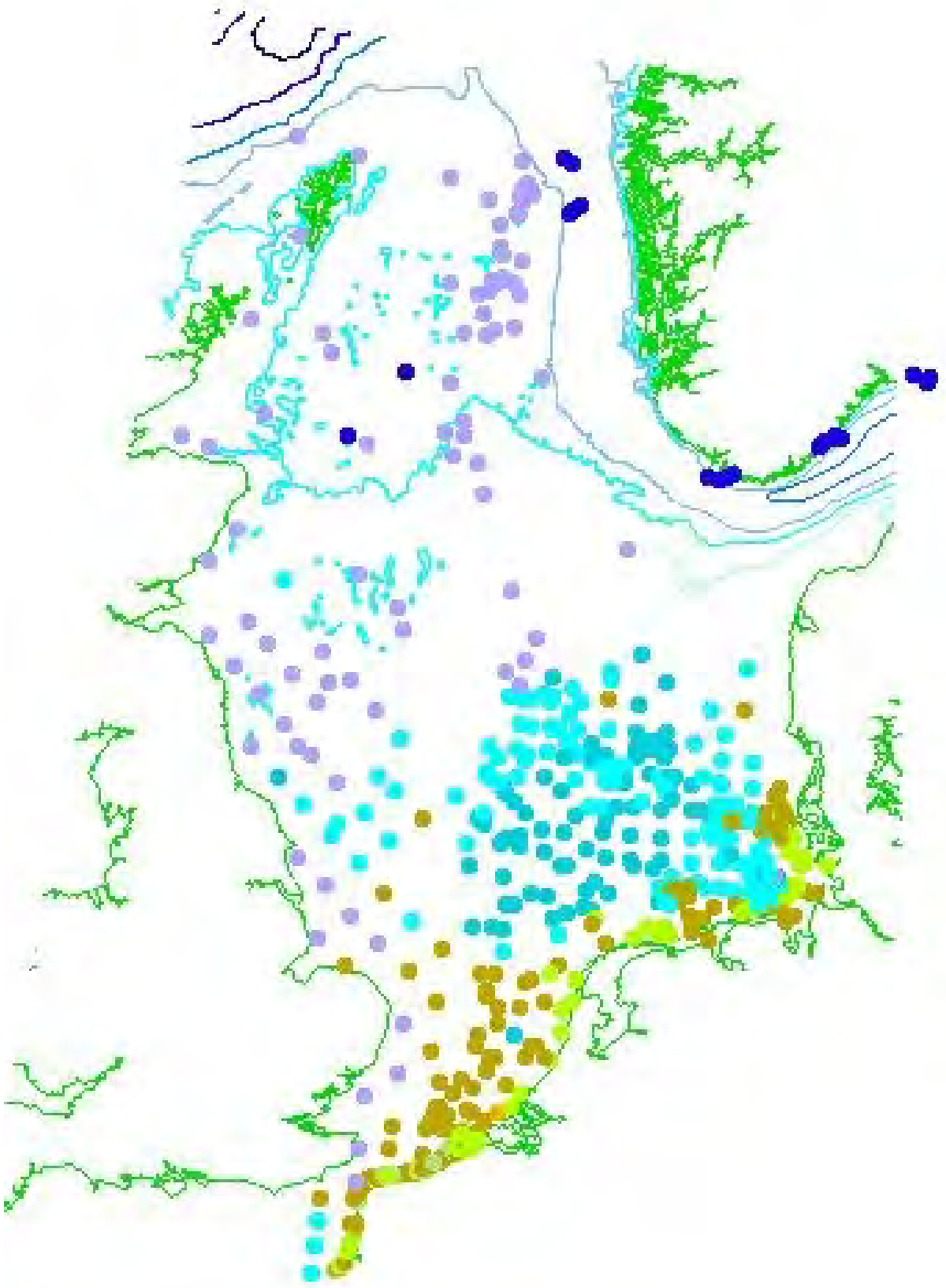

Figure A5.2. Output from TWINSPAN analysis of 2000 NSBP data.

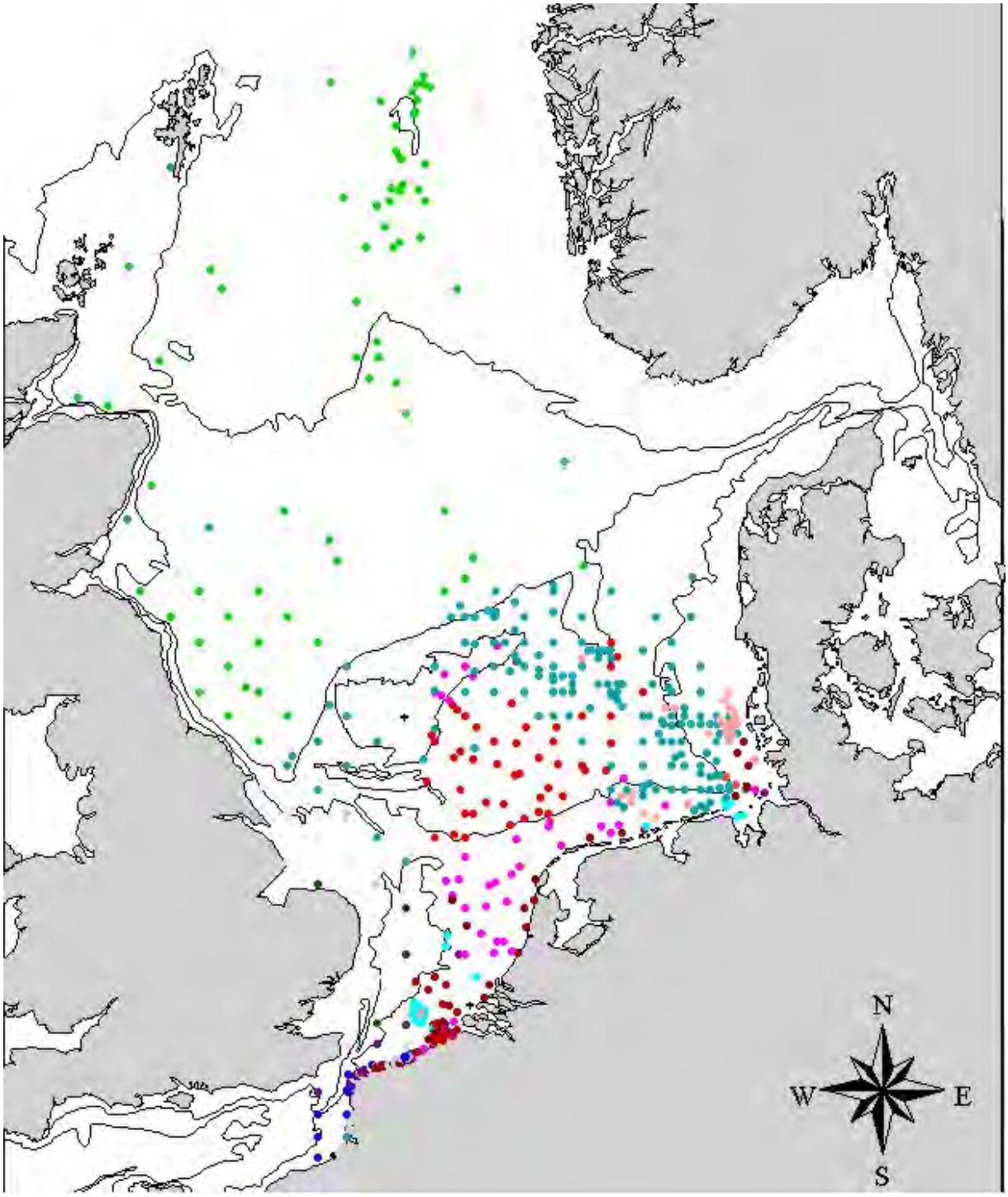

Figure A5.3. Outcome of cluster analysis from PRIMER using a presence/absence transformation.

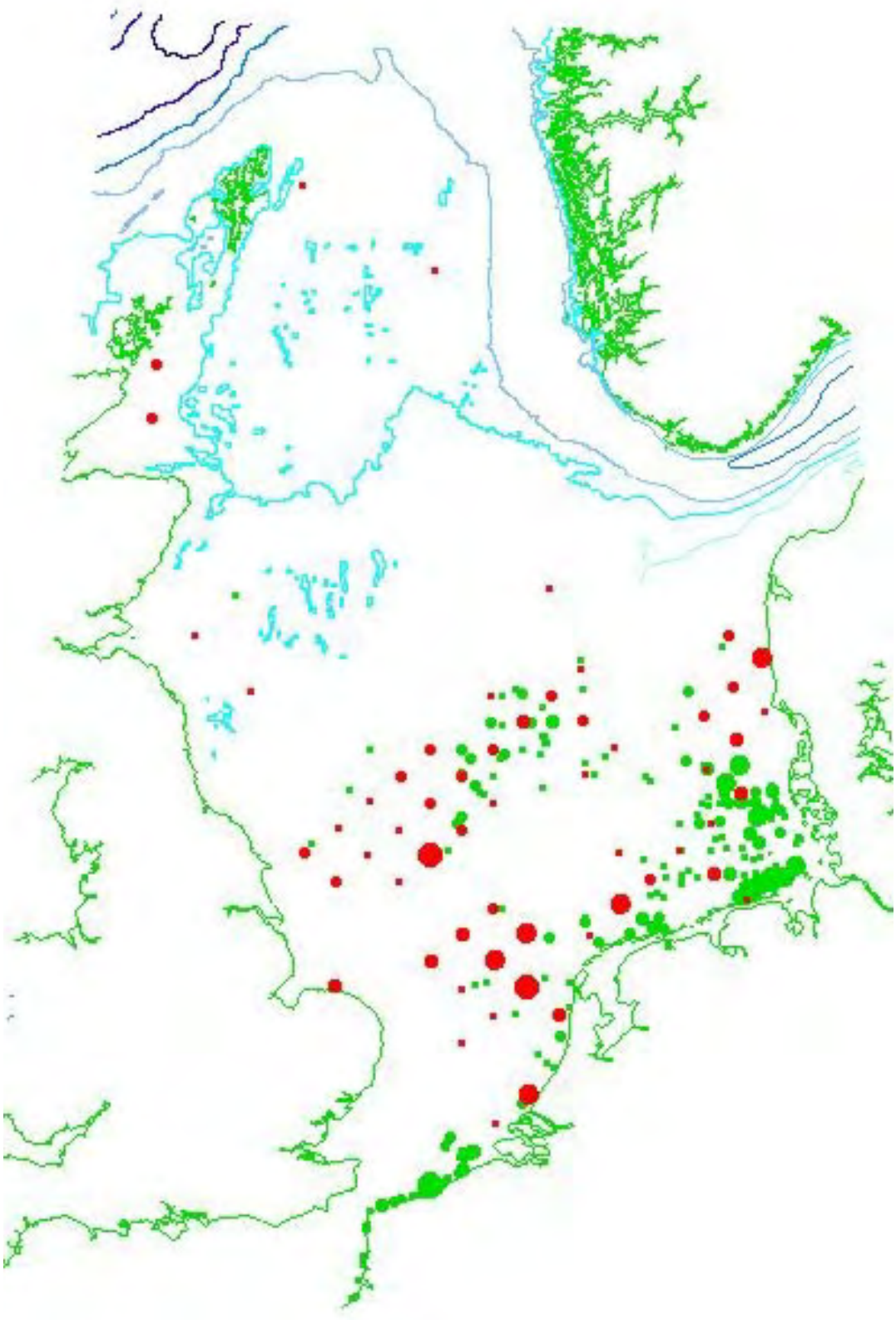

Figure A5.4. Comparison of densities of the bivalve *Tellina fabula* in the 2000 NSBP survey (green circles) and the 1986 survey (red circles)

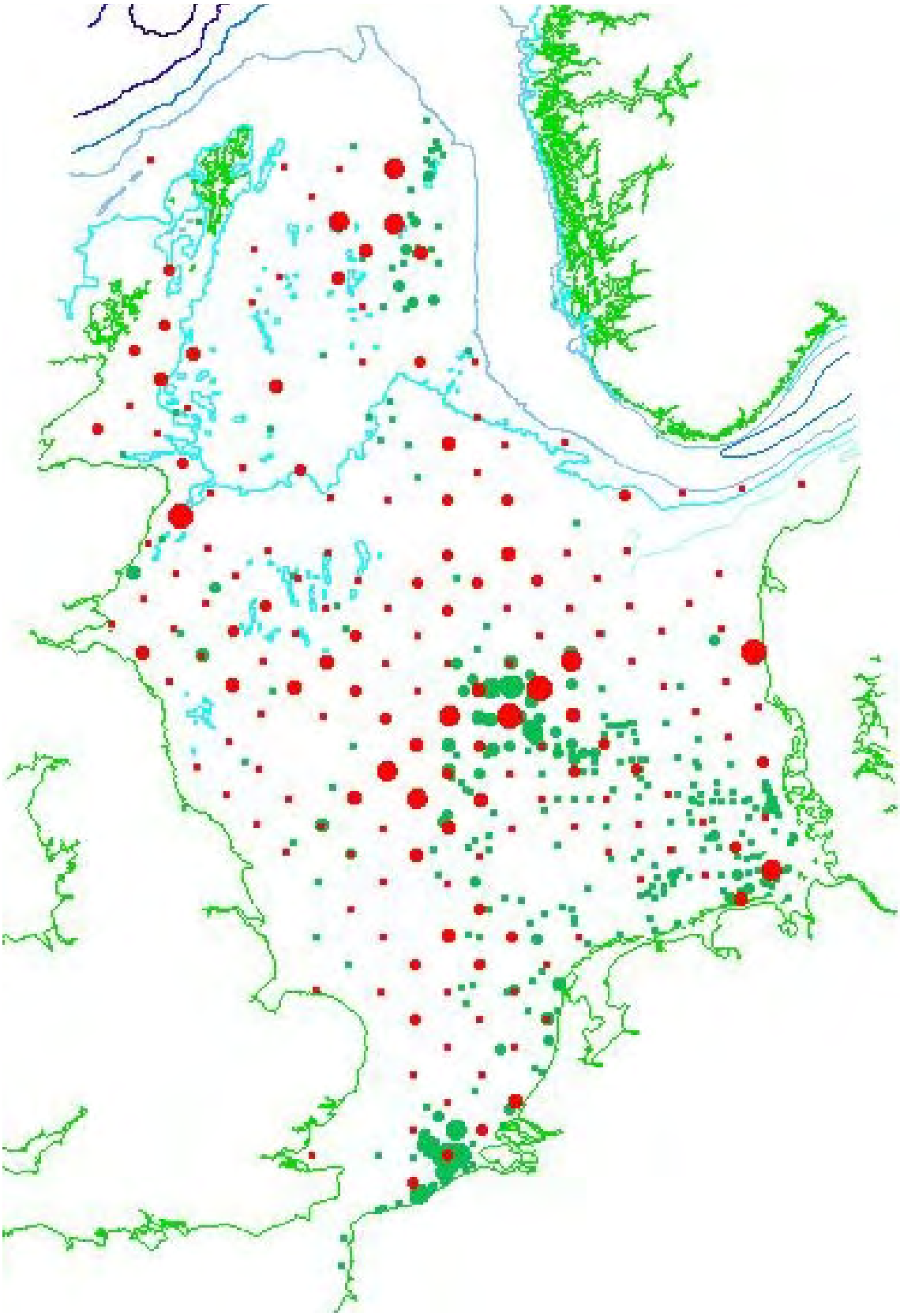

Figure A5.5. Comparison of densities of the tube-dwelling polychaete *Spiophanes bombyx* in the 2000 NSBP survey (green circles) and the 1986 survey (red circles).

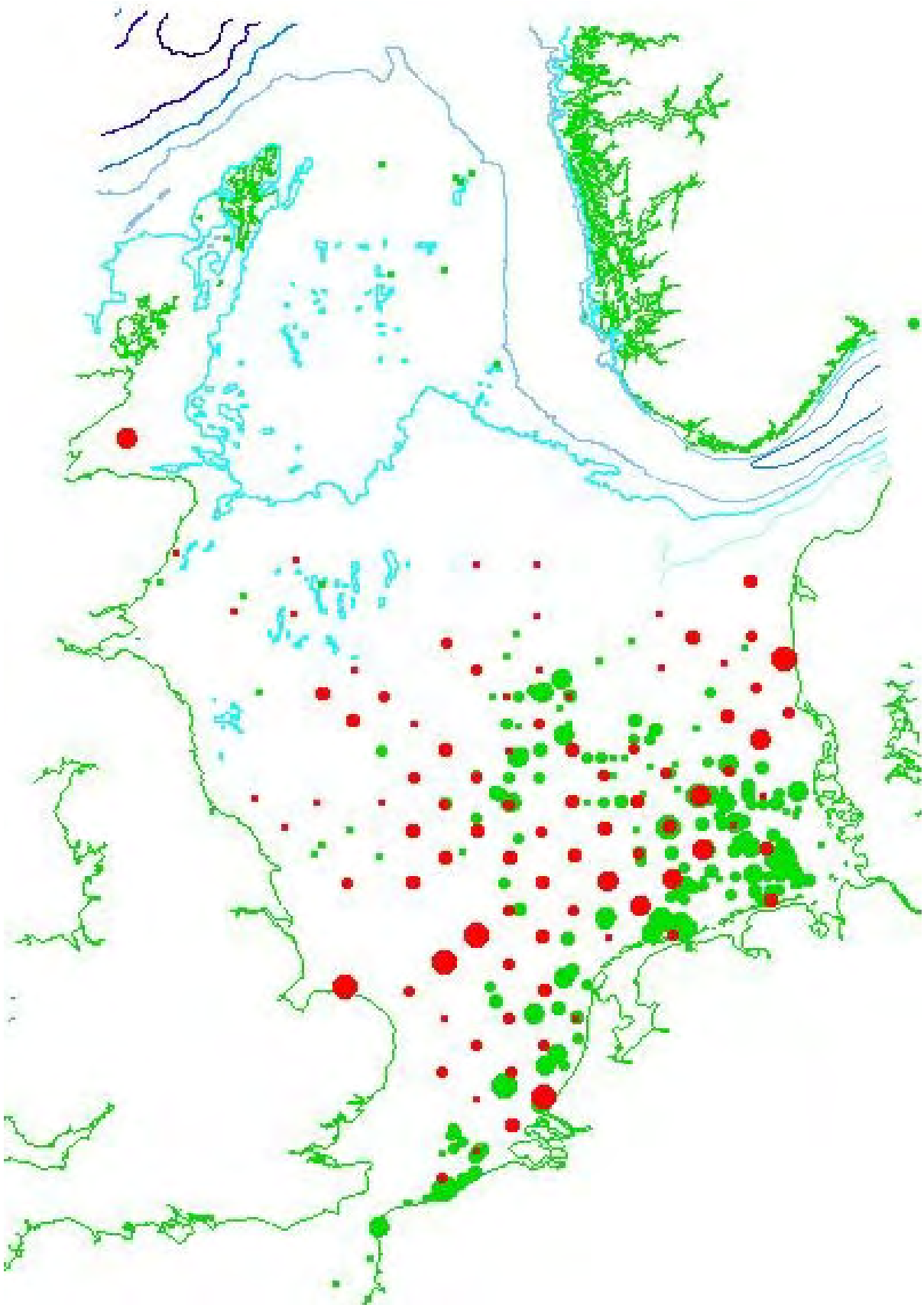

Figure A5.6. Comparison of densities of the echinoderm *Echinocardium cordatum* in the 2000 NSBP survey (green circles) and the 1986 survey (red circles).

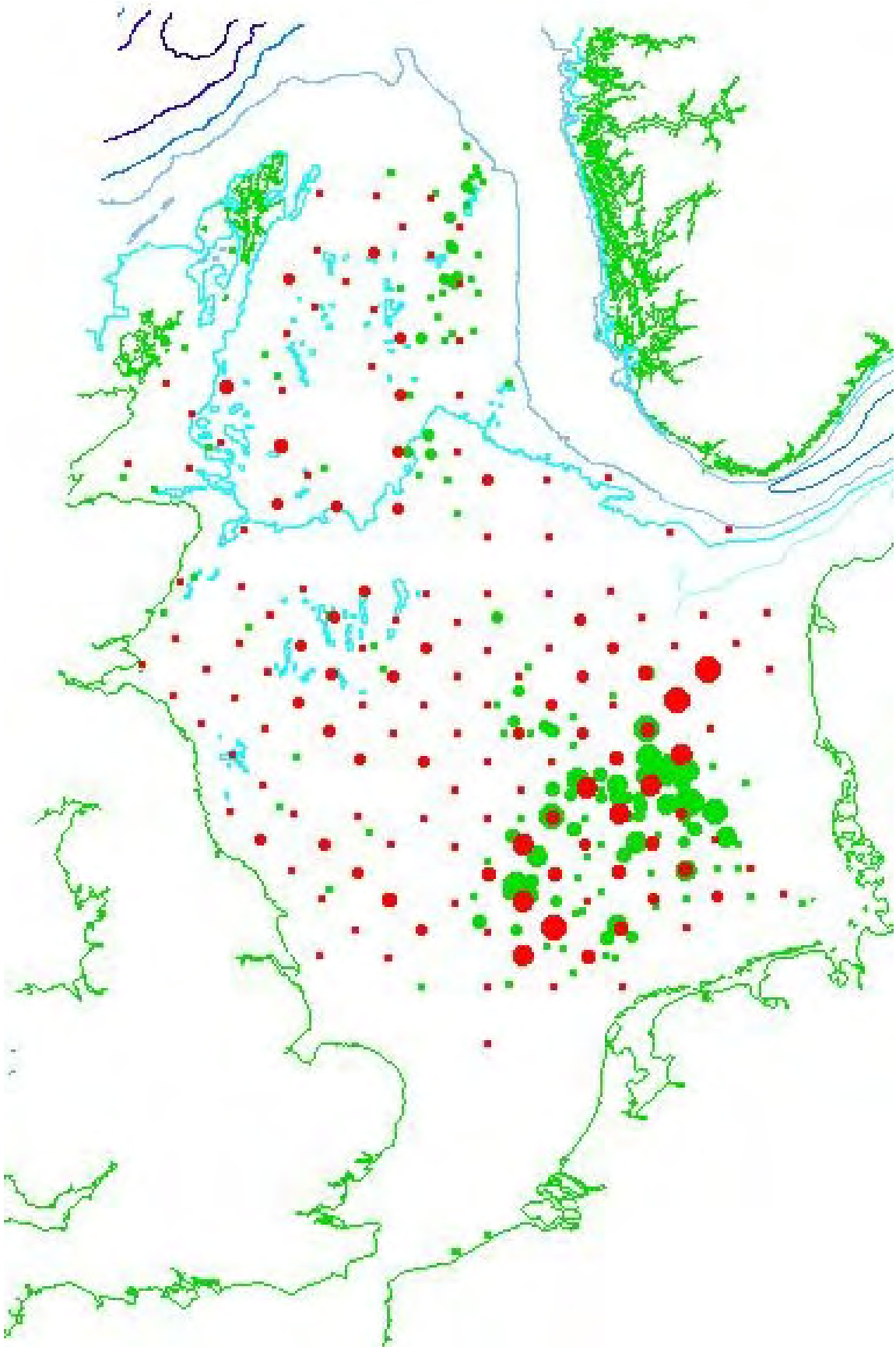

Figure A5.7. Comparison of densities of the brittlestar *Amphiura filiformis* in the 2000 NSBP survey (green circles) and the 1986 survey (red circles).

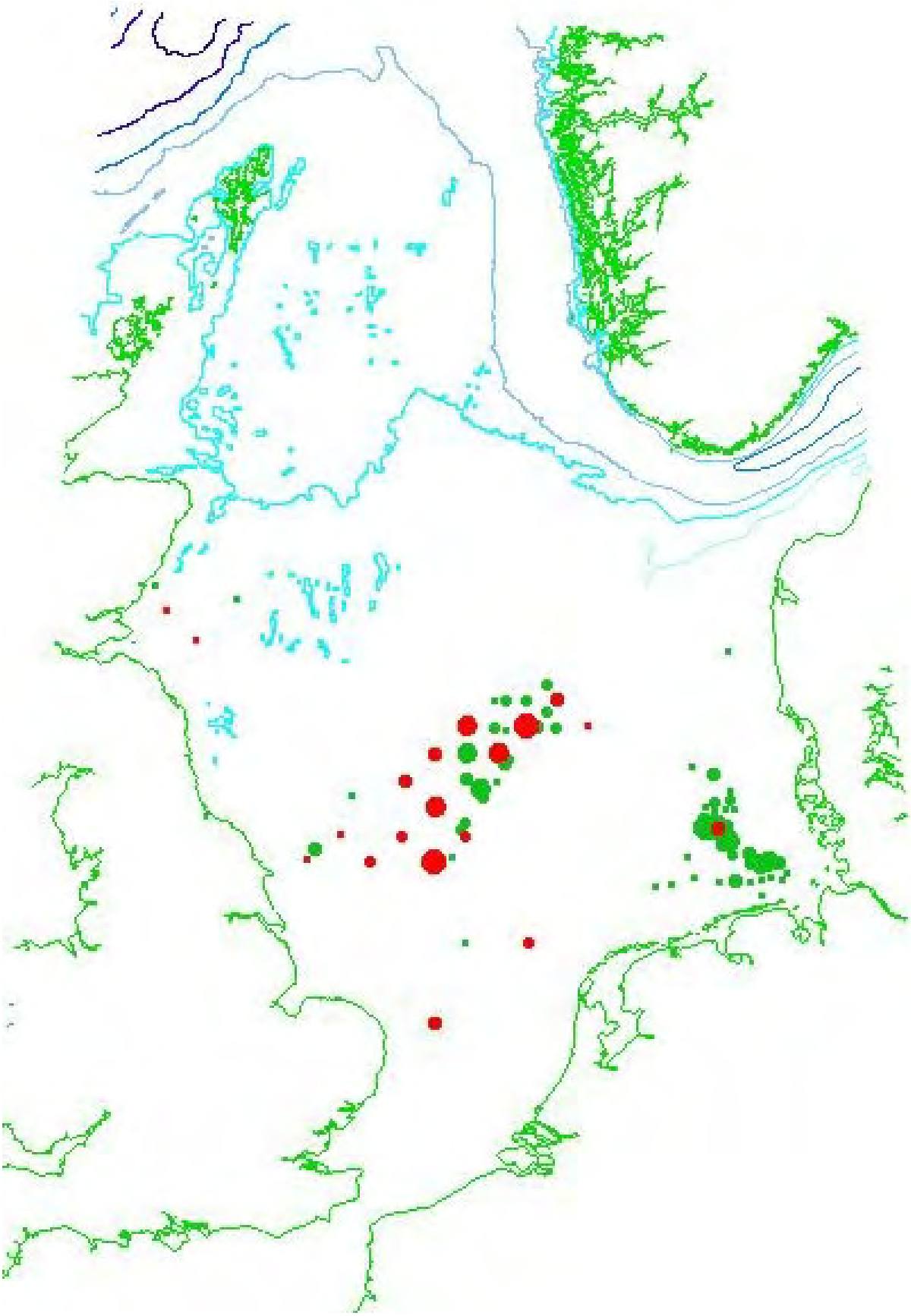

Figure A5.8. Comparison of densities of the brittlestar *Acrocnida brachiata* in the 2000 NSBP survey (green circles) and the 1986 survey (red circles).

Annex 6 Figures

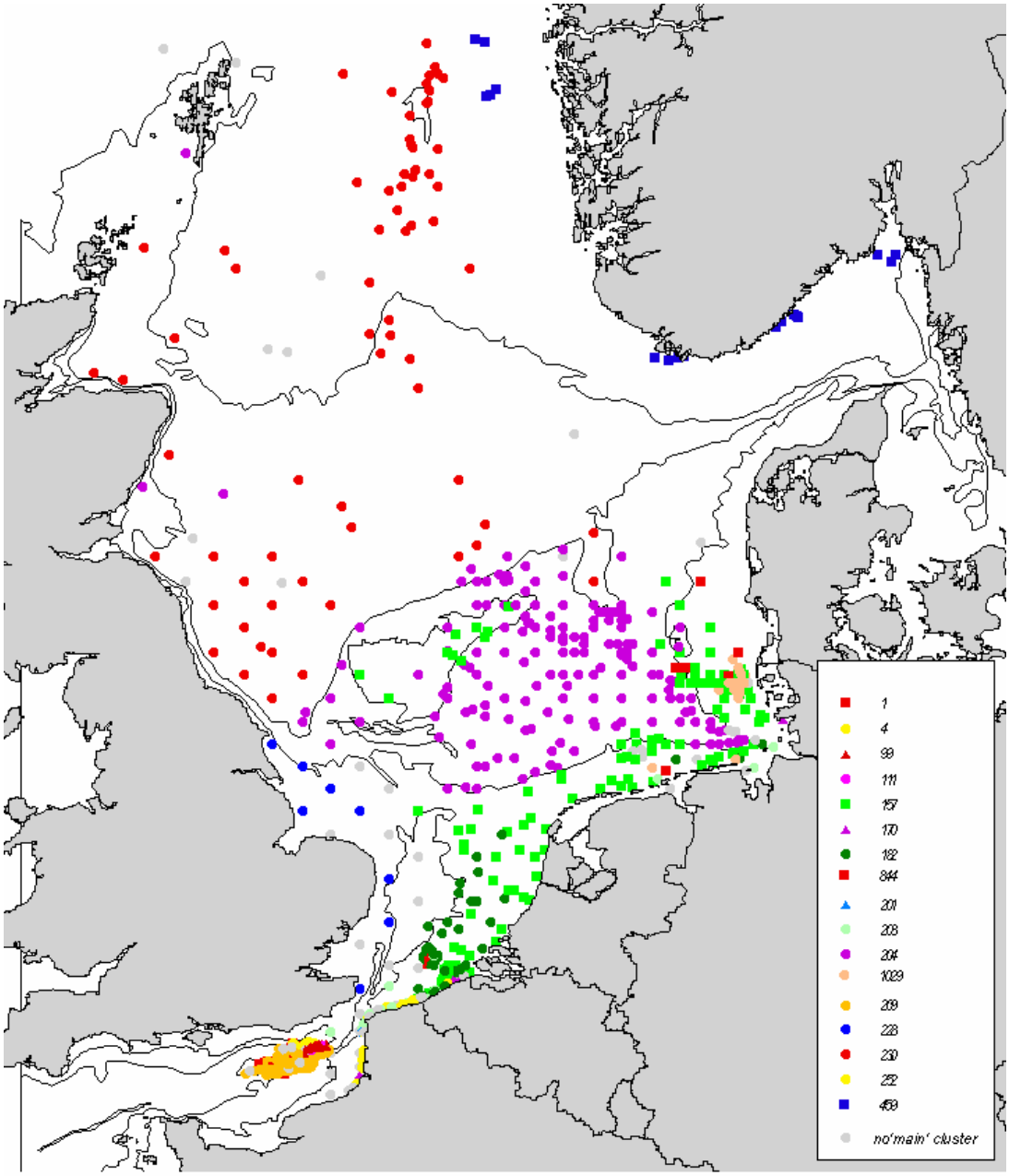

Figure A6.1. Results of the PC-ORD cluster analyses revealed with presence absence data

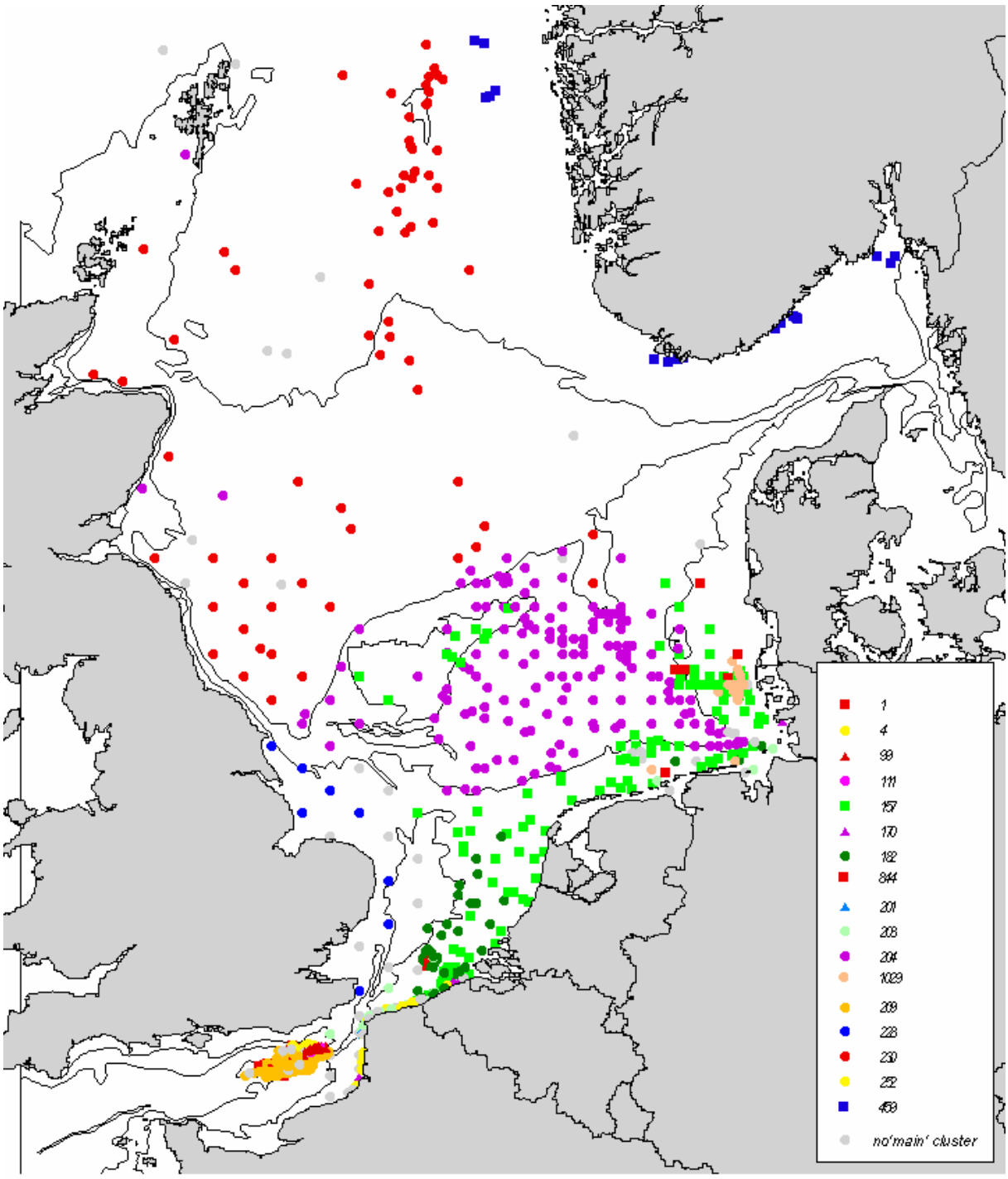

Figure A6.2. Results of the PC-ORD cluster analyses revealed with fourth root abundance data.

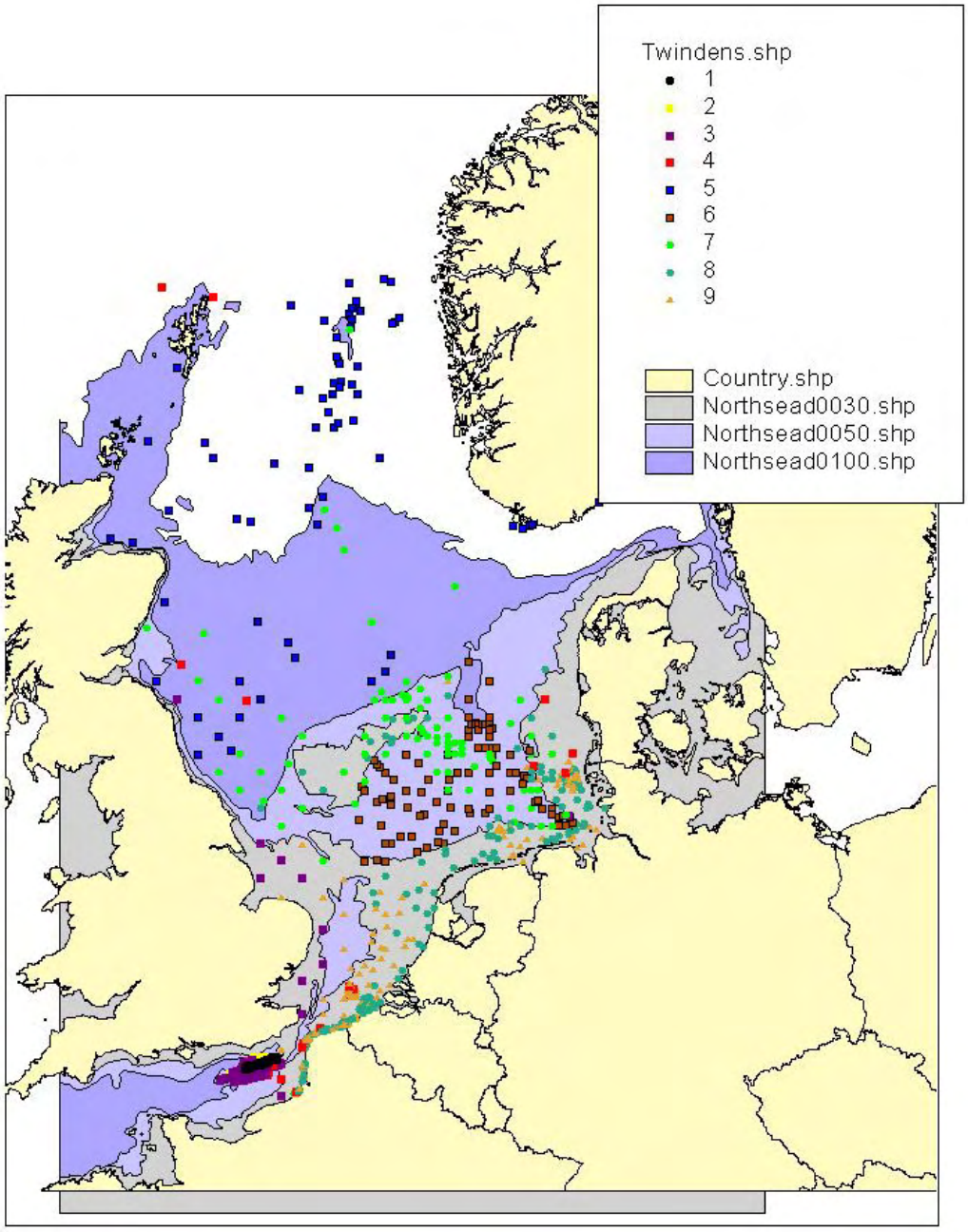

Figure A6.3. Results of the TWINSPAN cluster analysis using log transformed data.

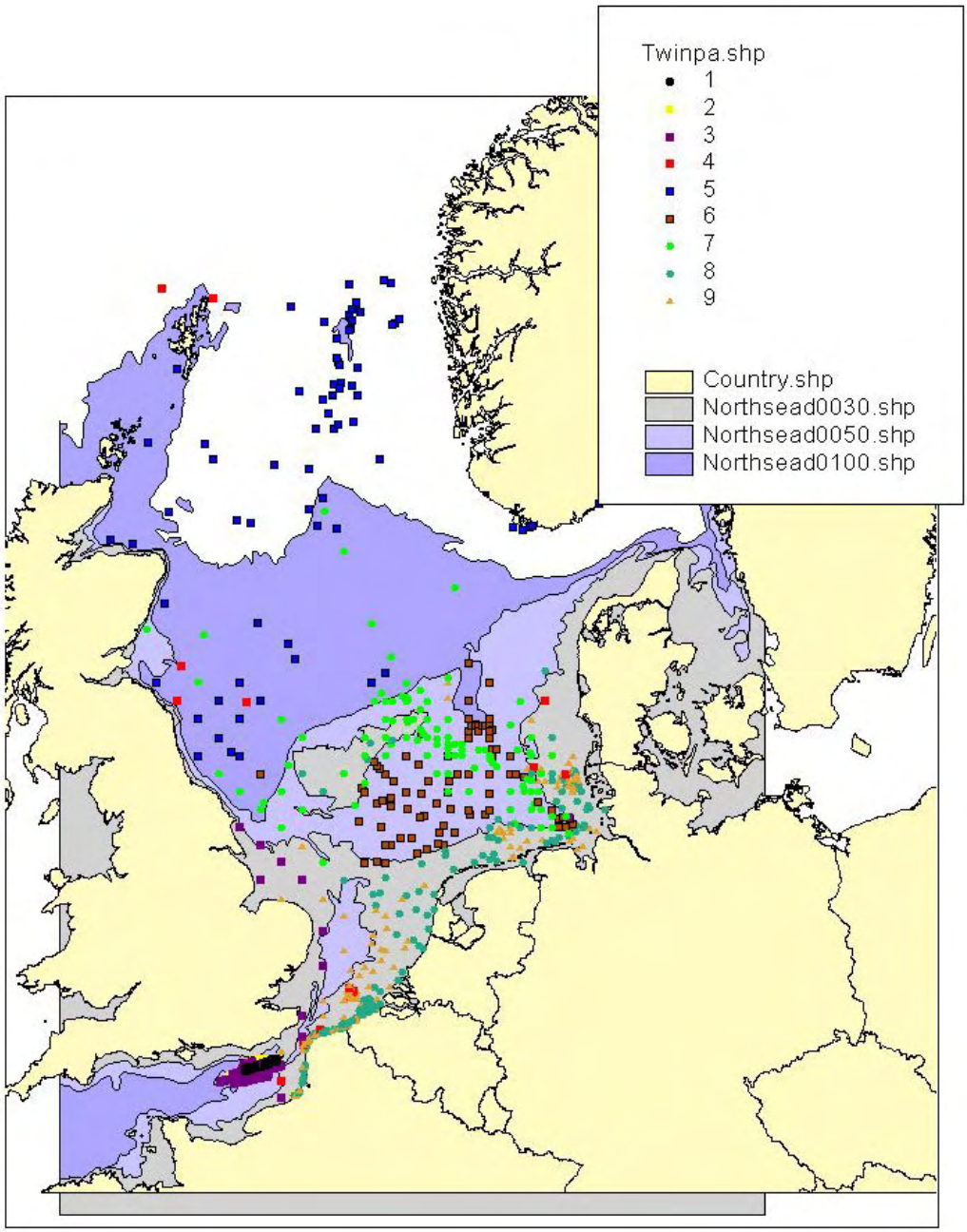

Figure A6.4. Results of the TWINSPAN cluster analysis using presence/absence transformed data.

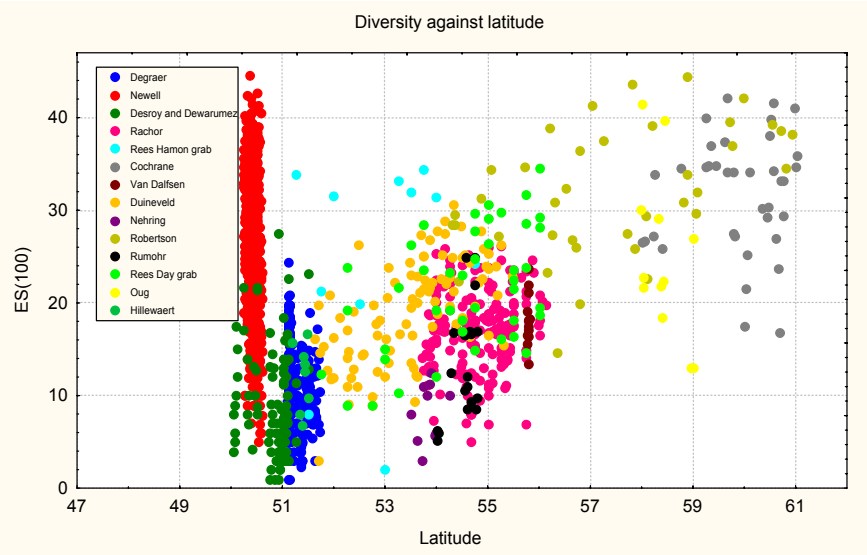

Figure A6.5. Latitudinal diversity gradient, showing the data from the separate data contributors. Data series "Newell" and "Rees Hamon grab" were collected with a Hamon grab, while all other data were collected with a Van Veen or Day grab.

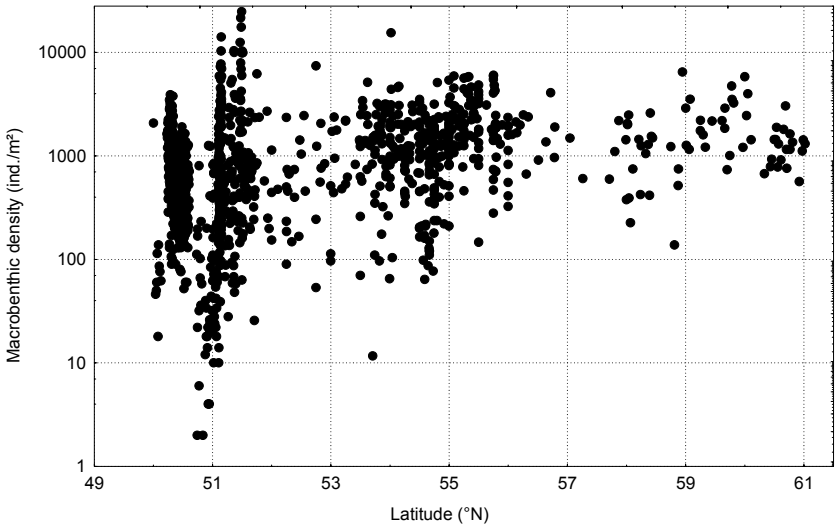

Figure A6.6. Latitudinal gradient in macrobenthic density.

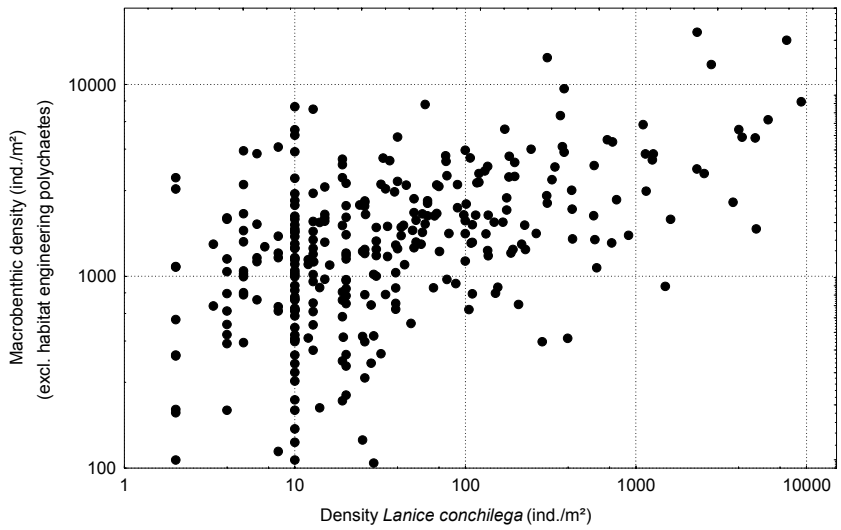

Figure A6.7. Macrobenthic density (excl. habitat engineering polychaetes) in relation to the density of *Lanice conchilega*. Data points were included only if the density of *L. conchilega* was > 100 ind./m².

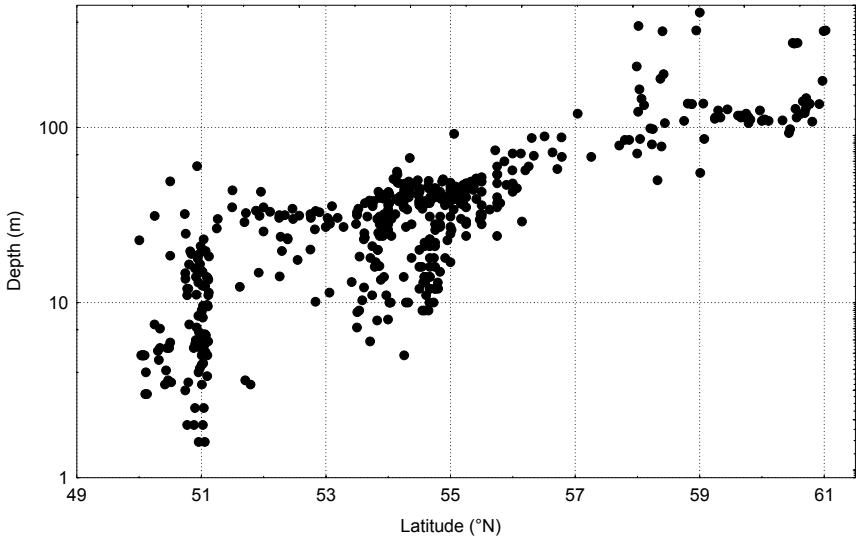

Figure A6.8. Latitudinal depth gradient.

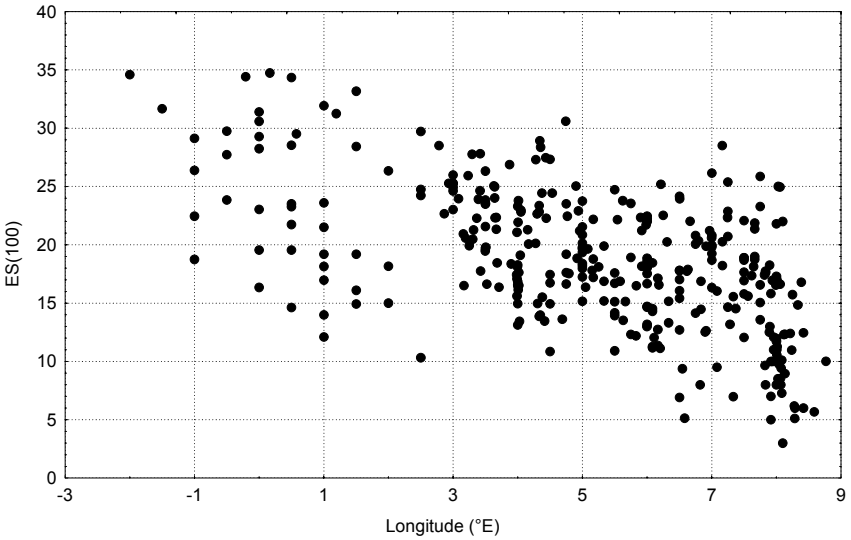

Figure A6.9. Longitudinal diversity gradient, using all datapoints situated between 53° and 56°N.

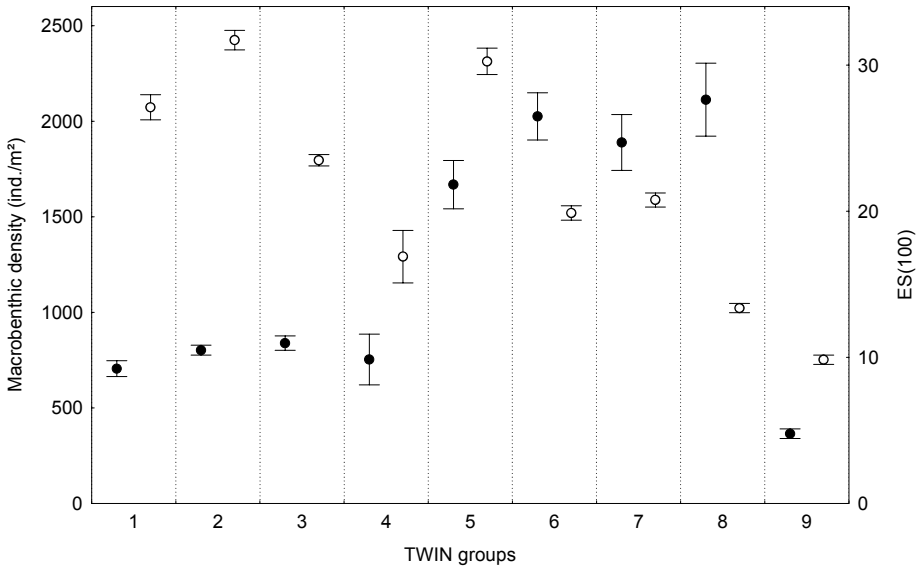

Figure A6.10. TWIN group specific macrobenthic density and diversity. Macrobenthic density, closed circles; diversity, open circles.

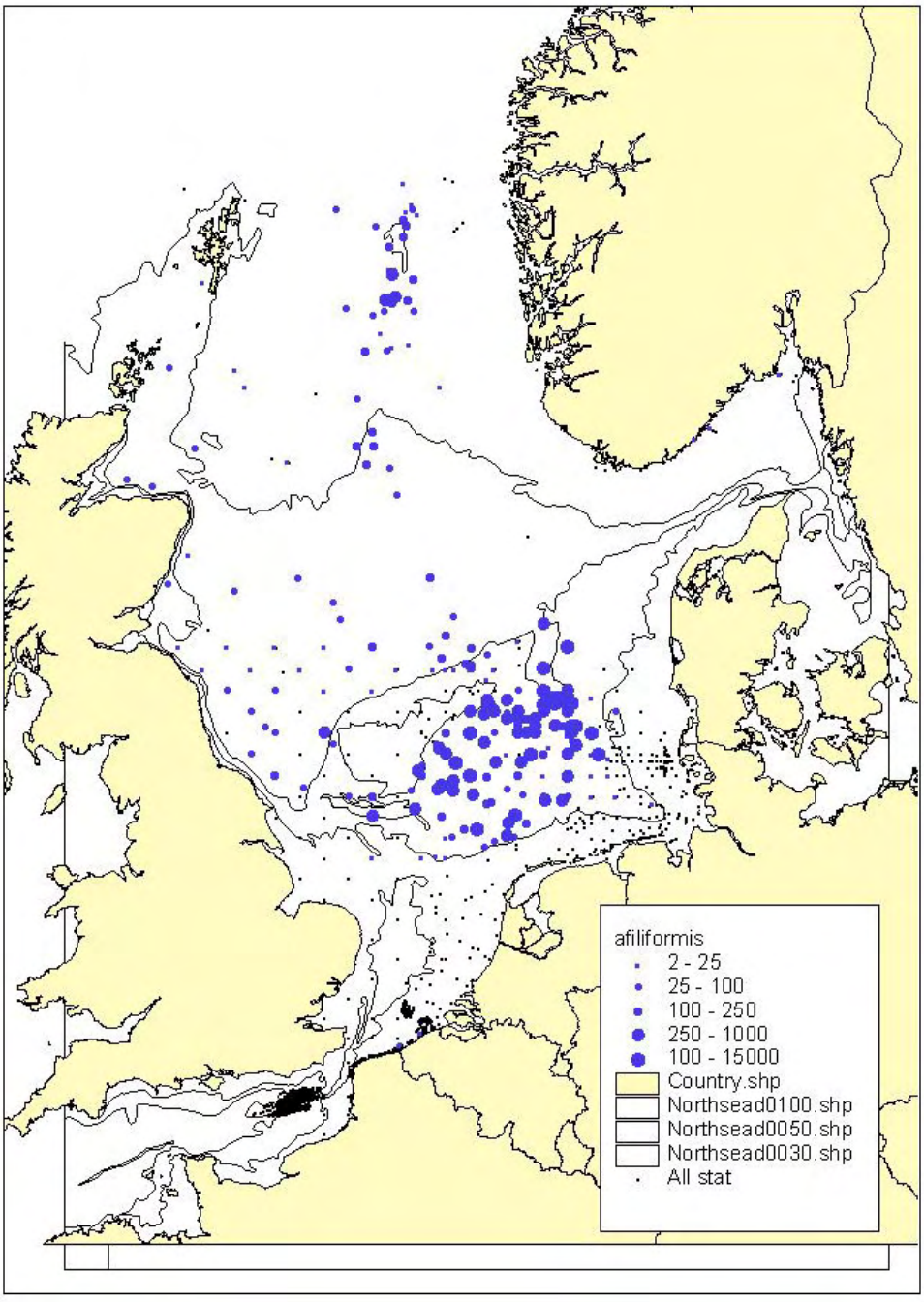

Figure A6.11. Distribution of *Amphiura filiformis* in 2000 NSBP survey.

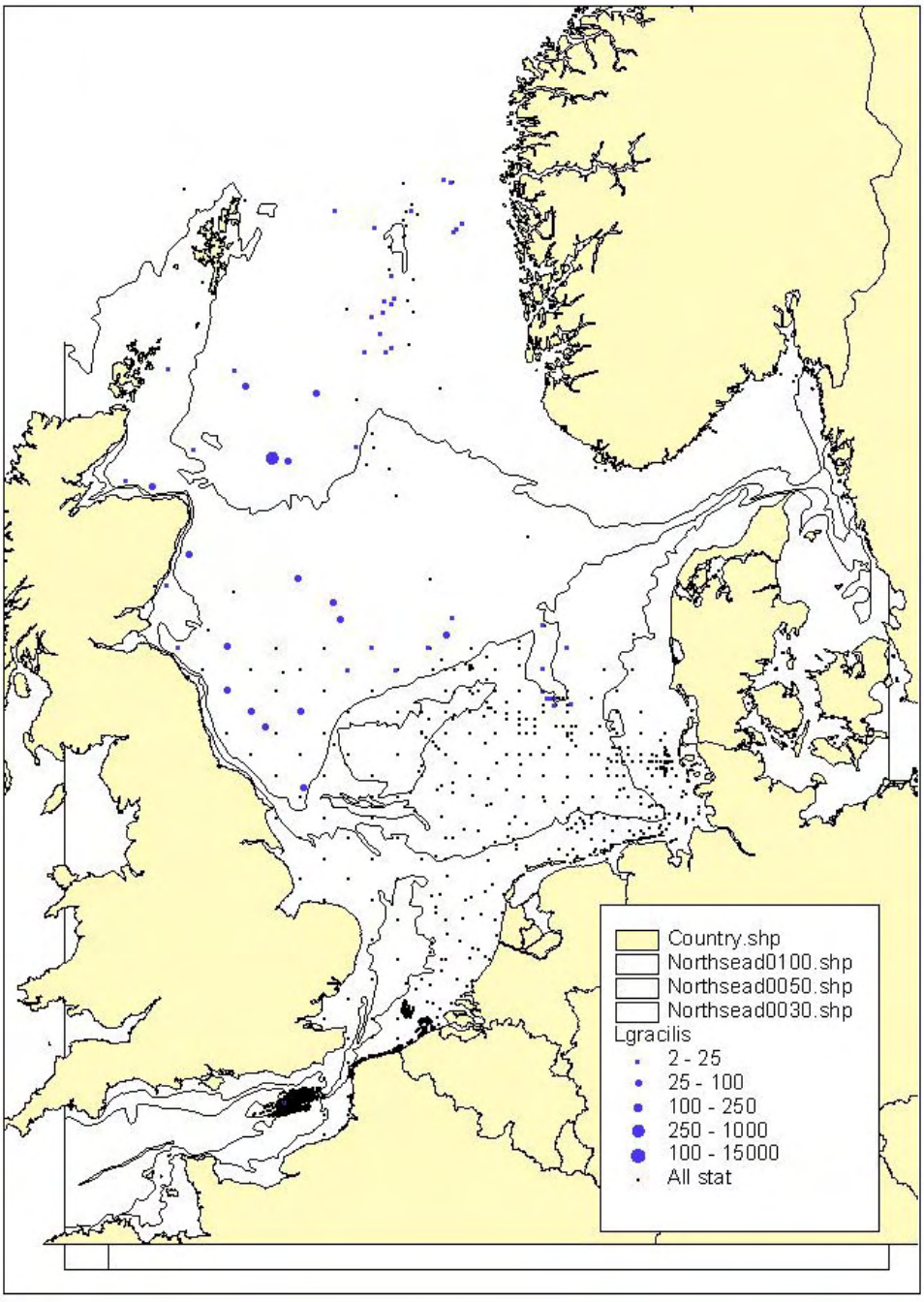

Figure A6.12. Distribution of *Lumbrineris gracilis* in the 2000 NSBP survey.

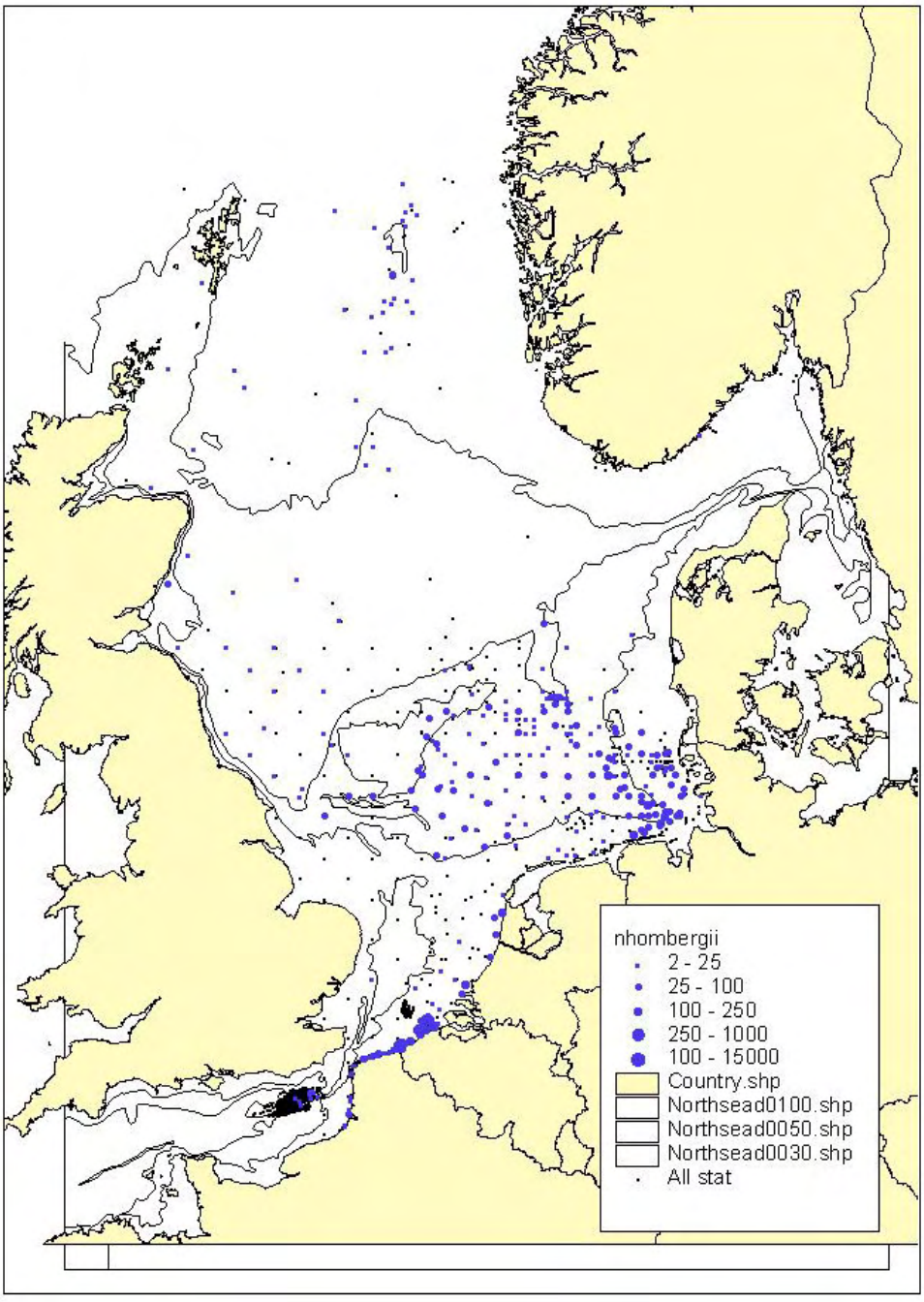

Figure A6.13. Distribution of *Nephtys hombergii* in the 2000 NSBP survey

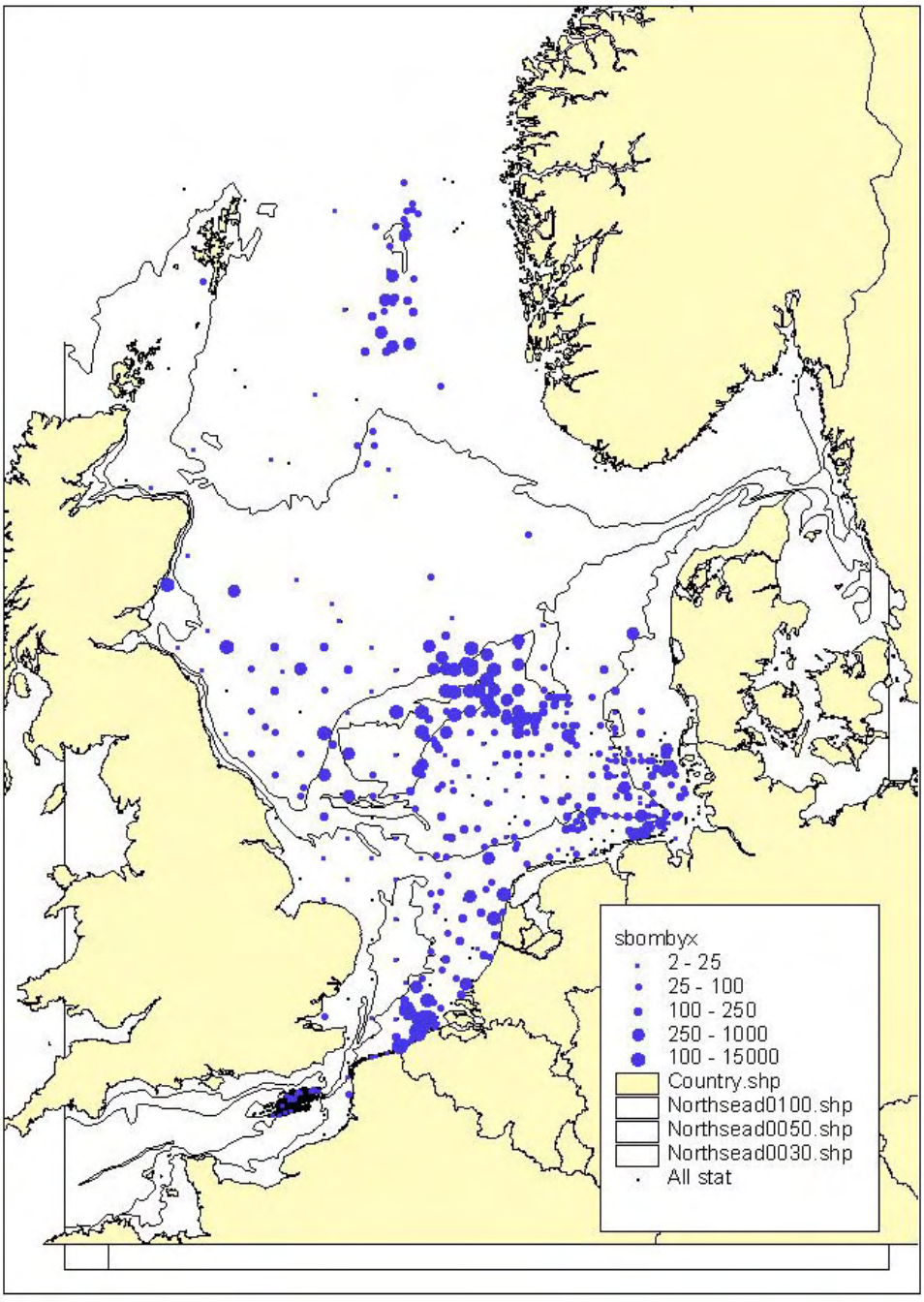

Figure A6.14. Distribution of *Spiophanes bombyx* in the 2000 NSBP survey.

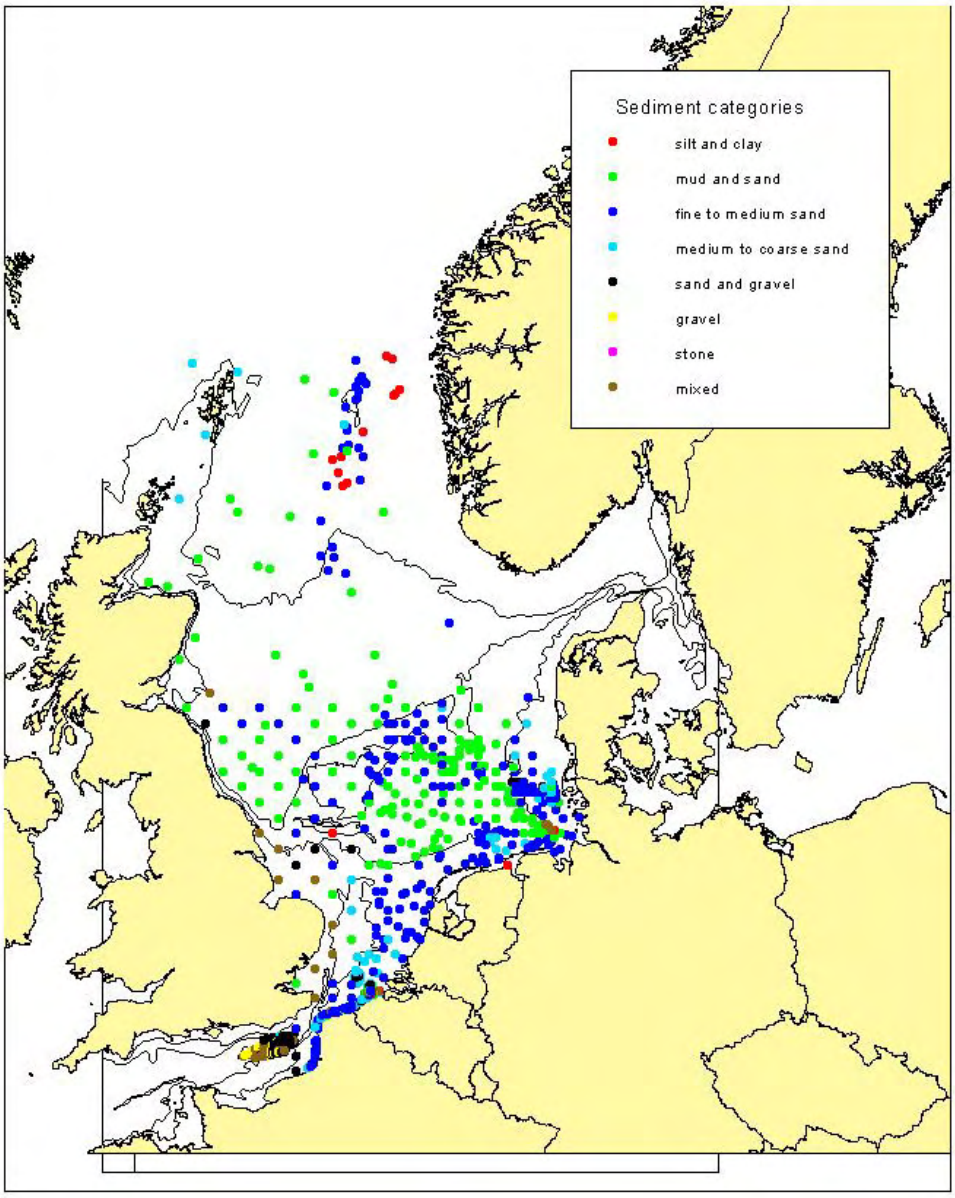

Figure A6.15. Map of distribution of sediment types according to assigned categories.

Annex 7 Recommendations

Recommendations to ICES

The **ICES Study Group on the North Sea Benthos Project 2000** [SGNSBP] recommends that it meets at ICES Copenhagen from 5–8 April 2005 in order to:

a) review the outcome of an intersessional workshop held at CEFAS Burnham-on-Crouch from 3–5 November 2004 to:
   i) finalise the draft of an overview paper on benthic communities of the North Sea 2000, including comparisons with 1986 NSBS data (lead author: ER);
   ii) progress analyses/interpretation of the ICES NSBP 2000 data on the following themes:
   - fishing activities/impacts;
   - natural and human impacts (other than fishing);
   - functional properties – in particular feeding types;
   - comparison of epifaunal and infaunal community patterns;
   - benthos/habitat linkages;
   - NSBP 2000 data management;

   iii) assess/report on the status of physico-chemical data for sediments sampled as part of the NSBP 2000
   iv) review the suitability of biomass data for North Sea-wide *versus* sectoral appraisal
   v) identify/locate additional information sources (data/maps)
   vi) identify specific questions(s) regarding statistical analyses of NSBP 2000 data (e.g., formal tests for similarities in patterns) for consideration by WGSAEM 2005.

b) Conduct further analysis of the NSBP 2000 data in relation to fishing activities, natural and other human influences, functional properties and epifaunal/infaunal patterns, and draft texts for publication;

c) Report on the distributions of sub-sets of opportunistic and sensitive species identified by the ICES Study Group on EcoQOs for opportunistic and sensitive species, and examine the utility of the recommended metrics;

d) Apply biotic/diversity indices to NSBP 2000 data;

e) Consider the scope for contributing to North Sea spatial models, through liaison with experts;

f) Identify products suitable for habitat mapping;

g) Commence preparation of an ICES Cooperative Research Report on the ICES NSBP 2000 survey;

h) Identify additional analytical/reporting ideas relevant to ICES/OSPAR interests;

i) Review the cost/benefits of a repeat ICES North Sea Benthos Survey in 2007–2010;

j) Liase with the ICES database manager regarding the future operational interface with the NSBP 2000 database.

Supporting Information

Priority:	High (the assessment of benthic biological status in the North Sea is relevant to the ongoing interests of ICES, OSPAR and the EU, particularly with regard to its contribution to the development of an ecosystem-level approach to environmental management).
Scientific Justification and relation to Action Plan	Proposed TOR a)–j) will be met through a combination of Workshop and Plenary activity by Study Group members, as follows: a) a subgroup, representative of the major data contributors, will meet intersessionally from 3–5 November 2004 (at CEFAS Burnham, UK) to make further progress with the analyses and write-up of recent North Sea benthos data. This practical (workshop-based) activity is

	essential to maintain the momentum of the exercise in order to ensure timely outputs; b) progress to date, with particular reference to the outcome of the November 2004 workshop, will be reviewed by the wider Study Group membership at the April 2004 meeting (Copenhagen), and recommendations will be made for immediate resolution, or later (intersessional) work; c) this work will provide a practical follow-up to the important issue of EcoQO development for benthic species, in response to a recommendation of the Chair of the EcoQO study group; d) various derived measures of data structure will be compared to identify their 'indicator' value; the work will also complement T of R c.) above; e) this work is aimed at establishing collaborative links with those engaged in modelling of various elements of the North Sea ecosystem; the NSBP 2000 data may be very valuable in this context; f) this will further the collaborative link with WGMHM; g) as well as the drafting of papers for peer-reviewed publications, it is intended to produce a detailed overall assessment of the ICES NSBP 2000 exercise, including information on future data access, as a complement to the earlier report on the 1986 NSBS; h) this will ensure that important features of the ICES NSBP 2000 database are exploited to the maximum extent possible; i) it is important to take a longer view of the possible strategic value of future comparable exercises in relation to resource needs; j) progress will be sought with respect to the important issues of further database development (including the interface with the ICES Biological Community Database), and univariate and multivariate methodologies for data analyses. The work of this SG contributes to Action Plan Nos. 1.2.1, 1.11, 2.8, and 2.9.
Resource Requirements:	N/A
Participants:	Primarily benthos ecologists participating in the project
Secretariat Facilities:	N/A
Financial:	None
Linkages to Advisory Committees:	ACME, ACE
Linkages to other Committees or Groups:	BEWG, WGECO, WGEXT, WGMHM, WGSAEM, WGMDM, SGQAE Reports to BEWG too.
Linkages to other organisations	OSPAR, EU
Secretariat Cost Share	ICES 100 %

Actions for intersessional activity are listed at Annex 8.

Recommendations to ICES/OSPAR

The ICES SGNSBP 2000 recommends to ICES/OSPAR that it employs the NSBP 2000 data to:

- report on the distributions of sub-sets of opportunistic and sensitive species identified by the ICES Study Group on EcoQOs for opportunistic and sensitive species, and
- examine the utility of the recommended metrics.

Annex 8 Actions for intersessional activity

1) **ALL: FURTHER REVIEW DATABASE INTERSESSIONALLY FOR MINOR INCONSISTENCIES**
2) Edward Vanden Berghe to obtain raw data all data surveys currently aggregated;
3) Edward Vanden Berghe to contact all data contributors for re-submission of biomass data following preparation of a form for biomass data submission;
4) Edward Vanden Berghe to determine statistical relationships between TWINSPAN and PC-ORD outcomes, and between 1996 and 2000 patterns, from chi squared contingency tables;
5) Ingrid Kroncke to liase with the Institute of Physical Oceanography at Hamburg University in order to identify output from hydrographic models which may be suitable for analysis of relationships with the NSBP 2000 data;
6) Eike Rachor, Ingrid Kroncke and Henning Reiss (and others as necessary) to make further progress on the draft overview paper prior to the November 2004 meeting;
7) Rebecca Kilbride to contact G Irion regarding raw data on trace contaminants at UK NSBP sites, and any further material for analyses;
8) Hubert Rees to liase with the Chair of WGSAEM regarding future collaboration on analytical issues arising from the NSBP 2000 exercise;
9) Hubert Rees to contact the Chair of WGMHM regarding progress with analyses of the NSBP 2000 data and the scope for future interaction;
10) Hubert Rees to report SG progress to the BEWG (April 2004);
11) Edward Vanden Berghe/Rebecca Kilbride to review the status of physico-chemical data for sediments sampled as part of the NSBP 2000;
12) Edward Vanden Berghe to place certain elements of the NSBP 2000 data onto the VLIZ website, including a full species list;
13) Hubert Rees to provide introductory text for the NSBP 2000 web page;
14) Johan Craeymeersch to circulate remaining queries regarding feeding types for benthic species in order to complete the information necessary for application to the NSBP 2000 data by November 2004;
15) ALL – to consider availability of additional data relating to the N Sea for the November 2004 intersessional workshop;
16) Hubert Rees – to further explore sources of contemporary information on non-fisheries human activities and inputs;
17) Ingrid Kroncke – to explore sources of information relating to eutrophication (nutrient, CPR data, ERSEM);
18) Ingrid Kroncke and Eike Rachor – To examine contemporary distributions of species in relation to earlier information on biogeographical preferences;
19) Edward Vanden Berghe/Hubert Rees to compile a list of relevant biodiversity initiatives with a view to development of new projects within and beyond the North Sea;
20) ALL: To provide Ingrid Kroncke with any recent papers/national reports they have on the status of the North Sea to contribute to the overview paper on the NSBP 2000;
21) Steven Degraer – to develop ideas for establishing quantitative links between benthic biota and habitats ("time-and cost- efficient spatial extrapolation").