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# Report of the Working Group on Fish Ecology (WGFE)

22-26 October 2012

Venice, Italy

ICES International Council for the Exploration of the Sea
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## Contents

## Executive summary

In 2012, WGFE (Working Group on Fish Ecology, Chaired by: R van Hal) met at the University Ca'Foscari, Venice Italy, 22-26 October. Six participants from four different countries, 4 present in Venice and 2 by correspondence, contributed to the meeting. The meeting was held jointly with the meeting of WGSAM, which resulted in that most plenaries by WGSAM were attended by the WGFE members present and that the members of WGFE contributed to the report of WGSAM, especially related to the ToRs c on stomachs and e on MSFD.

Owing to the small number of participants, WGFE, besides the contributions to WGSAM, only worked on their own ToR a on applying spatial methods. This is an extension of the case studies mentioned in the 2011 report.

ToR b was discussed with WGSAM as this group is now running the Size-Based-model used in 2009 by WGFE as well as other Size-based-models. There have been changes to the spatial aspects in the North Sea size-based-model and WGSAM is reporting on results of the model. It is considered best that WGSAM will continue using these models and that the ToR no longer will be dealt with by WGFE.

WGFE has had problems with a reducing number of participants in the last years with the smallest number of four participants this year. Last year and also prior and during the meeting this issue was discussed and the conclusion is that the current group sees no solution for this. Therefore it is considered best to dissolve the group especially because the group recognizes that many of their original and potential future ToRs are dealt with in other (temporary) groups.

# 1 Opening of the meeting

The ICES Working Group on Fish Ecology (WGFE) convened its meeting in Venice at University Ca'Foscari on 22 October and adjourned on 26 October 2012. The local host was Fabio Pronovi, many thanks to him for having us, especially because he is not a member of this group himself.

The meeting was chaired by Ralf van Hal, The Netherlands. Six participants from four different countries, 4 present in Venice and 2 by correspondence, contributed to the meeting. A full participants list is found in Annex 1.

The meeting was held at the same time and place as the meeting of WGSAM. The meeting of WGFE start earlier on the first day allowing a discussion on how WGFE would proceed in the coming week and how we could best combine our work with that of WGSAM. The decision has been to participate in the plenaries of WGSAM and contribute to their report where possible. Only Adrian Jordan would continue working on WGFE's ToR a together with the members participating by correspondence.

## 2 Adoption of the agenda

The agenda was considered and owing to the small number of participants present in Venice, it was agreed to focus initially on three ToRs, e.g. ToR's a, c and f. It was decided to follow the agenda of WGSAM and participate in their plenaries and if possible contribute to their activities. Therefore our activities related to WGFE's ToR c have been a contribution to the work by WGSAM on their ToR e, both focusing on indicators for the MSDF. ToR f was in the end not considered at all, as only one person was available to work on it, with only limited background knowledge of the specific question. It was considered best to put effort in the contributions to the WGSAM report rather than getting half an answer ready for ToR f that would be read by nobody.

# 3 Introduction

## 3.1 Terms of Reference

2011/2/SSGEF17The Working Group on Fish Ecology (WGFE), chaired by Ralf van Hal, the Netherlands, will meet in Venice, Italy, 22–26 October 2012 to:

a ) Apply multiple spatial methods to compare and summarize fish and fish community distributions in relation to environment and habitat finalizing the case studies mentioned in WGFE 2011;

b ) Include spatial aspects in the Size-Based model (SIBmo) of the North Sea fish community to analyse the interacting effects of climate and fisheries on productivity and community structure;

c ) Review existing fish-based indicators (e.g. of biodiversity) suggested for the descriptors of the Marine Strategy Framework Directive, assessing their basis in theory (e.g. linkage to changes in ecosystem function), feasibility and performance; suggest new and alternative indicators where appropriate.

- i ) Consider species-specific metrics currently proposed by member states as indicators in support of criteria 1.1, 1.2, and 1.3 and comment on their advantages and drawbacks. In particular consider the suite of species that might be used in each region to support these species-specific indicators.
- ii ) Consider the advantages and drawbacks of various Ecosystem-level metrics as indicators in support of criterion 1.7.
- iii ) Discuss the merits of the indicators proposed for fish communities under Descriptor 4. Consider alternative indicators (as requested in the EC Decision document) and state reasons for their use.

d ) Evaluate shifts within fish communities:

- iv ) What constitutes regime shift in fish communities? Can mechanizms be identified?
- v ) State changes - Cycles vs. regime shifts
- vi ) Are anthropogenically induced changes alterable?

e ) Review and report on existing indicators of biodiversity that are linked to predictable changes in ecosystem function and/or to develop, assess and report on the feasibility and performance of such indicators;

f ) Identify and report on functional characteristics that could lead to species being defined as 'keystone'.

Long term Terms of Reference

g ) Examine climate change processes and predictions of affects on fish communities.

WGFE will report by 20 November 2012 (via SSGEF) for the attention of SCICOM.

# 4 Apply multiple spatial methods to compare and summarize fish and fish community distributions in relation to environment and habitat finalizing the case studies mentioned in WGFE 2011

## 4.1 Introduction

Incorporation of species-habitat relationships is well established in the formulation of European, Canadian and USA policy. The European Union Marine Strategy Framework Directive Good Environ-mental Status Criteria, Descriptor 1 states "The assessment of species also requires an integrated understanding of the distribution, extent and condition of their habitats to make sure that there is a sufficiently large habitat to maintain its population, taking into consideration any threat of deterioration or loss of such habitats". The Canadian Species At Risk Act (SARA) requires assessment and protection of critical habitat for species at risk, similar to the Endangered Species Act (ESA) in the United States. The Federal Fisheries Act provides Fisheries and Oceans Canada with authority for the conservation and protection of fish and fish habitat essential to sustaining commercial, recreational and Aboriginal fisheries. Federal fisheries in the USA are subject to the Magnuson Stevens Fishery Conservation Management Act which requires that all fisheries management plans identify Essential Fish Habitat (EFH) and minimized to the extent practicable the adverse effects of fishing on EFH. Federal regulations define EFH as "those waters and substrata necessary to fish for spawning, breeding, feeding, or growth to maturity", and adverse effects as those which are "more than minimal and not temporary".

Policy directives that require measures for protecting habitats imply an understanding of fish and fish community distributions in relation to environment and habitat factors. However, these relationships are often poorly understood and approaches generally rely on assessing proxies (e.g. loss of seabed vertical structure) or indicators (e.g. decreases in biodiversity) to identify where to enact spatial management measures (e.g. MPAs). Delimiting MPAs to protect such habitats requires mapping and spatial analyses which often use Geographical Information Systems and spatial statistical methods. Examples are provided to demonstrate applications of mapping and spatial methods currently emanating from the above directives to protect fish habitats.

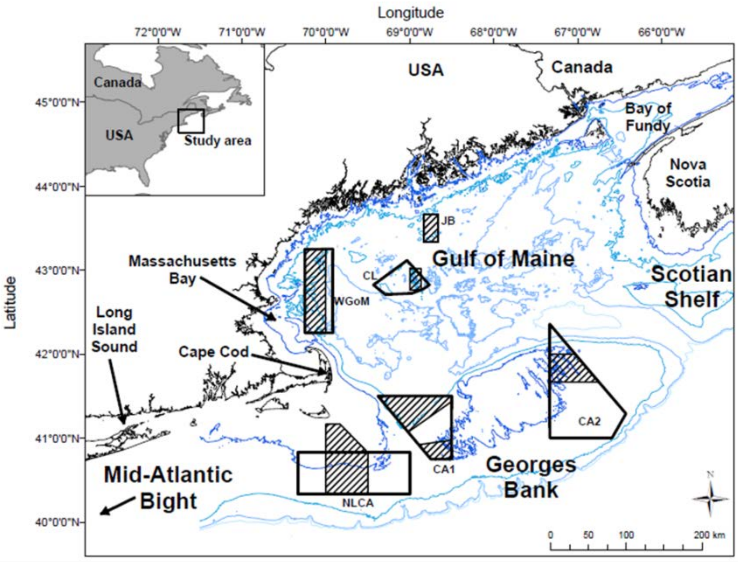



Figure 4.1. The location of the Gulf of Maine and Georges Bank, including areas with year-round fishing closures. Closed areas are represented by polygons and EFH closures by hatched polygons. NLCA = Nantucket lightship, CA1 and CA2 = closed area 1 and 2, WGoM = western Gulf of Maine, CL = Cashes Ledge, JB = Jeffery's Bank.

### 4.1.1 Georges Bank closures

We will focus the discussion on permanent closures, but it is important to note that a complex arrangement of temporal spatial closures exists. Permanent closures in the Georges Bank/Gulf of Maine region (Figure 1) are currently used to reduce fishing effort on and destruction of essential habitat for groundfish stocks. It was determined that complex habitat, particularly gravel, on Georges Bank was essential to juvenile Atlantic cod, (*Gadus morhua*) and four permanent habitat closed areas were developed using information on fish distribution and sediment data from Poppe *et. al.* (1989; NMFS, 2003). A detailed fine-scaled sediment analysis by Harris and Stokesbury (2010) indicated that this stated objective was not achieved, and the intended habitat that were to be protected only account for between 0.9% to 38% of each of the current closed areas. A gap between the location of closed areas and intended protected habitat exists (Harris and Stokesbury 2010). The reason for the gap was a paucity of sediment data, generally speaking, at the time of the closed area development. Multivariate analyses, specifically interpolated PCA scores on species count data, appeared to identify locations of cobble habitat that may allow for more comprehensive area-based management (Jordaan *et. al.* In Press).

Although closed area 1 (CA1, Figure 1) existed in various forms prior to 1994, the NMFS implemented closure year-round through emergency action to reduce mortality on groundfish stocks, which had experienced dramatic declines through the 1980s and early 1990s. The remaining area and Essential Fish Habitat (EFH) closures (CA1, CA2, NLCA) were enacted in 2004 to minimize affects of the groundfish fishery on EFH. There has existed a groundfish survey in the region since 1963, thus if the survey could be used to delineate locations of EFH, or multispecies assemblages that managers are seeking protection for, these data could have been useful in closed area design. Further, while there is expanding data coverage for sediment data, trawl data (either fisheries dependent or independent) is often more widely available.

Here we will relate data from the National Marine Fisheries Survey trawls survey to sediment and shear-stress data collected by Harris and Stokesbury (2010) and Harris *et. al.* (In Press) as well as physical variables (bottom temperature and depth) collected during the survey. The results will focus on a finer-scale that previous survey analyses and relate the two unique datasets through various multivariate techniques.

## 4.2 Methods

### 4.2.1 Sediment data

There were 5 sediment variables available from Harris and Stokesbury (2010) and Harris *et. al.* (In Press) and they are shown in Table 4.1.

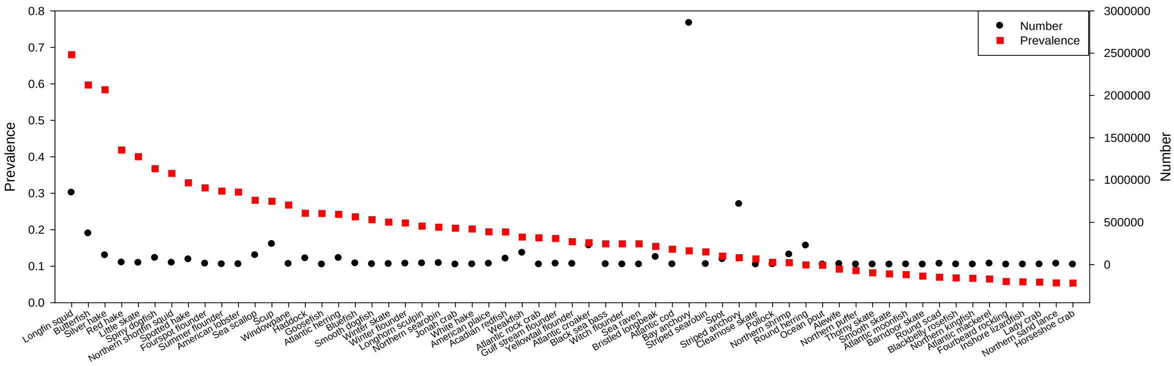
Table 4.1. Sediment and shear-stress variables.

| VARIABLE | VALUES | DETAILS |
|---|---|---|
| Maximum Size Sediment Type | | 1842-1843 (Harris and Stokesbury 2010) |
| Dominant Sediment Type | 4 replicate samples per station | 1842 - 1843 (Harris and Stokesbury 2010) |
| Sediment Coarseness | < 2 = Smooth, >2 but <4 = Intermediate, ≥ 4 = Coarse | 1842 - 1843 (Harris and Stokesbury 2010) |
| Sediment Stability Index | ≥ 1 = unstable, < 1 = Stable | section 2.3 (Harris et al In Press) |
| Benthic boundary shear stress | N $m^{-2}$, annual mean max M2+S2 tidal = biweekly | section 2.1 (Harris et al In Press) |

### 4.2.2 Fish Data

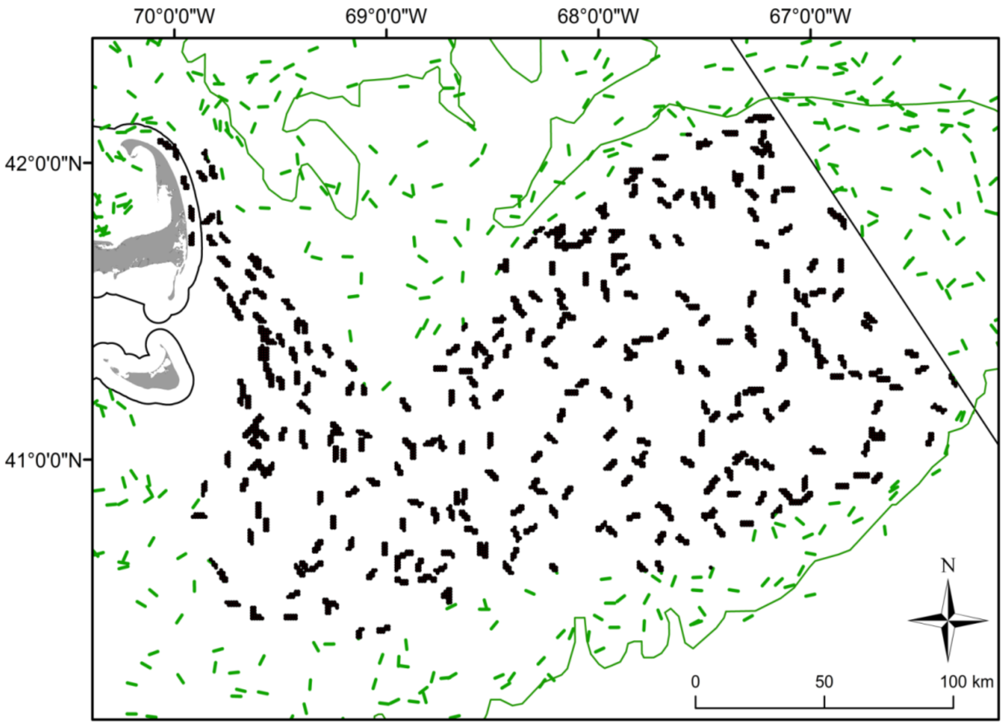
The primary fish dataset to be used in this work is a subset of the National Marine Fisheries Survey (NMFS) fall trawl survey. Conducted primarily by the research vessels Albatross IV and Delaware II, the NMFS survey used a Yankee 36 bottom trawl with a 1.27 cm mesh liner, towed for 30 min at 3.79 knots and sampling was conducted during the day and night (Sosebee and Cadrin, 2006). A total of 300–400 trawls were executed each season from the Gulf of Maine (GOM) to just south of Cape Hatteras, NC. The NMFS fall survey began sampling in 1963 and primarily sampled the waters of Southern New England and the Gulf of Maine before being expanded to include inshore stations in 1973. The survey data were linked to sediment data (described above), resulting in a prevalent set of species (Figure 4.2).

**Figure 4.2. Prevalence (left axis) and numbers (right axis) of the top 61 species caught for the 1999-2006 period in the NMFS fall trawl survey.**



The resolution of the NMFS survey is one station per 872 km² each year. There are 3 distinct periods when the NMFS trawl survey was prosecuted, with a gradual shift from a later to earlier mean survey date (Jordaan *et. al.* in Press). Only available years that overlapped with the years of sediment data collection (1999-2006) were used (Figure 4.3; Harris and Stokesbury 2010).

**Figure 4.3. Location of tows (green lines) in the National Marine Fisheries Trawl survey, and those that have benthic sediment data available (black dots) within 1km of the trawl path.**




The species list shown in Figure 4.2 was trimmed to exclude small pelagic species and benthic invertebrates, which have been shown to have different relationships with physical variables (Jordaan *et. al.* 2010; in Press). The resulting species list used for all remaining analyses is shown in Table 4.2.

### 4.2.3 Analytical techniques

There is a rich history of analyses that relate structure to physical variables and a variety of these will be tested (see Anselin 1995, Anselin 1996. Anselin *et. al.* 2006, Boots 2002, Fotheringham *et. al.* 2002, Ord and Getis 1995, Ord and Getis 2001). These include simple correlations, Principal Component Analysis (PCA) including Hellinger and square-root transformations, bootstrapped-PCA, boosted regression trees, geographically weighted regression, tests for local spatial autocorrelation, Moran scatterplots and tools such as GetisOrdGi hot spot analysis available using ESRI® ArcMap™ ArcToolbox™ spatial analysis software. While all these will be eventually tested and are summarized below, this report will focus on the results of initial redundancy analysis and multivariate regression trees.

**Table 4.2. List of fish species used in the analyses**

| FAMILY | SPECIES | COMMON NAME | ABBREVIATION |
|---|---|---|---|
| Squalidae | *Squalus acanthias* | spiny dogfish | Spidog |
| Triakidae | *Mustelus canis* | smooth dogfish | Smodog |
| Rajidae | *Leucoraja erinacea* | little skate | Litska |
| | *Leucoraja ocellata* | winter skate | Winska |
| | *Raja laevis* | barndoor skate | Barska |
| Merlucciidae | *Urophycis chuss* | red hake | Redhak |
| | *Merluccius bilinearis* | silver hake | Silhak |
| | *Urophycis tenuis* | white hake | Whihak |
| | *Urophycis regius* | spotted hake | Spohak |
| Gadidae | *Melanogrammus aeglefinus* | haddock | Haddoc |
| | *Gadus morhua* | Atlantic cod | Atlcod |
| Pleuronectidae | *Hippoglossoides platessoides* | American plaice | Amepla |
| | *Paralichthys oblongus* | fourspot flounder | Fouflo |
| | *Citharichthys arctifrons* | gulf stream flounder | |
| | *Scophthalmus aquosus* | windowpane flounder | Window |
| | *Pseudopleuronectes americanus* | winter flounder | Winflo |
| | *Limanda ferruginea* | yellowtail flounder | Yelflo |
| | *Paralichthys dentatus* | summer flounder | Sumflo |
| | *Citharichthys arctifrons* | gulf stream flounder | Gulstr |
| Scombridae | *Scomber scombrus* | Atlantic mackerel | Atlmac |
| Pomatomidae | *Pomatomus saltatrix* | bluefish | Bluefi |
| Sparidae | *Stenotomus versicolor* | scup | Scup |
| Cottidae | *Myoxocephalus octodecemspinosus* | longhorn sculpin | Lonscu |
| | *Myoxocephalus aeneus* | grubby | Grubby |
| Hemitripteridae | *Hemitripterus americanus* | sea raven | Searav |
| Zoarcidae | *Macrozoarces americanus* | ocean pout | Ocepou |
| Triglidae | *Prionotus carolinus* | Northern searobin | Norsea |
| Labridae | *Tautogolabrus adspersus* | cunner | Cunner |
| Lophiidae | *Lophius americanus* | goosefish | Goosef |

#### 4.2.3.1 Species richness

Species richness, one of the proxies or measures of biodiversity, is an example of an ecosystem emergent property that can be measured and perhaps used in the development of decision criteria in fisheries management (Link 2002). Fish species richness, the number of unique fish species per tow, can be estimated from survey or observed commercial data. There are a variety of biodiversity metrics available including, but not limited to, species richness and evenness. Once values are determined, they can be interpolated across space to determine regions of high biodiversity, and temporal changes assessed. Physical variables can be tested against the richness measures to identify correlates with increased biodiversity.

#### 4.2.3.2 Principal Component Analysis

There has been substantial effort to classify areas of the ocean, based on characteristics that consider spatial structure of biodiversity in support of geographically based management. Ordination techniques demonstrate persistent biological structure along environmental discontinuities on the Northwest Atlantic continental shelf using trawl survey data (Overholtz and Tyler 1985; Gabriel 1992; Mahon *et. al.* 1998). While the broad assemblage designations of Mahon *et. al.* (1998) and others have been generally supported (Jørgensen *et. al.* 2005), one valid critique of these techniques is the subjectivity with which cutoffs in eigenvalues and eigenvectors were made (Souissi *et. al.* 2001).

There has been a progression from a heuristic to probability-based methods to identify true patterns in datasets over the past few decades (Field *et. al.* 1982). Bootstrapped and standard principal component analysis (PCABTSP and PCA, respectively) were employed to address this deficiency in the analysis of multivariable ecological datasets (Jackson 1993; Jackson 1995; Pillar 1999). Despite allowing axis reversal among bootstrap runs (Mehlman *et. al.* 1995), PCABTSP-based techniques have been shown, using both simulated and real data, to outperform other methods in determining the number of nontrivial principal components (Jackson 1993, 1995; Pillar 1999) and eigenvector loadings (PeresNeto *et. al.* 2003).

PCABTSP provides a methodology for determining the cutoff (stopping rule) and determining relation-ships among species using a probability-based method. PCA has a significant advantage in that each new variable (principal component) is uncorrelated with others and can be statistically tested against physical variables. This is particularly helpful in dealing with multiple scales within datasets and the multiple, interacting influences of physical variables in determining species' distributions, and allows species to belong to multiple species groups. However, it is important to recognize that while contri-bution to multiple assemblages does allow for some of the non-linear interactions in ecological systems to be accounted for, the linear nature of each principal component does mean that complex non-linear processes will not.

Analysis of NMFS trawl survey data follows procedure outlined by Jordaan *et. al.* (2010) for analysing PCABTSP and a "normal" PCA with three steps:

1 ) Evaluate $PCA_{BTSP}$ eigenvalues and establish stopping rules using 95% confidence intervals to divide PCs between those that provide a meaningful dissection of the data and those which are considered trivial components (Jackson 1993). Only relevant PCs are included in further analyses.

2 ) Using the relevant PCs, species eigenvector 95% confidence intervals are compared to each other, and to a score of 0. This allows a determination of both which species are correlated in abundance (i.e.: form assemblages) and which (groups of) species are driving the patterns for PCs (significantly different from 0).

3 ) Relate relevant PC scores at each site to spatial data and map spatial biodiversity indices. An inverse distance weighting (IDW), or other interpolation technique, can then be used to established assemblage areas.

#### 4.2.3.3 Multidimensional scaling/ANOSIM

Field *et. al.* (1982) suggested that patterns in species should be examined prior to determining important physical factors, which precludes the use of some analyses such as canonical correlation analysis. Current ecological classification has widely adopted nonparametric ranking of similarities in order to create a matrix that can identify geographically related divisions in assemblages and species that contribute to patterns (Field *et. al.* 1982). Heavy computing loads were identified as a limitation in classification analysis and stopping rules (Field 1969; Field *et. al.* 1982). Fortunately this is a factor that no longer exists. However, this method has a long history in ecology and continues to be the most widely used technique. The Bray–Curtis measure of similarity and nonmetric multidimensional scaling ordination can accommodate robustness and flexibility, but sacrifice information by using rank data (Field *et. al.* 1982). In contrast, the PCABTSP sacrifices flexibility and robustness to gain a more quantitative edge.

Ranked matrices of similarities among samples can be constructed using the Bray–Curtis similarity measure. Then ordination by nonmetric multidimensional scaling (MDS) (Kruskal and Wish 1978, Clarke and Green 1988) can be used to detail patterns. Formal significance tests for differences between groups can be performed using the ANOSIM permutation test (Clarke 1993).

#### 4.2.3.4 Unsupervised Bayesian clustering to determine sub-assemblage structure

Determining sub-assemblage structure can be a valuable method for investigating the distributions of fish in relation to habitat and/or the environment. Further, by time-slicing long-term datasets it is possible to incorporate a dynamic element to the subset of sub-assemblages in space, perhaps in relation to changing environmental conditions.

A recent study used unsupervised Bayesian clustering to look at patterns of sub-assemblage structure through time in the Northeast Atlantic demersal fish assemblage in response to recent warming (Simpson *et. al.* 2011). This method was used in preference to k-means clustering, since it is unsupervised and so is not prescriptive about the number of clusters that should be found.

#### 4.2.3.5 Redundancy Analysis

Redundancy analysis derives a specified number of variables from one set of independent variables that explain as much variance as possible in another independent set. It is considered the multivariate version of a regression analysis. Hellinger transformation (Legendre and Gallagher 2001) were completed on the count data, which down-weights abundant species, gives low weights to rare species, and combined with Euclidean distance in PCA and redundancy analysis (RDA), these ordinations behave a lot like Principal Coordinates Analysis with Bray–Curtis distances.

Redundancy Analysis (RDA) was completed with the transformed count data in a forward selection mode using the environmental data with no interactions. The order of entry at each step is given in table 4.3.

**Table 4.3. Results of redundancy analysis**

| Variable | Eigenval | p-value | parms | n | var y | sum eigen | AIC | AICc | |
|---|---|---|---|---|---|---|---|---|---|
| Depth | 0.125 | 0.0010 | 1 | 76 | 0.022 | 0.13 | -78.934 | -78.601 | |
| BT | 0.033 | 0.0010 | 2 | 76 | 0.022 | 0.16 | -79.856 | -79.292 | |
| SStM | 0.029 | 0.0010 | 3 | 76 | 0.022 | 0.19 | -80.519 | -79.662 | Min here |
| Sx | 0.017 | 0.0010 | 4 | 76 | 0.022 | 0.20 | -80.125 | -78.908 | |
| SmS | 0.009 | 0.0010 | 5 | 76 | 0.022 | 0.21 | -78.990 | -77.343 | |
| Year | 0.008 | 0.0010 | 6 | 76 | 0.022 | 0.22 | -77.766 | -75.617 | |
| BS | 0.008 | 0.0020 | 7 | 76 | 0.022 | 0.23 | -76.551 | -73.823 | |
| SmGP | 0.006 | 0.0160 | 8 | 76 | 0.022 | 0.24 | -75.144 | -71.760 | |
| SdC | 0.005 | 0.0310 | 9 | 76 | 0.022 | 0.24 | -73.643 | -69.518 | |
| SSTSD | 0.003 | 0.2867 | 10 | 76 | 0.022 | 0.24 | -71.943 | -66.991 | |

The eigenvalue is the fraction of explained community variation gained at each step, and "sum eigen" is the cumulative amount. Nine variables were significant using a permutation test; however, trimming with AIC knocks that down to three variables: depth, bottom temperature (BT), and mean benthic boundary shear stress (SStM) (Table 4.3).

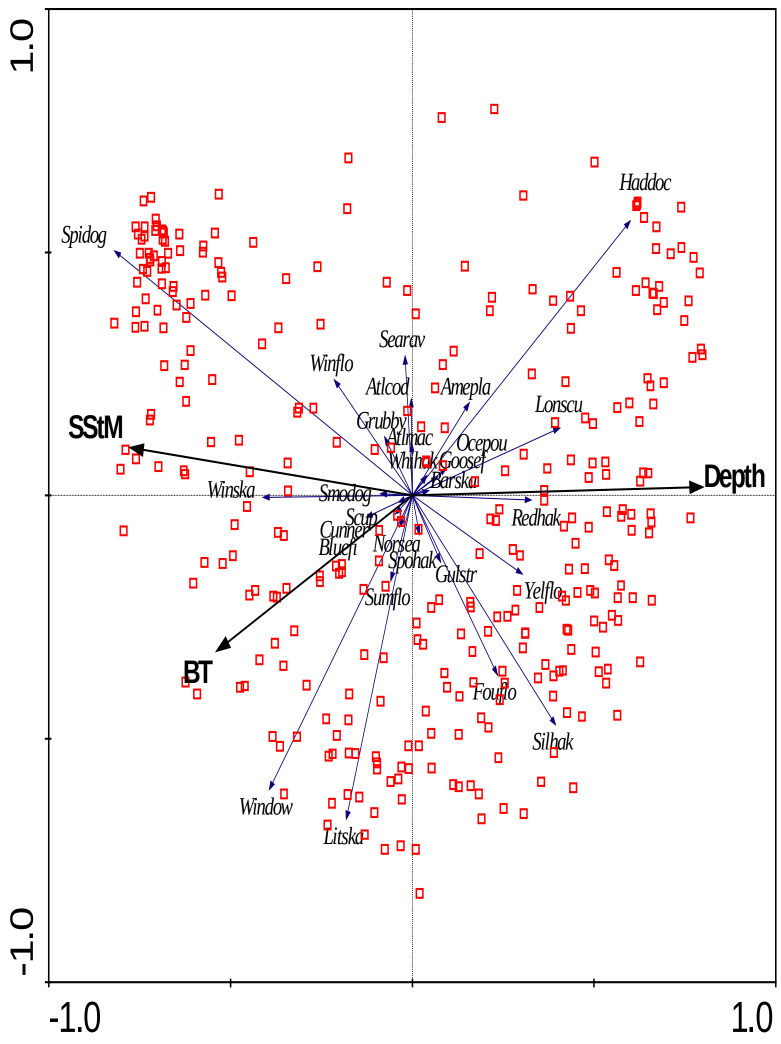



**Figure 4.4. An ordination triplot of the data with the three environmental variables deemed to contribute meaningfully to the redundancy analysis. The arrowhead represents high, the origin average, and the tail (when the vector is extended through the origin) low values. Arrows always point in the direction of increase. So, for example depth increases from left to right, and spiny dogfish from lower right to upper left. The length of the vector indicates the size of the gradient. So, species with small vectors do not show strong changes. Squares are samples. Projecting a sample point perpendicularly onto an individual species vector approximates the Hellinger transformed abundance value of that sample for that species.**

The two axes capture about 94% of the explained variation. Species are abbreviated using the first three letters of the first and second word in the name (e.g. Silhak = silver hake). Continuous explanatory variables and species are depicted as vectors (Figure 4.4). Projecting a sample point perpendicularly onto an environmental vector approximates the environmental value of that sample. Projecting a species arrowhead perpendicularly onto an environmental vector indicates the direction and magnitude of the relationship between the two. A projection on the arrowhead side of the environmental variable indicates a positive effect and on the tail side a negative effect. Species-species and Environmental-environmental relationships are also examined by projections. For example, SStm and Depth are negatively correlated. So are

Haddoc and Window. Silhak and Fouflo are positively correlated. Projecting objects is important to interpret the figure.

Attribute plots better illustrate how the vectors represent variables (Figure 4.5, 4.6), demonstrating that patterns do emerge from the analysis that can be related to individual species and physical parameters. Year did not survive the AIC trimming process and to better understand this observation, a new ordination was created with envelopes for each year (Figure 4.7). The results indicate that year is spread throughout the ordination plot and is thus not an important variable.

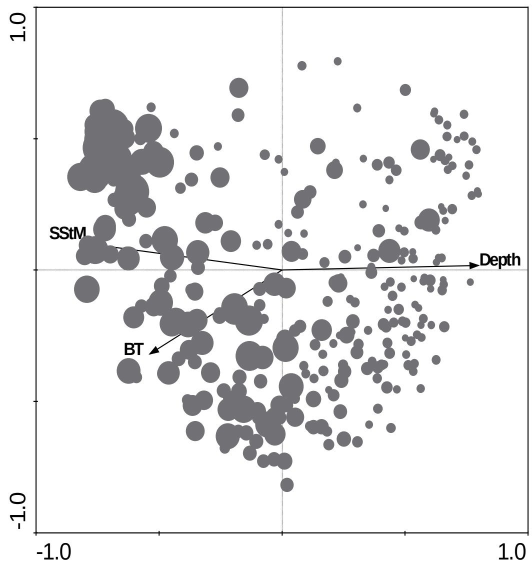



**Figure 4.5. Plot of mean benthic boundary shear stress (SStM) for each sample**

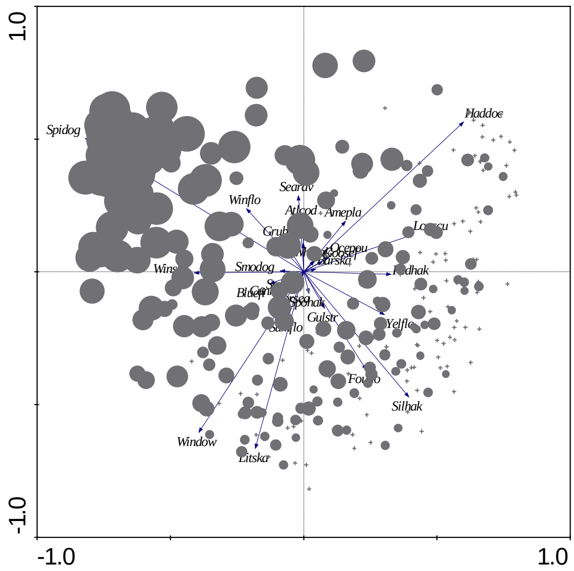



**Figure 4.6. Hellinger transformed Spidog counts (crosses=0).**

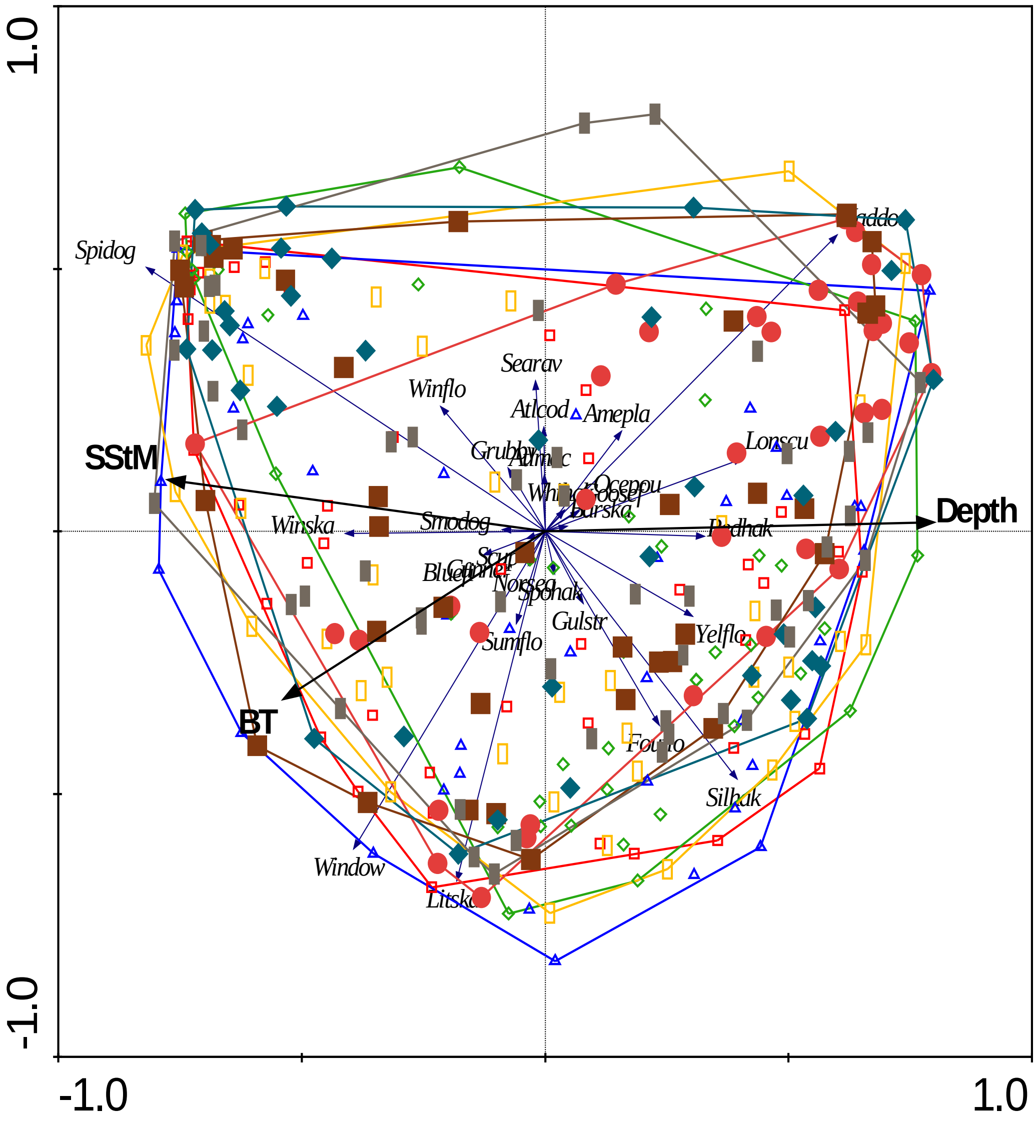



**Figure 4.7. Redrawn ordination with symbols for each year and envelopes enclosing all of the samples in each given year.**

#### 4.2.3.6 Multivariate regression trees

Multivariate regression trees (MRT) were introduced to ecology by De'ath (2002). In regression trees, each split is binary, defined by a simple rule, and is chosen to minimize the dissimilarity within and, therefore, maximize the dissimilarity between groups of samples. In our case, dissimilarity was determined by Euclidean distance of Hellinger transformed counts and hence the split minimized the total sums of squares about the transformed group means. Each final group is termed a leaf and is characterized by the multivariate mean of all species belonging to the samples in the group. In practise, MRT splitting is carried out until the regression tree is over-fitted. The tree is then pruned back in size by reducing the number of leafs based on a cross-validation process that looks like a jackknife procedure but with 10% of the samples left out in each of 10 cross-validation runs. This results in a parsimonious tree with the smallest number of splits justified by the data. AIC can also be applied as a pruning method. MRT is especially useful in identifying non-linear relationships, interactions, and thresholds. It is not efficient at identifying gradients that are smooth, monotonic, and continuous.

To begin identifying potential interactions among environmental variables, multivariate regression trees (MRT) were used to group samples of Hellinger transformed species count data into clusters by repeatedly splitting the data based on criteria obtained from explanatory variables (Breiman *et. al.* 1984).

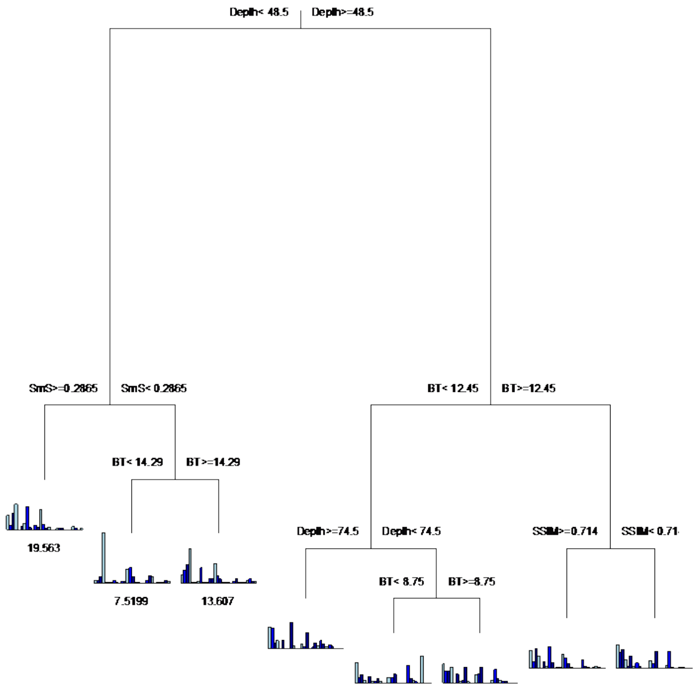



Figure 4.8. Results of the multivariate regression trees (MRT) using Hellinger transformed species count data. The results divided species into clusters by repeatedly splitting the data based on criteria obtained from explanatory (physical) variables. Histograms at each leaf are mean transformed counts for each species. Numbers under the leaf are deviances, i.e., the sum of the squared deviations from the mean of each species for all samples in the leaf.

Splits based on depth, bottom temperature (BT), benthic boundary layer shear stress (SStM), and the proportion of stations where largest sediment type was sand (SmS) were observed (Figure 4.8, Figure 4.9). Note that variables can be reused multiple times in the tree (e.g. depth, bottom temperature). Environmental values that send samples to left and right branches are shown for each binary split. For example, the first split sends samples shallower than 48.5 to the left branch and those deeper than 48.5 to the right. The little histograms at each leaf are mean transformed counts for each species. The numbers under the leaf are deviances, i.e. the sum of the squared deviations from the mean of each species for all samples in the leaf.

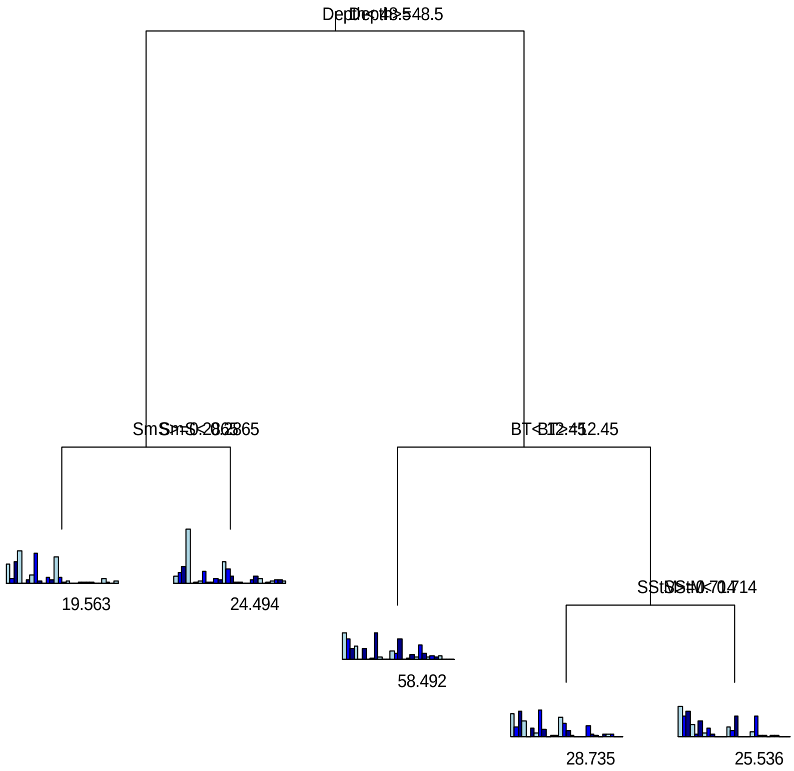



**Figure 4.9. Cross-validation suggested only 5 leafs were justified resulting in a pruned tree.**

## 4.3 Discussion

Both the redundancy analysis and the multivariate regression tree identified depth, bottom temperature, and benthic boundary layer shear stress as the principal environmental variables relating to the species assemblages. The other variable SmS, the proportion of stations where the largest sed type was sand, was significant in the stepwise RDA, but it was eliminated by the AIC process. Both the regression tree (discreete cuts) and RDA (continuous) appear to have good agreement that about 20% of the variation in species can be explained by variation in physical variables. While depth and shear stress were negatively correlated, even after accounting for depth the shear stress still added ability to classify com-munity.

No temporal changes were detected. The lack of year effect can be attributed to many potential factors. First, the period examined represents a post-exploitation phase where species that were reduced due to overfishing in the 1980s have maintained relatively similar (and low) abundance.

The effect of environmental variables on the efficiency of the trawl and, thus, the catchability of species will be an important consideration in this work. There is probably a reduction in trawl efficiency and increased noise in selectivity for most species with increasing proportions of coarser sediments. If this is true then species detectability goes down with increased sediment size (autocorrelated with increased sediment stability). This might influence the importance of the proportions of sand, and other sediment characteristics, on the species captured. Further, because it is likely that all the physical variables are correlated, this may result in some variables being ignored, despite their importance. More work is required relating interactions among variables to the resulting species composition.

Multivariate-based indicators of species assemblages can help distinguish species-habitat relationships using survey data, and because multiple assemblages are identified can also be used in biodiversity conservation. Depth was a primary variable, as it has been in other analyses (Jordaan *et. al.* 2010; in press). However, neither depth, nor temperature or shear stress are involved in developing a comprehensive ocean zoning strategy in the northeastern United States.

Other analyses completed in the Gulf of Maine suggest scale-dependent organization of species assemblages from tide pool assemblages that structure along vertical (position relative to tide height) and horizontal (wave exposure, estuarine) conditions (Jordaan *et. al.* 2011). The intertidal zone follows much the same pattern (Jordaan 2010). Further, isolated habitat types can only be colonized by species that have adapted sufficient dispersal ability and required physiological and physical characteristics (Jordaan 2010).

Completing a regional picture relating the influence of physical variables will require further analyses and datasets. The primary next step is to complete the remaining analyses and determining whether interactions between environmental variables are worth including.

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# 5 Discussion on the small number of participants and the continuation of WGFE

## 5.1 Letter to chair of SSGEF

It has been a difficult struggle to get some members to attend the WGFE meeting of this year. As it has been in the last three years. The last well visited WGFE meeting took place in 2009 with 15 members attending the meeting. In 2010 attendance was 6, in 2011 5 and this year only 4 members attended the meeting.

In 2011 it was suggested to combine the meeting of WGFE with another relevant ICES meeting. In the period WGFE was held, the meeting of WGSAM was considered the most relevant to join with. Therefore this year the meeting was held jointly with WGSAM, same week and same location, in order to hold joint sessions on selected ToRs. This meant that most of the plenary sessions were combined and some of the topics have been discussed by both groups.

The critical mass of WGFE 2012 by itself was however too small to address all ToRs, and even to have in-depth discussions on the ToRs dealt with, much of the original expertise concentrated in WGFE is no-longer present. As this situation was anticipated (although to a less severe degree!), prior to the meeting a discussion on cancellation of WGFE 2012 took place. However, various encouraging e-mails from members incapable of attending this year, but enthusiastic about the work done by the group, and also an advise by SCICOM that it would be worth continuing with the meeting, made a strong case for deciding otherwise.

During the first day of the WGFE 2012 meeting, various pros and cons for continuing WGFE were discussed along with possible reasons behind the currently low attendance. The members of the group as well as the SSGEF chair strongly feel that ICES should have a fish ecology group - it seems pretty fundamental to underpin ICES advice in times with high requirements for ecosystem considerations in human activities, visible in the on-going work in relation to the MSFD or the ecosystem approach to fisheries. Especially in relation to the ICES Science Plan, WGFE should play its role. However, the group itself does not appear to be able to live up to this goal any more, given the low attendance which now has become a regular problem.

Other WGs on particular groups of species have their own role within ICES, e.g. Benthos Ecology (BEWG), Seabird Ecology (WGSE), Marine Mammal Ecology (WGMME), along these lines there should be a function for WGFE, and it would be almost on thinkable that a group on Fish Ecology would not exist. On the other hand, this alone is not a good reason to continue a group. We understand, that Seabird ecology now is in a similar position to WGFE and without these dedicated groups of experts to do the necessary work, WGFE fears that the Member States will cease to come to ICES for this sort of ecosystem advice, and increasingly turn to the working groups that are now starting to be set up in OSPAR.

The discussion on the decreasing attendance came up with many reasons that varied but can be grouped under the following three:

1 ) Funding reduced
2 ) ToRs are historic remnants rather than up to date
3 ) Many of the interesting fish ecology subjects have been taken over by other/new groups.

Funding issues are not a surprise in these times, but some members commented that it was difficult to convince their managers of the need of the WG, especially due to the "academic" formulation of the ToRs and limited direct management influence, e.g. the ToRs are not applied enough for managers to supply funds. But that seems to be an issue that many science groups have to deal with. It is also related to the fact that some remnant ToRs are on the list with limited connection to the Science Plan and current projects.

However, the discussion in the years with well attendance has been that applied ToRs would reduce attendance of members from the academic world. A part of the members at that time indicated that they would no longer attend if that would happen. This might have created the impression that WGFE was not going to pick up requests from other groups and these questions were directed to other groups or new (temporary) groups to deal with these request were created, e.g. SGSPATIAL. While actually WGFE would be an ideal place to deal with these questions. Moving these questions to other groups means that these groups are attended rather than WGFE. This is a problem for WGFE but not in the broader sense because the questions are still answered within ICES. A downfall of single topic groups may be that their discussions focus on the single topic rather than that the questions are answered in broader discussions on fish ecology.

This week the meeting of WGFE was combined with WGSAM, and with some success. Unfortunately, it did not attract more members to WGFE, but it is clear that there is some overlap in topics. WGFE's modelling ToR (ToR b), a remnant, is much better dealt with by WGSAM. In contrast, WGSAM is dealing with evaluating the output from their models on MSFD-indicators, while data driven evaluation of similar indicators would much better fit with the original scope of WGFE. This is shown by the results of WGFE on the large fish indicator in recent years ((Greenstreet *et. al.* 2012) and various WGFE reports) and the broader role of WGFE in the development of ecological indicators and their application to support the OSPAR EcoQO concept of an ecosystem approach to management.

Similar links between the two WGs exist on studies on the spatial patterns of species, where analysis of data on (shifts in) spatial patterns would fit in the scope of WGFE (Tor a), while the results of these analyse could be used by WGSAM in their models or they could validate their outputs with WGFEs analysis. Similar options exists related to the stomachs collected owing to requests by WGSAM, for example data driven analyses on diet overlap and spatial distributions in diet choice might be done by WGFE and the results of this are valuable for WGSAM.

While a combined meeting was a success, we think this type of cooperation would better work when the groups are not meeting at the same time. Thus a combined meeting is not proposed for next year.

Another option for a combined meeting was suggested by the chair of WGBIODIV. WGFE was invited to combine their meeting with that of WGBIODIV in 2013. In this case WGFE might fill the fish aspects of the Biodiversity group, which is actually already ToR c of this year (also ToRs e and f are closely related). This would however mean two things, first that WGFE will continue to meet and second that the date of the meeting is moved again to early in the year (and a new chair as the current chair is occupied by the IBTS at that time). The last seems difficult to realize as this would mean the next meeting of WGFE would occur already within 4 months, most likely before new ToRs (and the continuation of the WG) are agreed upon by SCICOM.

A better approach seems to be that the WGFE members available at that time attend the WGBIODIV meeting, rather than a combined meeting.

A final group that might be discussed here is SGSPATIAL. This SG formulated ToRs that are very closely related to work done by WGFE in latest years. Their plan is however to focus solely on the Baltic, while WGFE's focus has been much wider covering the whole ICES area. If SGSPATIAL might develop plans for extending their scope to cover the full ICES area, using similar analysis in all these areas it would mean they can take over that role of WGFE.

By saying this, most ToRs that WGFE has at this moment are or could possibly be covered by other groups, making the actual ground for the existence of WGFE limited which would plea for cancelling WGFE, while the work of the group is continued within ICES.

However a risk of cancelling WGFE is that a lot of the data gathered by the various surveys will not be used in the way it was intended by WGFE, while it might actually be very valuable at the time in relation to the work on the MSFD. This risk, underuse of survey data, was also one of the main points stressed by the chair of WGSAM. This was related to some potential requests for WGFE by WGSAM. Some other topics for WGFE related to requests by other groups or the Science plan were discussed e.g. "The role of coastal zone habitat in population dynamics of exploited species" and "Identify the locations of ecologically important habitats for elasmobranch fish".

However, WGFE has decided not to formulate new ToRs for next year as prospects for attendance are low and possibilities to change this limited. If this means requests made by other WGs can't be dealt with, WGFE thinks it is better to start SGs around these requests (as is done already for some subjects of WGFE), where new groups tend to attract new people, rather than to force the continuation of WGFE having another year of struggle and low attendance.

The current members present at the meeting are happy to join one or more of these groups if this lines up with their work. But will have difficulty convincing their managers to attend future meetings of the current group as the value of the group has been limited in the last years.

## References

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## Annex 1: List of participants

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## Annex 2: WGFE terms of reference for the next meeting

The **Working Group on Fishing Ecology** (WGFE), chaired by Ralf van Hal, The Netherlands, will most likely not be continued

### Supporting Information

| | |
|---|---|
| Priority | The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority. |
| Resource requirements | |
| Participants | The Group should normally be attended by some 20–25 members and guests. However was attended by 4-8 members and guests in the last years |
| Secretariat facilities | None. |
| Financial | No financial implications. |
| Linkages to advisory committees | SSGEF, SSGSUE, SSGHIE, SSGESST |
| Linkages to other committees or groups | The work of this group is an important information source for WGECO (Ecosystem Effects of Fishing)<br>This group has provided key scientific products to the Strategic Initiative on Climate Change (SSICC) |
| Linkages to other organizations | |

# Annex 3: Recommendations

The following Recommendations have been generated by WGFE in 2012.

| RECOMMENDATION | ADRESSED TO |
| --- | --- |
| 1. WGFE thinks it is better to start SGs around single fish ecology topics for now (as is done already for some subjects of WGFE), where new groups tend to attract new people, rather than to force the continuation of WGFE having another year of struggle and low attendance. | SSGEF |
| 2. Some potential ToRs and activities suppositly performed by WGFE are mentioned in this report. It should be considered how these will be achieved and how the actvities will find continuation within ICES | SSGEF |