How Good is Good?: A Rapid Appraisal Technique for Evaluation of the Sustainability Status of Fisheries of the North Atlantic

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Abstract

Sustainability is a key policy requirement for fisheries throughout the world. Until recently it was difficult to assess fisheries sustainability, especially when it required the integration of information on the ecology, as well social and economic aspects. RAPFISH is a new multi-disciplinary rapid appraisal technique for evaluating the comparative sustainability of fisheries based on a large number of easy-to-score attributes. Fisheries may be defined flexibly as entities with a broad scope, such as all the fisheries in a marine gulf, or with narrower scope, such as those in a single jurisdiction, target species, gear type or vessel. A set of fisheries may be compared, or the time trajectories of individual fisheries may be plotted. Evaluation attributes are chosen to reflect sustainability within each discipline and may be refined or substituted as improved information becomes available. Ordinations of sets of attributes are performed using multi-dimensional scaling (MDS), followed by scaling and rotation.

The choice of MDS as an ordination technique is justified. Ordinations are anchored by fixed reference points that simulate the best and worst possible fisheries using extremes of the attribute scores, while other anchors secure the ordination in a second axis normal to the first. Randomly scored reference points act as additional anchors. Monte Carlo simulations provide an indication of the variability of the analysis and therefore reflect how reliable an analysis may be. Sensitivity of each attribute on the final scores is estimated with a step-wise jack-knife procedure.

Separate RAPFISH ordinations are performed in ecological, economic, ethical, social and technological disciplines. Status results expressing sustainability in each of these fields are reported on a scale from zero to 100%. A further evaluation field, measuring compliance with the FAO Code of Conduct for Responsible Fisheries, is itself comprised of six sub-fields that articulate clauses in sections of the Code. Status scores from several fields are combined in kite diagrams to facilitate comparison of fisheries, or fisheries constructed to represent alternative policies. In this paper the method is applied to present day fisheries and some historical time series from the Gulf of Maine (39 fisheries) and the North Sea (77 fisheries). The results, which are compared with previous work from Newfoundland (19 fisheries), provide examples of the use of RAPFISH in a multidisciplinary evaluation of the sustainability component of the impacts of fisheries on marine systems, and in assessing compliance with the FAO Code of Conduct.

Introduction

This paper applies a recently developed rapid appraisal technique, RAPFISH, to evaluate sustainability of North Atlantic fisheries. The technique is scaleable and hierarchical and provides simple percentage scores, with their confidence limits, for fisheries entities that may be flexibly defined in space and time. In addition, RAPFISH may be used to score compliance with the FAO Code of Conduct for Responsible Fisheries.

RAPFISH relies upon ordination of scored attributes grouped in a number of evaluation fields. The fields cover ecological, economic, social, ethical and technological sustainability. We present a rationale for measuring sustainability in this way, and a full statistical justification of the numerical engine at the heart of the RAPFISH technique together with numerical methods of expressing the relative influence of attributes and uncertainty in the results.

In addition to a rigorous examination of the method, our aim in this paper is to compare RAPFISH analyses of selected fisheries from the North Atlantic (from the Gulf of Maine, North Sea, Canada) to show how interdisciplinary evaluations may be used to inform policy choices.

Rationale and Methods for Rapfish

The Concept of Sustainability

The 1990s saw a decade of change where fisheries management imperatives of maximising production and economic returns were replaced with managing for sustainability. This change was the product of a number of factors:

- Increasing environmental awareness amongst diverse stakeholders, reflected in events such as the Rio Earth Summit that highlighted the global need for improved management of natural resources including marine resources and instruments such as the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks;

- The collapse of a number of major fisheries, that highlighted not just the ecological but also the social and economic consequences of not managing for sustainability; and
- Empowerment of stakeholders, commercial and recreational fishers, as well as conservation groups who demanded a broader view of fisheries management

This change was reflected in political arenas where national and state fisheries legislation and policy was amended or rewritten to embrace the notion of sustainability (e.g. USA (Magnuson Act amendments), Canada (Oceans Act), European Union (Common Fisheries Policy proposed changes)). Some countries went even further to embrace the concept of ecosystem management (Australia). This worldwide change in the imperative has challenged conventional approaches to fisheries management. Until recently, prevailing approaches to assessing the sustainability of exploited marine species focused on determining the stock status of the target species relative to biological and in some cases ecological, reference points such as levels of fishing mortality, spawning biomass, or age structure (Smith 1993). Resource managers used these reference and target points, as indicators of the status of a resource and as early warning signs of exceeding target extraction levels.

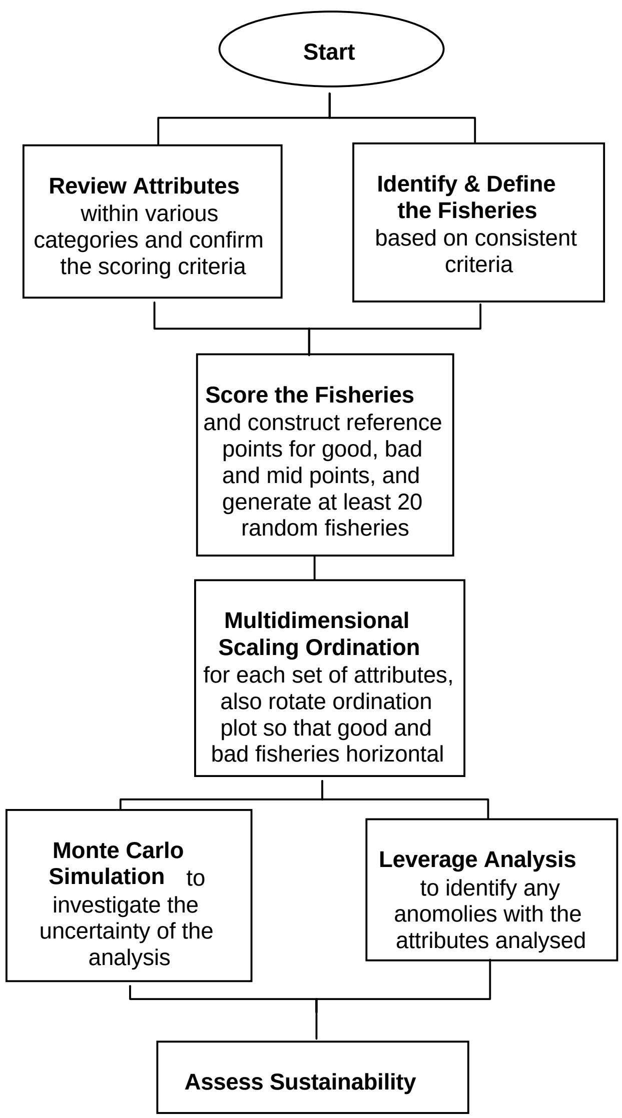

Figure 1 Elements of the process of applying RAPFISH to fisheries data.

These approaches, however, require substantial information, independent surveys and complex models to estimate past and present reference points representing management objectives for fisheries. The inherent uncertainty in fisheries research limits the ability of these complex models to estimate the sustainability indicators with a high degree of certainty (Walters 1998). The requirement for reliable data, complex models and widely-educated resources managers further limits less developed countries from assessing their fisheries with precision or accuracy. Conventional stock assessment approaches focus on the biological outcomes for single species and on the odd occasion ecological or economic issues. They do not, therefore, address adequately the question of sustainability.

The notion of sustainability is hotly debated amongst the community and there is no single agreed definition of what sustainability means (Buckingham-Hatfield and Evans 1996). There is some common ground in its meaning in that it is a multidisciplinary concept and therefore must include social and economic dimensions (Buckingham-Hatfield and Evans 1996). This debate is also found in fisheries management. Indeed, in assessing fisheries management regimes the ecological, social and economic consequences as well as technological and ethical outcomes need to be considered (McGoodwin 1990). The challenge for fisheries managers will be to assess the sustainability of fisheries using multidisciplinary approaches that integrate these diverse topics. RAPFISH is one such technique. It is a new multi-disciplinary rapid appraisal technique based on multivariate statistics that can be used to assess the sustainability of fisheries (Figure 1).

The Rapfish Technique

The RAPFISH technique uses simple, easily scored attributes from a range of disciplines to provide a rapid and cost effective appraisal of the sustainability of fisheries (Pitcher et al. 1998a) and compliance with the FAO Code of Conduct. The attributes are defined to reflect uncorrelated and discrete aspects of sustainability. The technique also provides managers with a considerable flexibility in defining fisheries, from a broadly defined geographically based fishery (e.g. North Sea Herring

Fishery 1990) to a fishery defined by its geographic range, target species, vessel type, and gear (e.g. Gulf of Maine Herring Sail Trawl Fishery 1890s). Fisheries should be defined at a scale such that impacts of changes in management or fishing practices can be identified. The inherent flexibility of the technique allows sets of fisheries or individual fisheries to be compared, or the trends of individual fisheries through time may be analysed (Pitcher 1999). Note that attributes should be fixed if cross-analysis comparisons are to be made.

The technique is based on a statistical ordination engine. The most appropriate method found to date is multidimensional scaling (MDS), a multivariate ordination method. MDS is used to construct a 'map' showing the relationships between a number of objects based on a table of distances between the objects (Manly 1994). The map can be in one or more dimensions, however, dimensions greater than three are difficult to visually represent and to interpret. In the case of RAPFISH, the individual fisheries are the objects, and their relative positions are based on the attribute scores from the various disciplines. A common set of attributes are scored for each fishery using a scale and for each attribute that is consistent among the different fisheries. Where a fishery is located on the map is only indicative of its relative sustainability compared to other fisheries analysed. Thus, there is a need that the attributes are representative of the objective of sustainability. In addition to the MDS algorithm that is used to place the fishery on the map, the attributes and the relevant scores are another key feature of RAPFISH and are discussed below.

Appendix 1 provides a full account of the choice of MDS as the statistical ordination engine for RAPFISH ordinations together with a discussion of methods of addressing uncertainty and the sensitivity of individual attributes.

Applying MDS in RAPFISH

The RAPFISH method used to assess the sustainability of a group of fisheries is outlined in Figures 1 and 2. The initial steps of defining the attributes and scores, identifying and scoring the fisheries are detailed in Pitcher (1999). These steps are summarised below.

Defining the Fisheries

In a RAPFISH analysis there is considerable flexibility in defining the fisheries. The definition can be based on a range of criteria including spatial, temporal, technological, anthropological and political measures. The choice of criteria applied to the fisheries do not affect the results, provided that roughly the same criteria are chosen for the fisheries to be compared and that each fishery is independent of the others. There is also scope within the RAPFISH technique for a hierarchical analysis since scores from groups of fisheries from a statistical region, ecosystem, gear type, or vessel type can be collapsed (Pitcher 1999).

Once the fisheries are scored, four 'reference fisheries' are constructed to act as anchor points for each evaluation field. One represents the ideal (or 'good') fishery, in which all attributes are scored in line with maximising sustainability characteristics

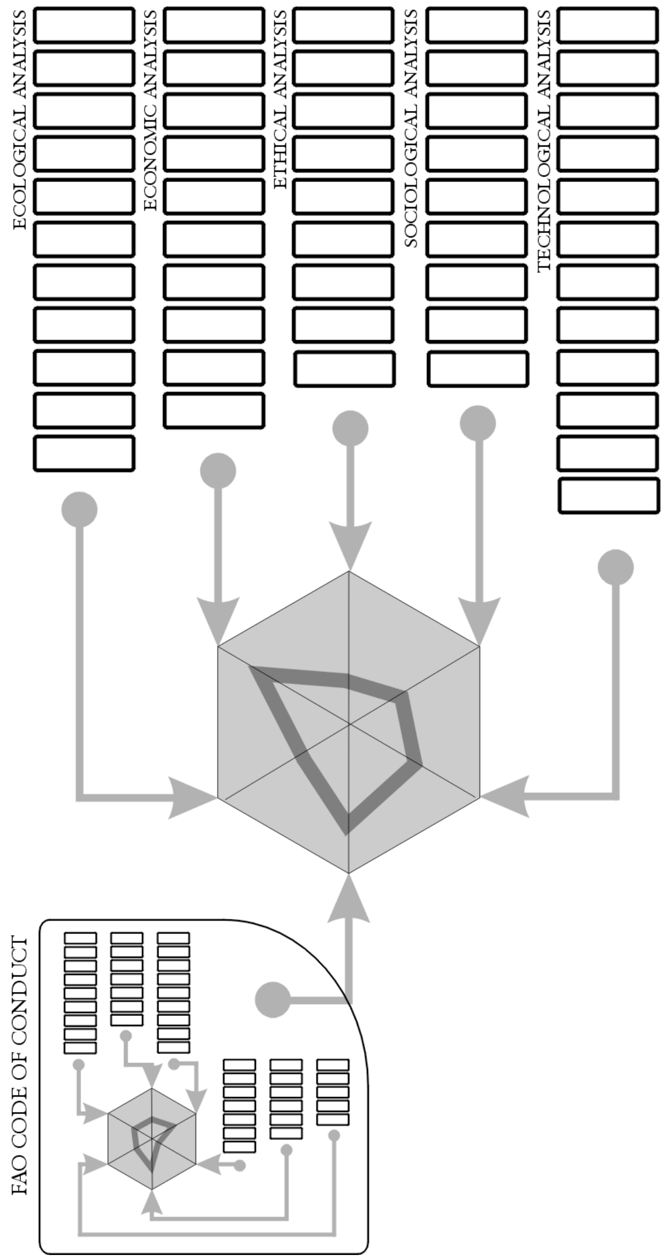

Figure 2. The RAPFISH procedure using a multidisciplinary kite to express sustainability. Boxes represent the attributes used to ordinate fisheries in each evaluation field. Kite apices represent a score between 0% = 'bad' (kite centre) and 100% = 'good' (the outer rim) from each field. Six evaluation fields are illustrated here, one of which, for the Code of Conduct, is comprised hierarchically of a five-field RAPFISH.

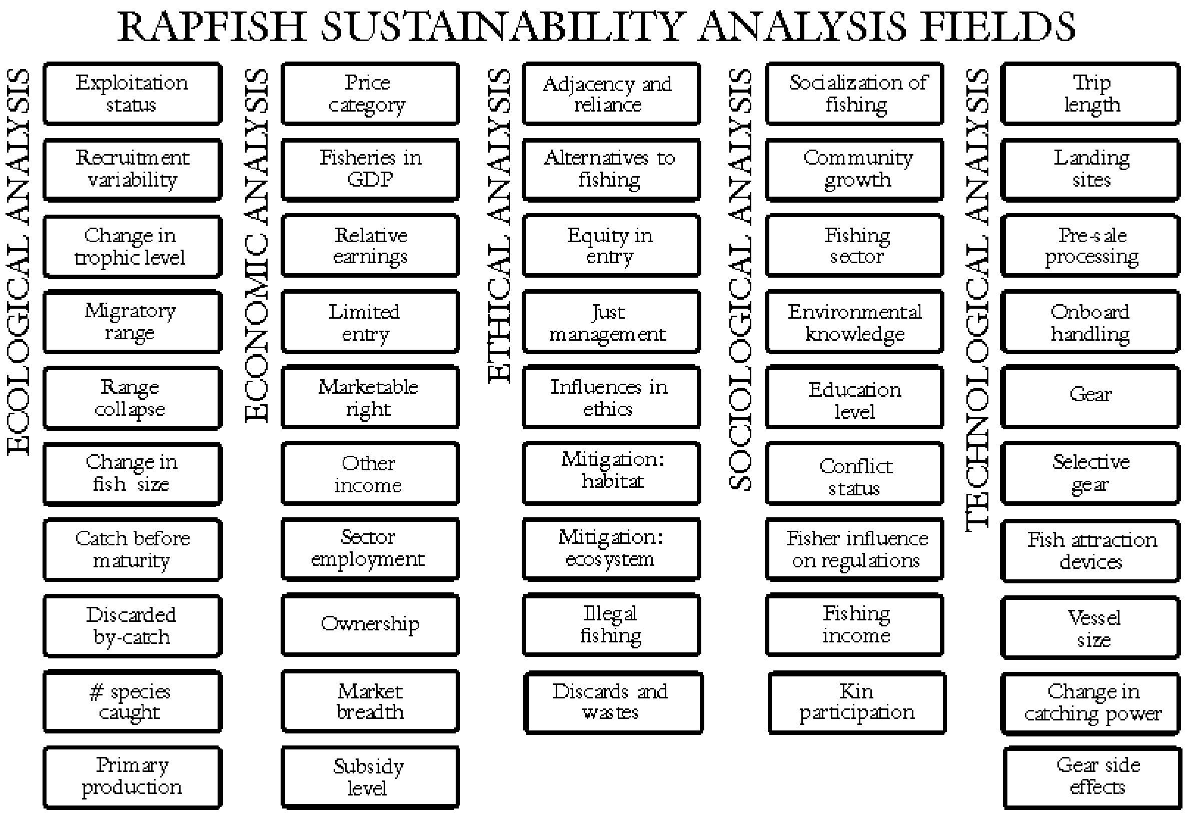

Figure 3. Showing the attributes within the five evaluation fields for assessing sustainability using the RAPFISH technique (attributes sets as of May 2000).

within each discipline. Another fishery representing a modelled 'bad' case is created in which all the attributes are scored as a worst-case scenario. These two extremes provide reference points with which to compare the sustainability scores of other fisheries. The other two anchor 'fisheries' are fixed reference points constructed from two halfway scores, these fisheries stabilising the vertical dimension of the plot against flipping (see Pitcher 1999 and Appendix 1). The addition of these points constrains the ordination so that points in the ordination can be compared to known good and bad points. Further research is under way to define a set of hypothesized points throughout the ordination so that comparisons can be made between analyses containing the same hypothesized points.

Random fisheries may also be added to increase the number of cases if the input data is small, i.e., if the number of fisheries is less than four times the number of attributes. These random fisheries help to avoid degenerate solutions. Many statistical packages can be used to generate fisheries scores (normalised) using a normal distribution with mean = 0 and standard deviation = 1. Constraints on the number of cases analysed in the MDS limit the total number of fisheries that can be analysed by SPSS to approximately 100; similar constraints apply to statistical packages. Further analysis, such as Monte Carlo simulations and sensitivity analysis, however, do not include these random fisheries. It is hoped eventually to replace these random fisheries with fixed anchor points to reduce flipping and improve the ability to overlay subsequent analyses. A regular grid of anchor points is envisaged (see Appendix 1).

Defining and Scoring Attributes

Work by Pitcher and Preikshot (2000) and others provides a well-developed set of sustainability attributes to assess a fishery with respect to its ecological, technological, social, economic and ethical characteristics (Figure 3). The individual attributes have been established through an iterative process with experts over the last three years. Attributes were also selected because they best measure and discriminate the objective of sustainability within an evaluation field. Pitcher (1999) using simulated fisheries and Preikshot (2000) using cluster analysis verified that the attributes used are reflecting the notion of sustainability. Sets of attributes have been added recently to encompass compliance with the FAO Code of Conduct (Pitcher 1999). These two sets of attributes are used in the *Sea Around Us Project* (SAUP) so that comparisons can be made between countries and fisheries. All attributes may not meet all situations outside of the SAUP resulting in the need for minor modifications and to ensure that attributes cover those aspects of the system that the stakeholders perceive to be important. Changes can be made without compromising the rigor of the technique, however, changes must be carefully

Table 1: An example of an input matrix of fisheries scores for ecological attributes. Labels in column 1 are codes used to refer to fisheries in one of the analyses.

	Ecological Attributes							
Fishery	Exploit	Recruit-ment	Catch	Trophic Change	Primary Product	By-Catch	Gear	Environ. Impacts
GoM_L89	0	2	5	3	2	4	3	0
GoM_S12	2	1	3	1	0	4	2	3
GoM_P56								

considered because experience has shown that defining attributes to reflect sustainability is not easy. If a number of changes are necessary it may be more appropriate to create a new evaluation field that suits users' specific needs.

If changes are necessary, they should be made in light of need to maintain the following attribute properties.

- Attributes within each set reflect the notion of sustainability, with sustainability meaning that the resource and its fishery can continue beyond the short term;
- The attributes are chosen for their ease of scoring and objectivity, including assigning 'good' and 'bad' to the extreme values in relation to sustainability for each attribute;
- The attributes are available to all fisheries through all time periods in the analysis (Pitcher 1999); and
- A number of attributes are used so that the discriminating power of the ordination method in MDS is maximised with three times as many fisheries as attributes used to ordinate them (Kruskal and Wish 1978; Stalans 1995).

The current list of attributes and their corresponding scores are shown in Appendix 2 (and an up-to-date list is maintained at www.fisheries.ubc.ca)

MDS Analysis – scoring attributes

The application of MDS in RAPFISH assists fisheries managers to evaluate the sustainability of fisheries past and present and to make comparisons between different types of fisheries as well as assessing national compliance with the FAO Code of Conduct. These differences or comparisons can be measured as distances between various fisheries in a multidimensional space that is defined by a range of attributes scored on an interval scale. As set out in Appendix 1, MDS is an appropriate multivariate method to evaluate these distances. Other multivariate methods, such as Cluster Analysis, Factor Analysis, Principle Components Analysis, Correspondence Analysis, are available but are not as appropriate as MDS in assessing fisheries sustainability, as discussed in Appendix 1.

In the RAPFISH analysis, each fishery is scored on several attributes, the scores generally range between 0 and 5. The result is a rectangular matrix with I rows representing fisheries and J columns representing the attribute scores (Table 1). The data within the matrix is interval since the extremes of the scoring scale represent good and bad. The scores vary with attributes having maximum values between 3 and 5. The scores need to be normalised to minimise the stress (Davison 1983) and to ensure that the assumption of monotonicity is not compromised (Pitcher and Preikshot 2000). This assumption was validated in RAPFISH by Pitcher (1999) when normalised scores are used with squared Euclidean distances in a metric MDS analysis.

One approach to standardising the scores is to convert them to normalised (Z) values:

$$Z = (x - \mu)/\sigma \qquad \text{...1)}$$

However, at this stage the normalised data do not express the distances between the fisheries. The squared Euclidean distances can be calculated using standard computer programs such as PROXIMITY in SPSS and DIST in SPLUS2000. The resulting distance matrix is used as input into the MDS analysis. Programs such as ALSCAL (Yound and Lewyckyj (1979) as cited in Manly 1994) and KYST (Kruskal, Young and Seery (1973) as cited in Carroll and Arabie (1998)) iteratively search for the best fit of the points in the specified dimension. These programs generally require additional parameters that specify whether the analysis is conditional or not, the scaling model (e.g. ASCAL an asymmetric Euclidean distance model), the data type, the number of iterations, the convergence and minimum stress levels, and minimum and maximum number of dimensions in the solution. The corresponding output can provide plots of the coordinates, matrix weights and coordinate weights, as well as a matrix of the coordinates of the points. The resulting dimensions are rotated and re-scaled for ease of interpretation.

Table 2. Example of a Monte Carlo data matrix.

	Dimension One				Dimension Two			
MC1 RUN	X1	X2	X3......	X_I	Y1	Y2	Y3......	Y_I
1								
2								
...								
50								

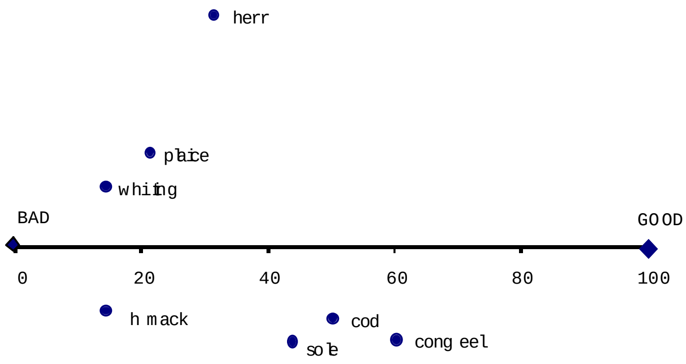

Figure 4. An example of the rotation to ensure the 'bad – good' axis is horizontal. Labels refer to fisheries in one of the analyses.

MDS Analysis – Rotation

The first dimension is rotated so that it is horizontal with the good (90°) and bad fisheries (270°) at either end of the axis. The first dimension can be re-scaled to percent with 0% as bad and 100% as good, so that the relative position of the fisheries can be assessed (Figure 4). Although the first axis is expressed as percent, calculating the % differences between points from two different ordination analysis is not valid because at this time the good and bad points are not necessarily the same points in the two analyses. The development of hypothesised reference points that would allow for comparing points from different ordination analysis (but with the same hypothesised points) to be compared is currently underway. established

MDS Analysis – computer package

RAPFISH currently uses the statistical package SPSS that contains the ALSCAL program. The SPPS package is used because:

- it handles a range of data types and MDS models including metric and nonmetric through the ALSCAL program;
- in two dimensions, ALSCAL is stable and meets most of the assumptions for MDS;
- widely available – most research institutions have access to the package;
- handles missing values;
- allows ties; and
- has a command language that can be used for complementary analysis.

MDS programs can be found in statistical packages such as SAS and SYSTAT, however, many are not as flexible in handling missing values or ties (Young and Hammer 1987).

The SPSS the programs PROXIMITY and ALSCAL are combined into one SPSS procedure (BatchRap) in the Rapfish analysis. The raw data are normalised prior to input into the PROXIMITY program. The PROXIMITY routine is only used to calculate the matrix of the Squared Euclidean distances as input into ALSCAL. The options selected in ALSCAL include using an Euclidean Model and setting the limits for convergences, stress and number of iterations, as well as specifying the number of dimension in the solution. The SPSS output provides the iteration history, the stress value, squared correlation coefficient, the coordinates

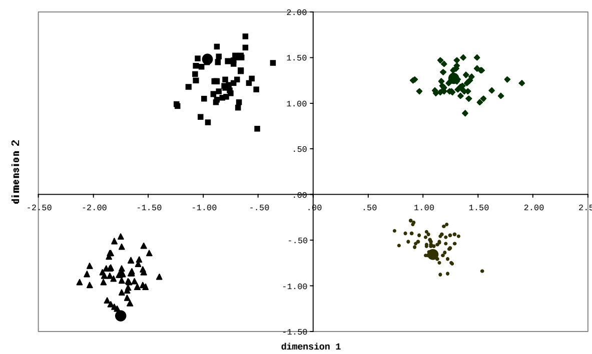

Figure 5. Distribution of points generated by Monte Carlo simulation for four different fisheries (the large dot represents the original point).

in two dimensions and plots of un-rotated and rotated fisheries (Appendix 3). The program also writes the information to files so that dimensions can be re-scaled (e.g. expressing the first dimension, sustainability, as a percent) or used for further analysis (e.g. Monte Carlo simulations or sensitivity analysis).

The ALSCAL program can not be used to derive parametric variables directly and therefore the confidence limits of the estimates can not be estimated. Monte Carlo simulations, however, are used in the SPSS analysis. The Monte Carlo procedure (MC1) perturbs each normalised fisheries score for each attribute by a random amount selected from a Gaussian distribution with mean

Table 3. Example of a sensitivity analysis data matrix.
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	Dimension One				Dimension Two			
Attribute Removed	**X1**	**X2**	**X3 ....**	**X_I**	**Y1**	**Y2**	**Y3 ....**	**Y_I**
1								
2								
...								
J								

equal to zero and variance equal to 1. These perturbed values are used to estimate the distance matrix and undertake the MDS analysis. A minimum of 50 simulations are run producing a 50 x (2xI) (I = the number of fisheries) matrix of coordinates (Table 2). Examination of the points indicates that they are not normally distributed about the mean (Figure 5); consequently the median values are plotted with their 95% confidence intervals. The distribution of the MC points is influenced by the ALSCAL program that "scales the configuration so that the average coordinate is zero in all dimensions and the sum of the squared coordinates is equal to the number of objects multiplied by the number of dimensions" (Manly 1994, p. 175). The use of jackknife and bootstrap methods to estimate confidence intervals may be possible, but requires further investigation at this stage.

A jackknife procedure (MC3) can be used in RAPFISH to investigate the sensitivity of the attributes. The jackknife method is used to generate the MDS analysis using J-1 attributes for each analysis. The procedure generates a J x (2xI) matrix (Table 3) which is used to explore the sensitivity of the analysis to specific attributes. The standard error of the squared differences between the original points and the re-sampled points can be used to compare attributes (Pitcher 1999).

Presentation of RAPFISH results

In general we have five ways of presenting the results of RAPFISH ordinations (Pitcher 1999). First, two dimensional ordination plots (as in Figure 6 below) provide the most detailed information; other presentations lose the information about the vertical position in the ordination representing differences that are not related to sustainability (or compliance with the FAO Code of Conduct). Secondly, RAPFISH scores along the 'bad' to 'good' axis may be compared using bar charts. Bar charts swung vertically and drawn to the left and right of a vertical line enables comparison between two sets of fisheries.

Thirdly, time trajectories used to assess changes in sustainability graph RAPFISH scores against time. Fourthly, rank orders may replace actual RAPFISH scores, and attention may be drawn to fisheries falling into the upper and lower quartiles, so that rank orders in different RAPFISH evaluation fields may be compared.

Finally, a convenient way to represent scores on the different axes of sustainability is a polygonal kite diagram (e.g. Figure 8). Each axis represents one RAPFISH evaluation field. For each of the axes, a score of zero (0%) lies at the centre and a score of 100% lies on the rim of the polygon. For two- or three-way comparisons, the kite provides a simple visual representation, but more complex simultaneous comparisons produce muddled pictures. Figure 8 illustrates how scores from six fields go to make up the points of a kite. Comparison made with the kite may be of individual fisheries, or gear types, or large- and small-scale sectors, or fisheries for a certain species, or date. Kite diagrams can be used to present a hierarchy of RAPFISH analyses, as described later.

CASE STUDIES

Three case studies, the Gulf of Maine Fisheries, the German Fisheries and the United Kingdom Commercial fisheries were subjected to a multidisciplinary RAPFISH analysis. Only the present day fisheries were scored for compliance with the FAO Code of Conduct for Responsible Fishing, since most of the fisheries predate the introduction of the Code. These three case studies include historical fisheries as well as present fisheries to demonstrate the range of Rapfish applications. Details of the historical development of these fisheries are outlined in Appendices 4, 6, 8 and 10 and details the scores and the MDS results are listed in Appendices 7, 9 and 11. A fourth case study of the East Coast of Canada previously analysed by Melanie Power, Tony Pitcher Mary Gregory (*in prep*) was included in this report to provide for a comparison of present fisheries on both sides of the Atlantic.

(A) GULF OF MAINE FISHERIES

Fifteen defined fisheries from the Gulf of Maine (Appendix 4), including three with historical time series that span almost the entire period of European colonisation were analysed to investigate uncertainty and the sensitivity of attributes. Monte Carlo simulation examined the influence of uncertainty in attribute scoring, and jacknife resampling determined the relative influence of individual attributes.

Table 4. Stress and RSQ values for the Gulf of Maine RAPFISH ordinations, and Monte Carlo and sensitivity analysis over the five evaluation fields.

	Original Analysis		Monte Carlo		SensitivityAnalysis	
Evaluation Field	STRESS1	RSQ	STRESS1	RSQ	STRESS1	RSQ
Ecology	0.284	0.722	0.276 - 0.290	0.708 - 0.736	0.263 - 0.286	0.657 - 0.774
Economics	0.272	0.743	0.297 - 0.279	0.726 - 0.744	0.262 - 0.279	0.551 - 0.775
Social	0.281	0.671	0.273 - 0.293	0.640 - 0.686	0.265 - 0.294	0.647 - 0.706
Technological	0.277	0.656	0.272 - 0.285	0.633 - 0.670	0.269 - 0.294	0.624 - 0.686
Ethical	0.273	0.728	0.270 - 0.281	0.728 - 0.732	0.267 - 0.281	0.755 - 0.738

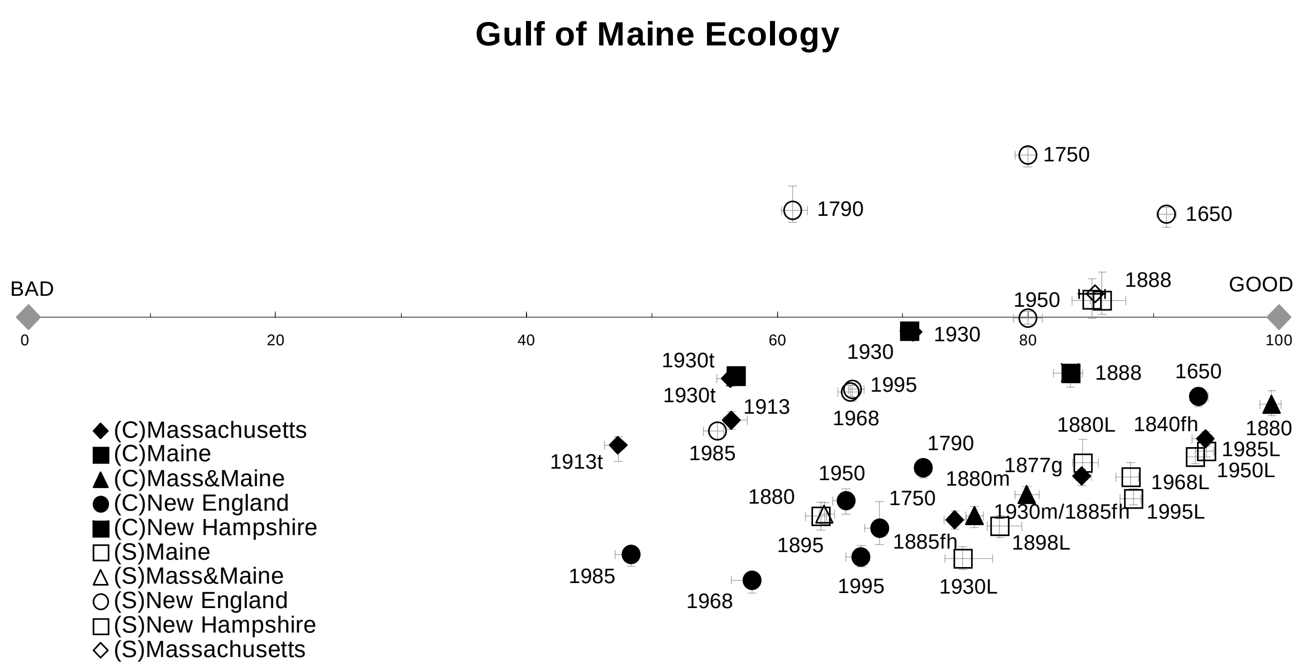
RAPFISH Analysis

The Gulf of Maine fisheries were coded (Appendix 6) and analysed (Appendix 7) for the five evaluation fields of ecology, economics, social, technological and ethical as defined in Pitcher (1999). RAPFISH ordination with Monte Carlo error simulations and sensitivity analysis as described above were used to explore the uncertainty associated with the scores.

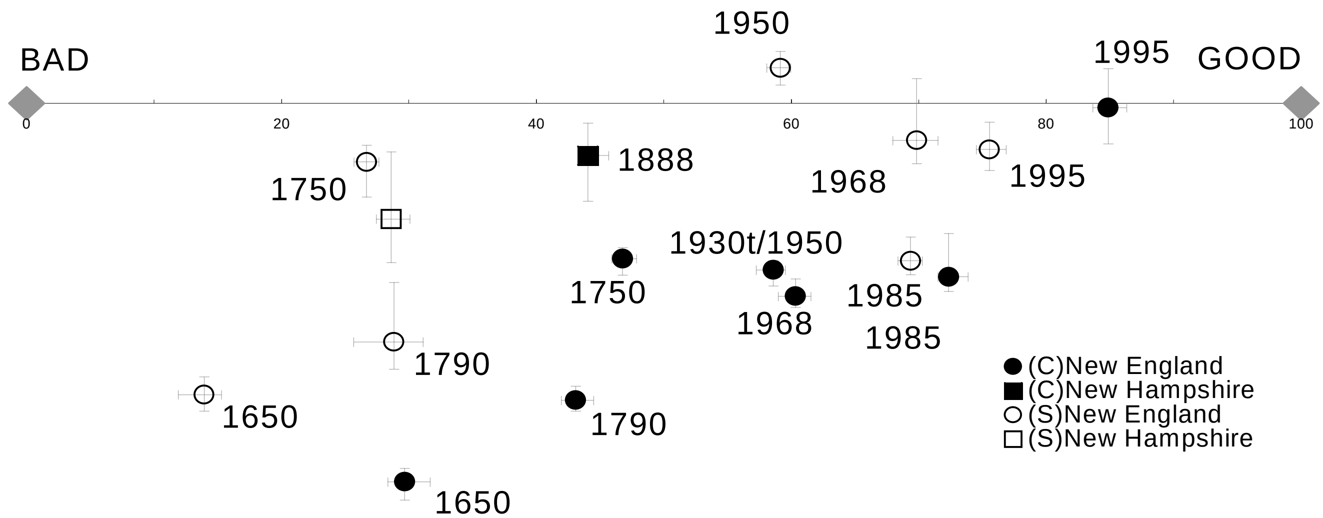
Two-D Rapfish ordination plots were constructed for all five evaluation fields. The scores in two dimensions were obtained within four iterations for all attribute sets. The initial STRESS1 values of all attribute sets ranged between 0.272 and 0.284 (Table 4). Although these stress values are high by statistical standards, they are considered acceptable given the high degree of measurement or sampling (scoring) error associated with the case study. Furthermore, the RSQ values that measure the proportion of variance of the disparities in the data that is accounted for by the corresponding distance, range between 0.734 and 0.656; these are considered acceptable values. In addition, Monte Carlo simulations (50 runs) and sensitivity analysis were also conducted to explore the uncertainty of this analysis.

The median values of the scores generated in the Monte Carlo runs and their 95% confidence intervals were plotted to explore the uncertainty of the results (Figure 6). The 95% confidence intervals are small and generally within 5% of the median sustainability scores with the exception of economic attributes where the limit exceeded 5% for one fishery. The confidence intervals in the second dimension, however, are much higher as expected since the second dimension accounts for the non-sustainability information in fisheries. Because the variation is small in the sustainability scores the separation of some fisheries is clearly evident as is the clustering of similar scores.
The 2-D RAPFISH ordination plots (Figure 6) clearly indicate that sustainability scores of the fisheries vary significantly through time and between the fisheries for all evaluation fields (Figure 6). The analysis has shown that historical fisheries as far back as the 1650s were not necessarily sustainable and that some modern day fisheries are indeed more sustainable than in the past, while others have become less sustainable than their historical counterparts. A plot of the 95 confidence intervals of the median values for the 38 fisheries (Figure 6a) makes interpretation of the plot difficult and therefore in such cases subsets (Figures 6b to 6e) can be plotted making interpretation easier and analysis of trends easier.

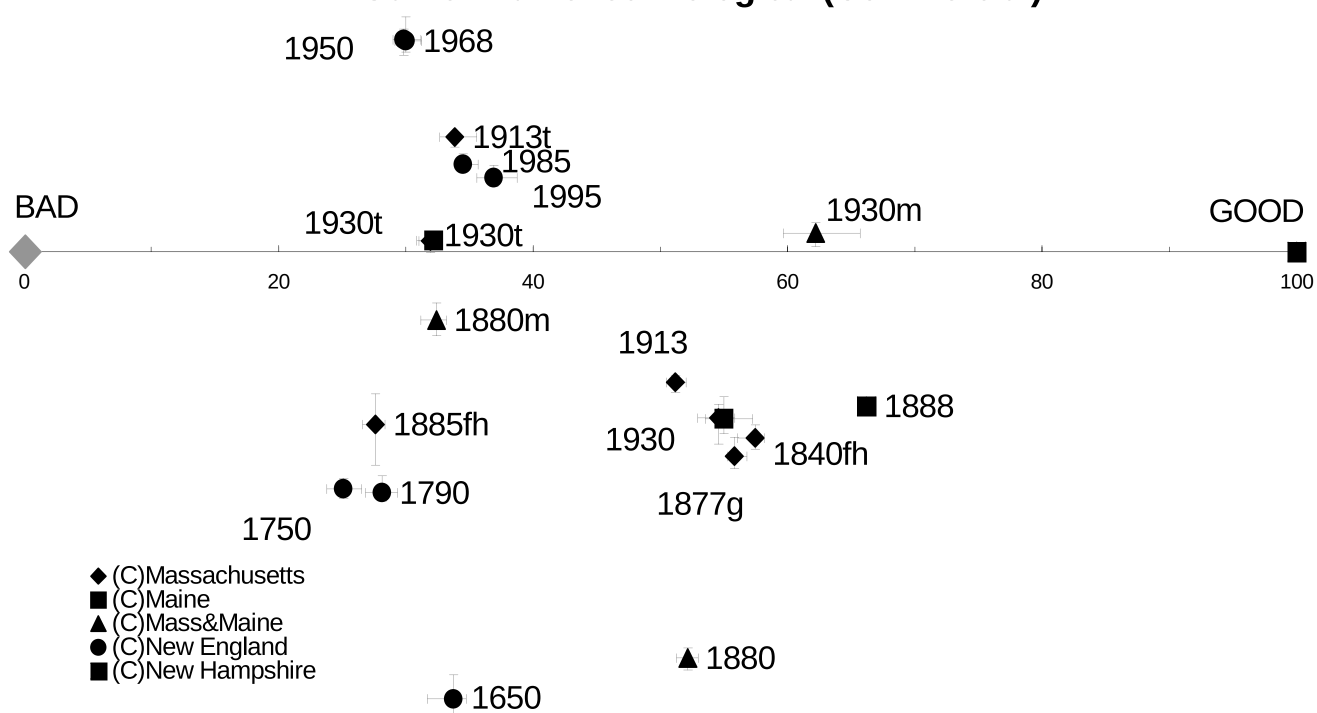
The standard error of the sustainability scores when a single attribute was omitted from the analysis was used to explore the importance of attributes to the analysis. As in other RAPFISH studies (Pitcher 1999; Pitcher and Preikshot 2000), the standard error was less that 14% for any single attribute (Figure 7). The highest standard error (14%) occurred when ownership within the fishery was omitted. This is because the attribute ownership separated out only four fisheries: the 1650 fisheries were foreign owned and two trawl fisheries were joint venture operations, while the remaining fisheries were owned locally. The standard error when the number of species caught was eliminated is also high (12%) due to the division of the fisheries into the small scale sector catching many species and the commercial sector catching only a few species. Similarly, 12% standard error when fishing income is dropped is due to a separation of income based on whether it is a small-scale inshore fishery or larger commercial offshore fishery.

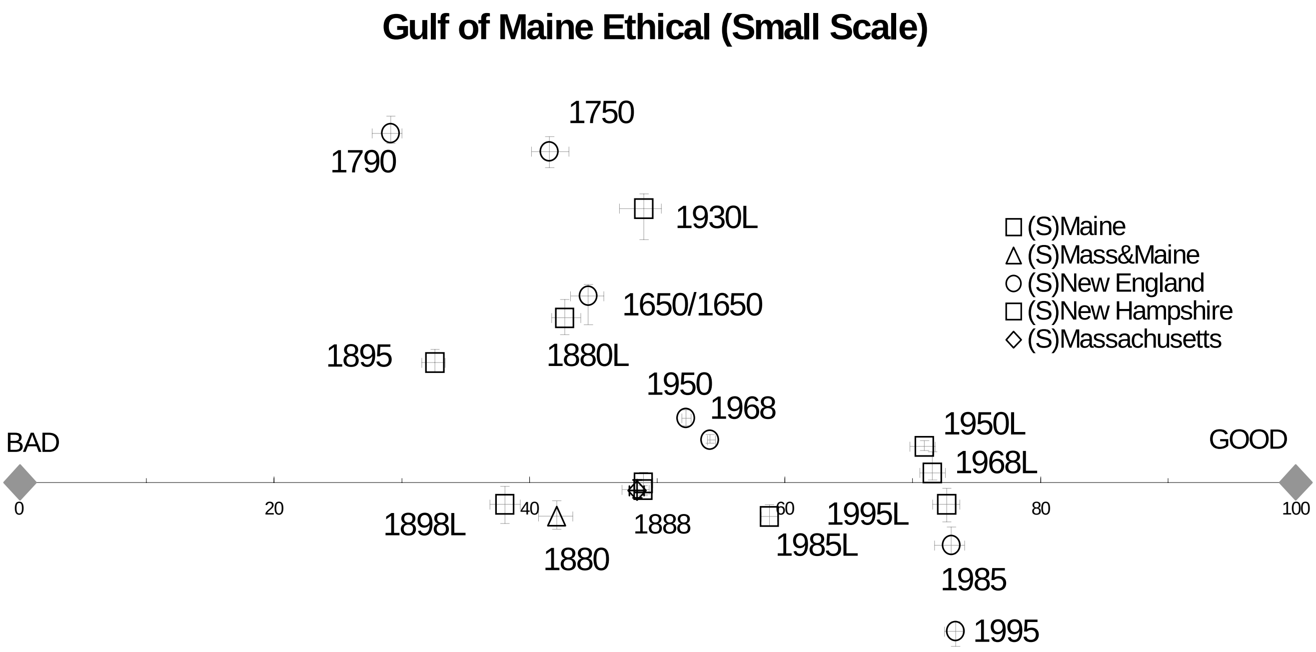


Gulf of Maine Social



Gulf of MaineTechnological (Commercial)





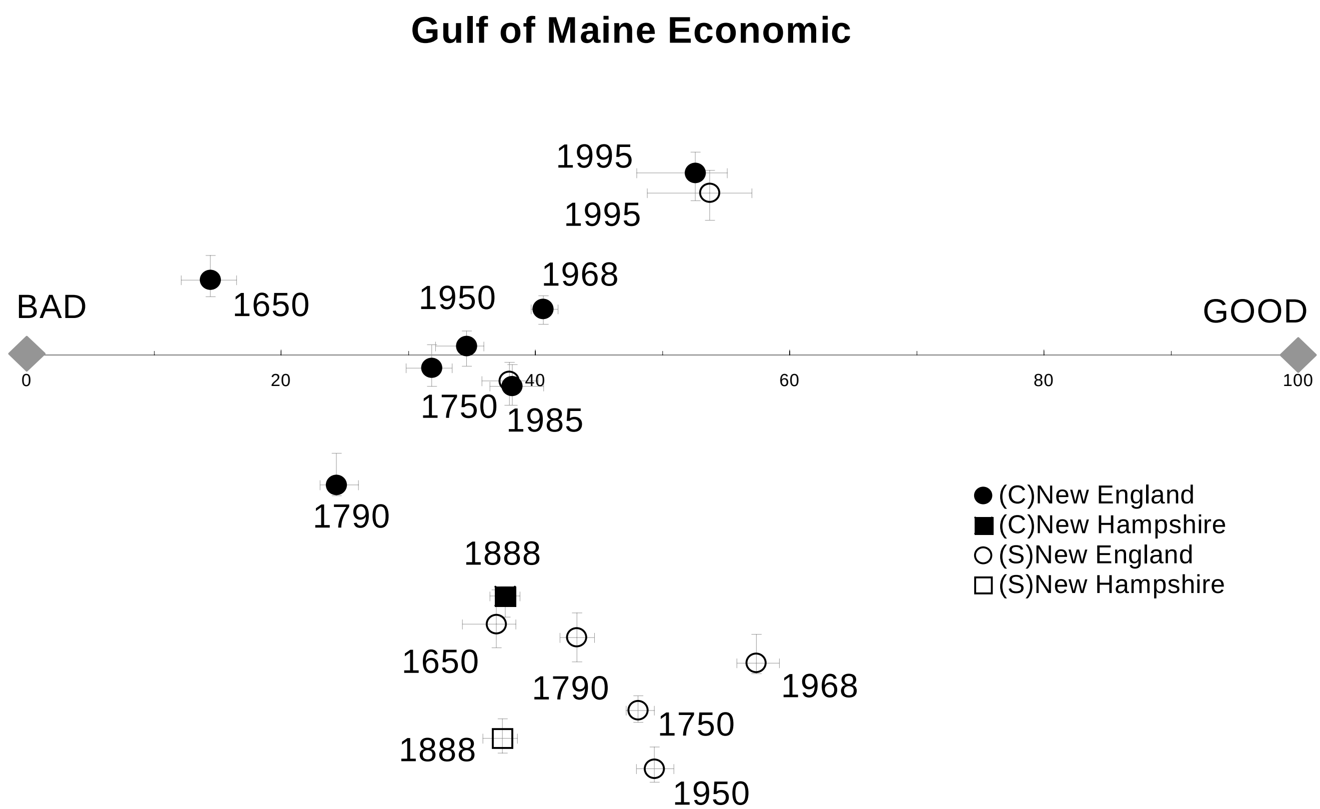


Figure 6. Two-dimensional RAPFISH ordinations, in five labelled evaluation fields, of the Gulf of Maine fisheries listed in Table 5. Symbols represent fisheries and numbers show time periods. Bars indicate upper and lower 95% confidence intervals for median values from 50 Monte Carlo simulations. Note that only the ecological plot contains the full 38 fisheries, the other four are subsets of the full fisheries

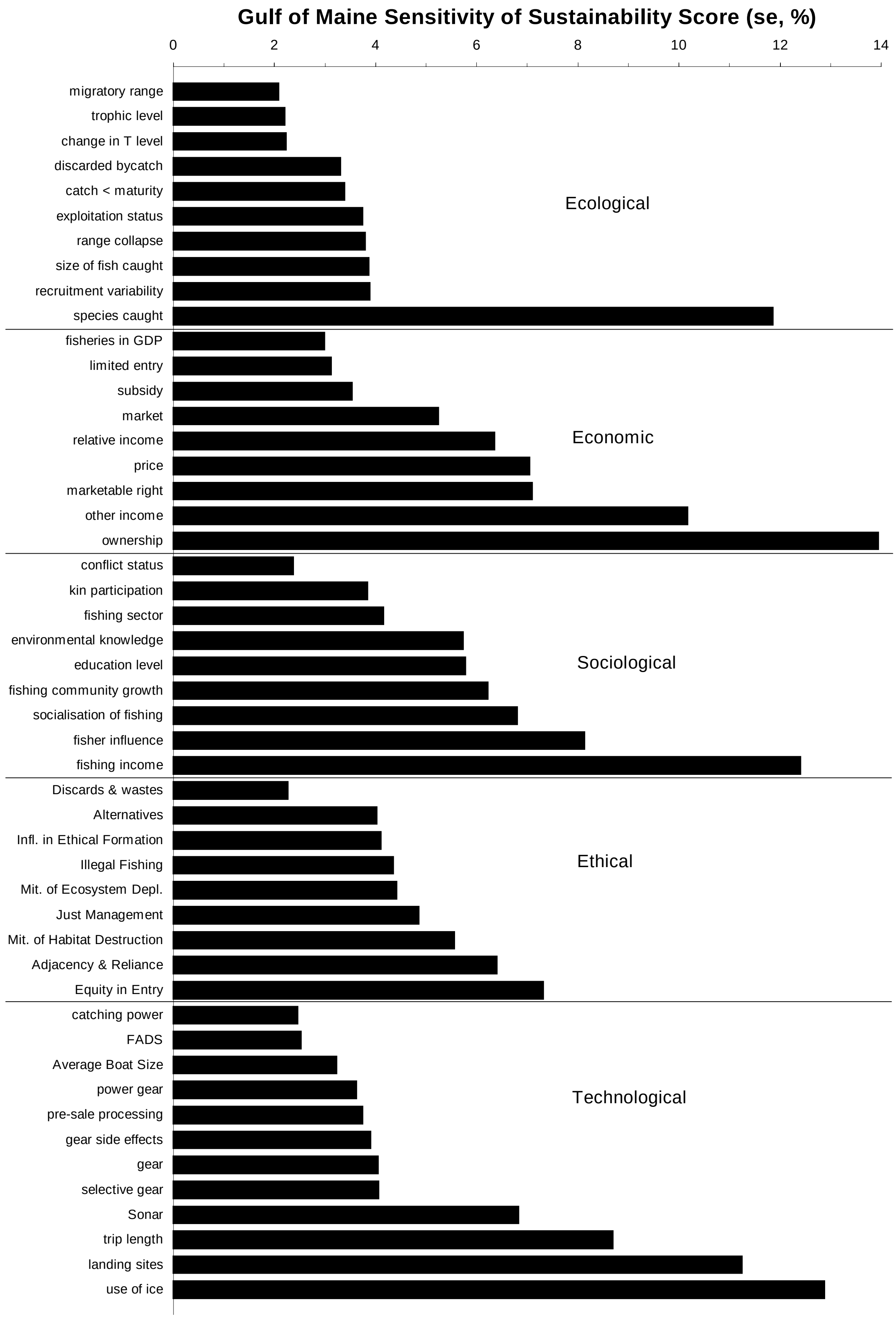


Figure 7. Gulf of Maine fisheries. Leverage (percentage influence on median) of individual attributes for five evaluation fields calculated from sensitivity analysis described in the text.

(B) East-West Analysis of North Atlantic Fisheries

The scores twelve previously defined fisheries from the present day from the Gulf of Maine, the United Kingdom and Germany and the scores of 19 fisheries from a Canadian study (Melanie Power, et al, *in prep.*) were combined to illustrate how Rapfish can be used to compare fisheries on both sides of the North Atlantic. These studies provided 22 fisheries on the west side and 9 fisheries on the east side of the Atlantic. This analysis is only for illustrative purposes since a) the above two cases studies and the Canadian East Coast study did not use identical attributes in all evaluation field and b) only four nations are included in the study and therefore the results are not necessarily representative of the entire area especially for the United States where only three fisheries from the Gulf of Maine are included in the analysis. Nevertheless there is sufficient information to illustrate the capabilities of Rapfish to undertake a more complete study of North Atlantic fisheries as part of the *Sea Around Us* Project.

This case study is divided into a general comparison of the evaluation fields for the four fisheries, followed by an analysis of compliance with the FAO Code of Conduct for Responsible Fisheries.

General Comparison

Scores in the five Rapfish evaluation fields (ecology, economic, social, technical and ethical) were combined with an overall Code of Conduct for Responsible Fisheries for the above case studies to examine differences in scores between fisheries on either side of the North Atlantic and differences between nations.

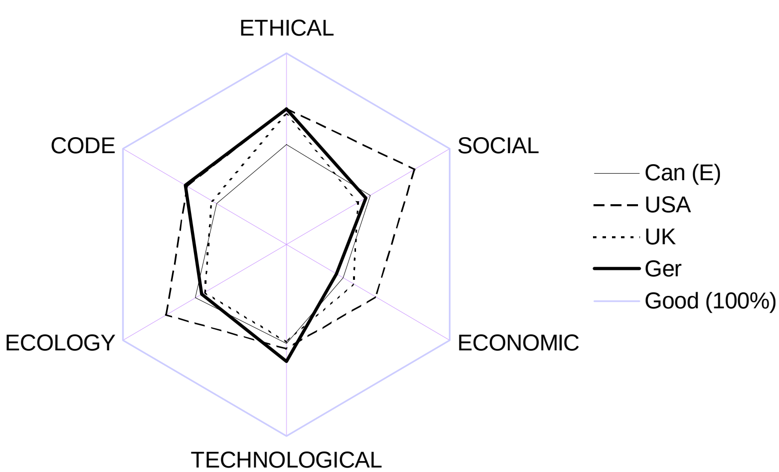


Figure 8. Multidisciplinary kite diagram expressing the North Atlantic Fisheries sustainability scores by country. The outer rim represents 100% = (good).

The kite (Figure 8) which expresses the average scores for the four nations studied shows the sustainability scores are highly variable between nations and evaluation fields. The USA (Gulf of Maine) had the highest average scores in 4 of the 6 evaluation fields. This result, however, represents only three fisheries from the Gulf of Maine. There were few differences between the average scores for technological sustainability that ranged between 50% and 60%. The average social sustainability score for the Gulf of Maine fisheries was substantially higher than for other nations. Average ethical scores were often the highest for all nations. The difference between the average ethical scores for German and United Kingdom fisheries was less than 2%, however, the difference between average scores for Canada and the Gulf of Maine was 19%. Economic sustainability scores were lower than for most other evaluation fields and the average scores was particularly low for German fisheries (30%) but the average Canadian score was only 3% higher. The highest average ecological sustainability score was for the Gulf of Maine (73%), overall scores were above 50% for the other three nations. Average scores for the combined Code of Conduct varied between the four nations with German and Gulf of Maine fisheries having higher scores than Canada and the United Kingdom.

Ethical

A ranking table (Table 5) used to explore ethical sustainability and shows clear differences between east and west fisheries in the North Atlantic. In the upper quartile 5 of the 8 fisheries were from the east while in the lower quartile all fisheries were from the west. Ethical scores from the east were all above the 50 percentile. Also in the upper quartile fisheries with high ethical scores were also scored high for code compliance. Similarly, fisheries that scored low for code compliance were often the in the lower quartile for ethical sustainability. This strong link between ethical sustainability scores and code compliance is also reflected in a table of correlation coefficients (Table 6).

Table 5. Rank orders(1 = highest rank) of the North Atlantic fisheries in the economic sustainability ordination, alongside rank orders from other evaluation fields. W = west and E = east side of the Atlantic.

	Evaluation Fields						
RANK ORDER	Econ.	Eth.	Ecol.	Soc.	Tech.	*Code*	Atlantic
Bay of Fundy (W)	1	3	14	6	6	2	W
German demersal	2	21	31	11	2	4	E
Gulf of Maine inshore	3	9	5	3	22	14	W
German herring	4	13	20	12	5	3	E
Gulf of Maine lobster	5	2	1	5	3	1	W
German shrimp	6	11	17	22	13	9	E
UK plaice	7	29	13	25	16	16	E
UK haddock	8	19	8	24	17	13	E
UK herring	9	12	16	23	14	15	E
Gulf of Maine trawl	10	8	4	1	26	10	W
German Cod	11	22	22	19	15	5	E
German mussel	12	25	15	21	25	11	E
Cod longline	13	24	26	16	18	22	W
Cod handline	14	23	27	14	1	26	W
UK cod	15	20	12	17	19	17	E
Snow Crab 19	16	16	2	2	12	6	W
Scallop	17	17	9	10	27	29	W
Cod trap	18	27	25	20	4	25	W
Cod inshore	19	26	29	28	10	27	W
Lobster (Ding)	20	18	7	18	8	7	W
Lobster	21	15	10	9	7	8	W
Shrimp (ES)	22	1	3	13	28	31	W
Snow Crab	23	10	11	7	9	20	W
Bay of Fundy (S)	24	4	23	26	21	12	W
Mackerel (Din)	25	5	24	4	24	19	W
Capelin	26	14	21	8	23	21	W
Mackerel (At)	27	7	30	15	20	18	W
Shrimp (N)	28	6	6	27	31	30	W
Cod gillnet	29	28	28	29	11	28	W
Cod trawl	30	30	18	30	30	23	W
Cod offshore	31	31	19	31	29	24	W

Table 6. Correlations among rank orders of 31 North Atlantic fisheries analysed by Rapfish in six fields. Shaded cells are non significant at the 5% level. (Spearman non-parametric correlations).

Economic	0.41				
Social	0.57	0.36			
Technological	-0.06	-0.23	0.21		
Ethical	0.15	0.18	0.36	0.46	
Code	0.27	0.21	0.40	0.46	0.65
	Ecology	Economic	Social	Technological	Ethical

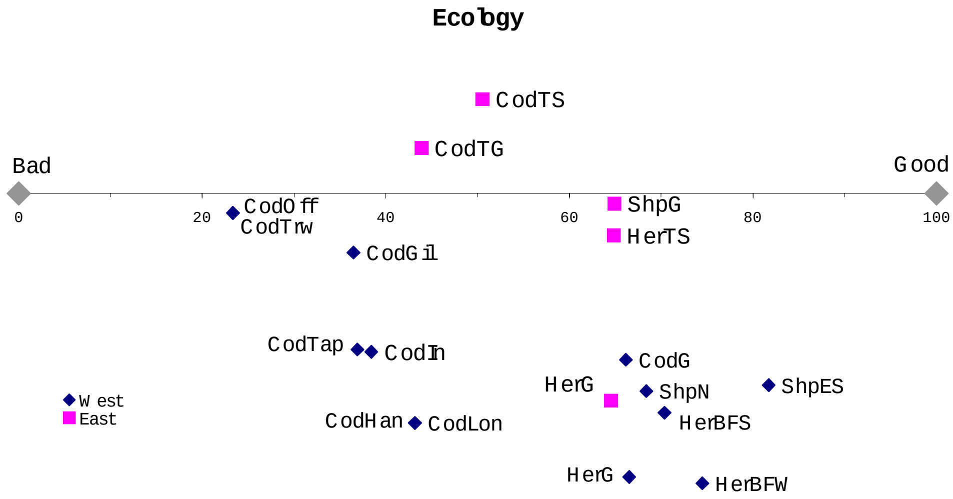


Figure 9: Two-dimensional ecological ordination of North Atlantic fisheries.

When the ranking table is resorted for economic sustainability west fisheries dominate both quartiles and most of the east fisheries are in the middle. The haddock fishery from the United Kingdom and the German demersal fisheries, however, scored in the

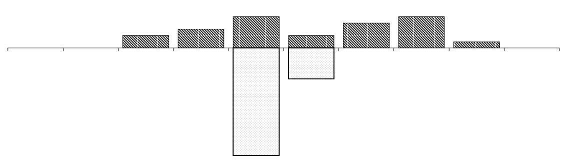


Figure 10. Frequency histogram of Rapfish social status scores for fisheries on the west (above the line) and east (below the line) side of the North Atlantic.

upper and lower quartiles respectively. The fisheries in the upper quartile are also often small scale and inshore whereas in the lower quartile the fisheries are either cod or other offshore fisheries.

Ecology

A subset of east and west fisheries was plotted on a 2-d ordination plot (Figure 9) to compare similar species. In this plot, all cod fisheries except one scored low for ecological sustainability compared to herring and shrimp fisheries. There is no difference between east and west cod fisheries, however, there may be an east-west difference for the other fisheries where ecological sustainability scores are higher for the west than the east fisheries.

Social

A frequency histogram (Figure 10) shows a wide spread of social sustainability scores along the usual 0% to 100% status axis for west fisheries (20% to 90%) while in the east the range is much less (40% to 60%).

Technological

A one dimensional ordination (Figure 11) of technological sustainability scores also shows a wider spread of scores for west fisheries compared to the east fisheries. When particular species are compared the cod fisheries in the United Kingdom and Germany have similar scores, but they are lower than most cod fisheries from the east. The east herring fisheries generally scored higher than the west fisheries. The trend was also evident when shrimp fishery scores were compared.

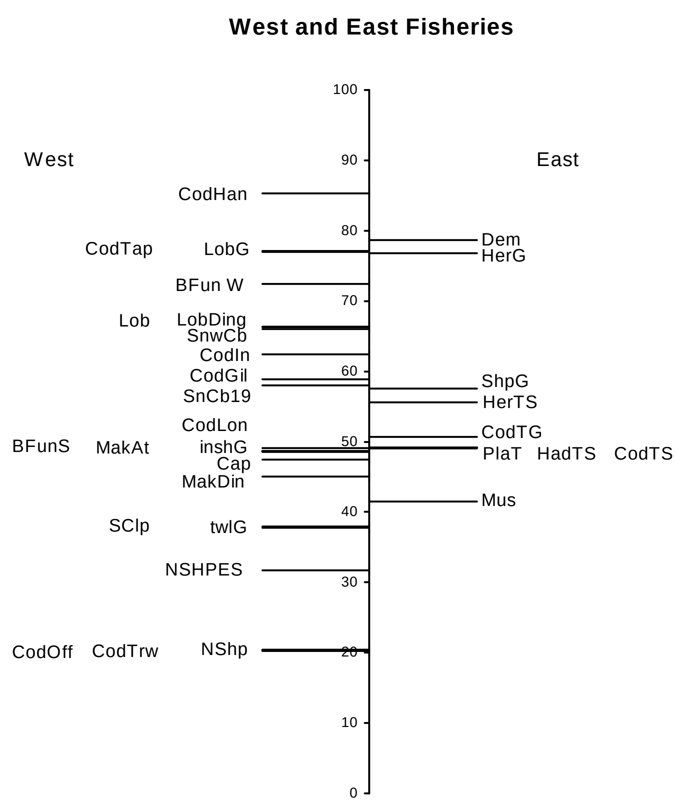


Figure 11. One dimensional ordination North Atlantic technological scores.

Compliance with the FAO Code of Conduct for Responsible Fisheries

RAPFISH Analysis

Twelve fisheries were coded (Appendix 9) and analysed (Appendix 10) for the six code of conduct evaluation fields (management objectives framework, precaution, monitoring-control-surveillance (MCS), social and economic, and stocks, fleets and gear) as defined by Pitcher (1999). Indigenous attributes were omitted from the analysis because they did not apply. The sample size of 12 is small and therefore the results presented here serve only to illustrate how the RAPFISH analysis can be used to evaluate compliance. A full analysis of North Atlantic Fisheries for compliance with the Code is proposed as part of the Sea Around Us Project.

The same RAPFISH method was used to undertake the MDS as in the previous case studies. The STRESS1 values (Table 7) were higher than in previous analysis and were anticipated because of the small number of fisheries used and the high degree of error in some of the scores.

The RSQ values, as expected, were lower than in the previous case studies. These results can be used to explore code compliance at the national and fishery level. When they are considered alongside results from a parallel analysis of Canadian East Coast Fisheries (Pitcher 1999) they provide an indication of their relative status.

Code of Conduct Evaluation Fields

General Comparison

The Canadian and German average scores are lower than the other nations especially for management objectives and framework (Figure 12). German and UK average compliance scores are higher than the others for stocks whereas in the Gulf of Maine average precaution scores are substantially higher. The average scores for MCS had the smallest range of only 10%.

Precaution

Table 8 lists the five highest and lowest ranking fisheries for compliance with the precautionary principle in the Code of Conduct.

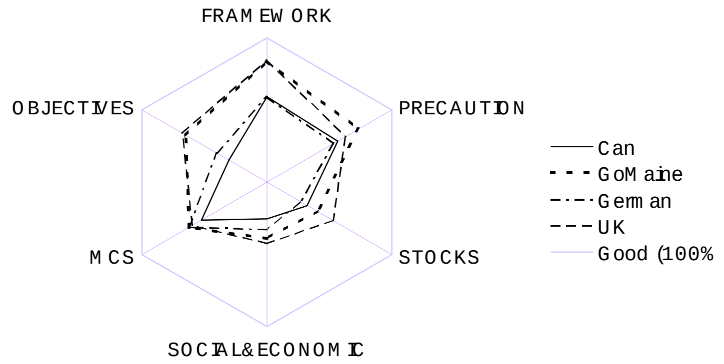


Figure 12. Kite diagram expressing the North Atlantic fisheries compliance scores by nation.

Table 7. The STRESS1 and RSQ values for the combined Gulf of Maine, German and United Kingdom RAPFISH ordination

Attributes	STRESS1	RSQ
Management Objectives	0.273	0.669
Framework	0.286	0.714
Precaution	0.295	0.660
MCS	0.297	0.695
Social & Economic	0.308	0.666
Stocks, Fleets & Gear	0.289	0.666

Stocks, Fleets and Gear

The scores for the stock, fleets and gear compliance for fisheries on either side of the North Atlantic are found along the entire length of the one-dimensional ordination axis (Figure 13). However, most of the fisheries are clustered in the lower half of the axis. As in previous analysis, the Canadian cod fisheries scores are low and for this compliance field the United Kingdom cod fishery compliance score falls with the range of Canadian scores. However, the score for the German cod fishery is well above the Canadian scores.

Framework

The top five fisheries for compliance with the framework code of conduct were mixed between the east and west side of the Atlantic, but German fisheries were the only European fisheries to rank in the top five. The bottom five fisheries were Canadian cod irrespective of the gear type (Table 9).

Management Objectives

When the scores for compliance with management objectives are ranked (Table 10) all five German fisheries are in the top quartile. The Gulf of Maine lobster fishery was the top ranked fishery and the Bay of Fundy weir fishery was the only Canadian fishery with a score in the top quartile. West fisheries, both inshore and offshore, dominated the lower quartile irrespective of the species. As expected, fisheries that ranked high for management objectives often scored high for other compliance evaluation fields.

Table 8 Rank orders of the top and bottom five North Atlantic fisheries in the precautionary compliance ordination, alongside rank orders from other evaluation fields. W = west, E = east side of the Atlantic, C = Canada, E= United Kingdom, G=Germany and U = United States (Gulf of Maine).

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Rank Order	Prec.	Fwork.	Obj.	Stocks	Soc&Econ.	MCS	Area/Nation
	Compliance Evaluation Fields						
Gulf of Maine trawl	1	10	6	12	20	2	W/U
Gulf of Maine lobster	2	3	1	3	5	1	W/U
German herring	3	2	2	2	13	6	E/G
German cod	4	4	4	7	17	7	E/G
Lobster (Ding)	5	7	17	5	6	9	W/C
UK haddock	27	16	9	20	10	12	E/E
UK cod	28	19	12	26	12	8	E/E
Scallops	29	21	31	29	23	28	W/C
Shrimp(N)	30	24	30	30	30	29	W/C
Shrimp(ES)	31	25	29	31	31	30	W/C

Table 9. Rank orders of the top and bottom five North Atlantic fisheries in the framework compliance ordination, alongside rank orders from other evaluation fields. W = west, E = east side of the Atlantic, C = Canada, E= United Kingdom, G=Germany and U = United States (Gulf of Maine).

Rank Order	Fwork.	Obj.	Prec.	Stocks	Soc&Econ.	MCS	Area/Nation
	Compliance Evaluation Fields						
German demersal	1	3	12	4	14	5	E/G
German herring	2	2	3	2	13	6	E/G
Gulf of Maine lobster	3	1	2	3	5	1	W/U
German cod	4	4	4	7	17	7	E/G
Snow Crab19	5	21	7	10	1	4	W/C
Cod gillnet	27	23	20	28	26	25	W/C
Cod longline	28	15	21	16	22	21	W/C
Cod inshore	29	20	18	24	28	24	W/C
Cod trap	30	14	22	25	29	27	W/C
Cod handline	31	16	23	27	27	26	W/C

Table 10. Rank orders of the North Atlantic fisheries in the management objective compliance ordination, alongside rank orders from other evaluation fields. W = west, E = east side of the Atlantic, C = Canada, E= United Kingdom, G=Germany and U = United States (Gulf of Maine).

Rank Order	Obj.	Fwork.	Prec.	Stocks	Soc/Ec	MCS	Area/Nation
	Compliance Evaluation Fields						
Gulf of Maine lobster	1	3	2	3	5	1	W/U
German herring	2	2	3	2	13	6	E/G
German demersal	3	1	12	4	14	5	E/G
German cod	4	4	4	7	17	7	E/G
German shrimp	5	11v	24	8	4	19	E/G
Gulf of Maine trawl	6	10	1	12	20	2	W/U
German mussel	7	12	13	9	3	20	E/G
Bay of Fundy (W)	8	9	8	1	2	3	W/C
UK haddock	9	16	27	20	10	12	E/E
Gulf of Maine inshore	10	6	10	23	8	31	W/U
Bay of Fundy (S)	11	13	9	11	9	14	W/C
UK cod	12	19	28	26	12	8	E/E
UK herring	13	18	25	21	16	13	E/E
Cod trap	14	30	22	25	29	27	W/C
Cod longline	15	28	21	16	22	21	W/C
Cod handline	16	31	23	27	27	26	W/C
Lobster (Ding)	17	7	5	5	6	9	W/C
Lobster	18	8	6	6	7	10	W/C
UK plaice	19	20	16	19	11	11	E/E
Cod inshore	20	29	18	24	28	24	W/C
Snow Crab19	21	5	7	10	1	4	W/C
Capelin	22	26	26	15	15	17	W/C
Cod gillnet	23	27	20	28	26	25	W/C
Mackerel (At)	24	14	14	13	18	22	W/C
Mackerel (Din)	25	15	15	14	19	23	W/C
Snow Crab	26	17	11	17	21	18	W/C
Cod trawl	27	22	19	18	25	15	W/C
Cod offshore	28	23	17	22	24	16	W/C
Shrimp(ES)	29	25	31	31	31	30	W/C
Shrimp(N)	30	24	30	30	30	29	W/C
Scallops	31	21	29	29	23	28	W/C

Social and Economic

A one dimensional ordination plot (Figure 14) indicates that overall east fisheries, especially small scale, scored higher for social and economic com-pliance than west fisheries. The lobster fisheries on the west side are the only fisheries that had comparable scores to the small scale coastal fisheries on the east side. Low cod fishery scores for social and economic compliance do-minate the lower end of the plot. The offshore fisheries of the east side, including cod, also scored higher than the Canadian cod fisheries.

Monitoring, Control & Surveillance (MCS

The top four fisheries for complying with the Code of Conduct for implementing MCS programs are from the west side (Table 11). These four fisheries were scored much higher (77% to 74%) than the fifth fishery from Germany (64%). The bottom five fisheries in this analysis were from the west, the lowest ranking fishery was the Gulf of Maine inshore fisheries. As expected fisheries that scored high for MCS often scored high for compliance with other evaluation fields. However, there are exception such as the Gulf of Maine inshore fisheries (Table-11).

Table 11. Rank orders of the top and bottom five North Atlantic fisheries in the management objective compliance ordination, alongside rank orders from other evaluation fields. W = west, E = east side of the Atlantic, C = Canada, E= United Kingdom, G=Germany and U = United States (Gulf of Maine).

	Compliance Evaluation Fields						
Rank Order	**MCS**	**Fwork.**	**Prec.**	**Stocks**	**Soc & Econ**	**Obj.**	**Area/Nation**
Gulf of Maine lobster	1	3	2	3	5	1	W/U
Gulf of Maine trawl	2	10	1	12	20	6	W/U
Bay of Fundy (W)	3	9	8	1	2	8	W/C
Snow Crab19	4	5	7	10	1	21	W/C
German demersal	5	1	12	4	14	3	E/G
Cod trap	27	30	22	25	29	14	W/C
Scallops	28	21	29	29	23	31	W/C
Shrimp(N)	29	24	30	30	30	30	W/C
Shrimp(ES)	30	25	31	31	31	29	W/C
Gulf of Maine inshore	31	6	10	23	8	10	W/U

DISCUSSION

Alternatives to Rapfish

Other approaches to assessing the sustainability of fisheries have been developed or are under development. The most advanced approaches include the Marine Stewardship Council Certification Program, the Fisheries Assessment Framework (Australia) and FAO's Sustainable Development Reference System.

Marine Stewardship Council Certification (MSCC)

The Marine Stewardship Council has initiated a global accreditation scheme for the commercial fishing sector. The scheme is based on defining performance criteria and guideposts for a particular fishery and then scoring the fishery. The fisheries are scored by accredited certifiers to reduce uncertainty and increase the consistency in the decision making process (MSC 1998a). Currently each fishery has its own set of criteria and guideposts. The MSC anticipates a generic set of criteria and guideposts will be available by March 2000. The performance criteria are used in conjunction with the Analytical Hierarchy Process as defined by the MSC. The fisheries are evaluated against three principles, Principles 1 and 2 focus on the biological or ecological aspects of the fishery while Principle 3 in 10 elements covers a diversity of issues spanning social, cultural, technological, cultural and ethical issues (MSC 1998a). Limited attention is given to specific social, ethical, economic

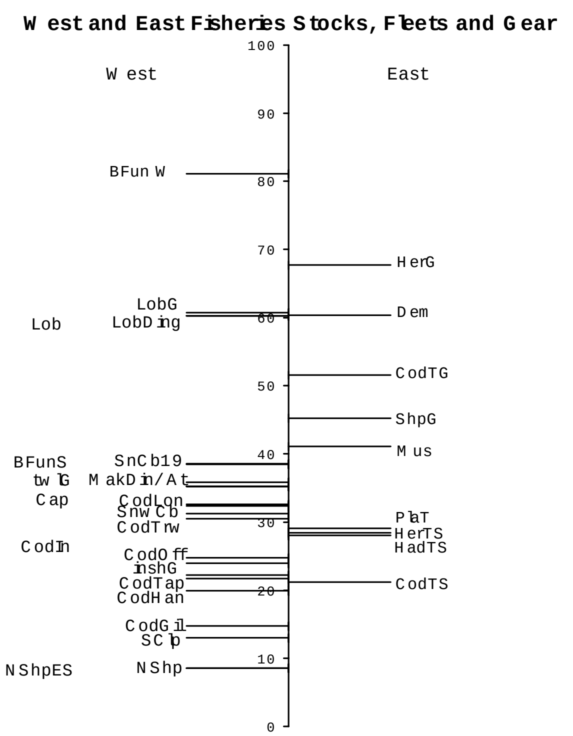

Figure 13. One dimensional ordination North Atlantic stock, fleets and gear compliance scores.

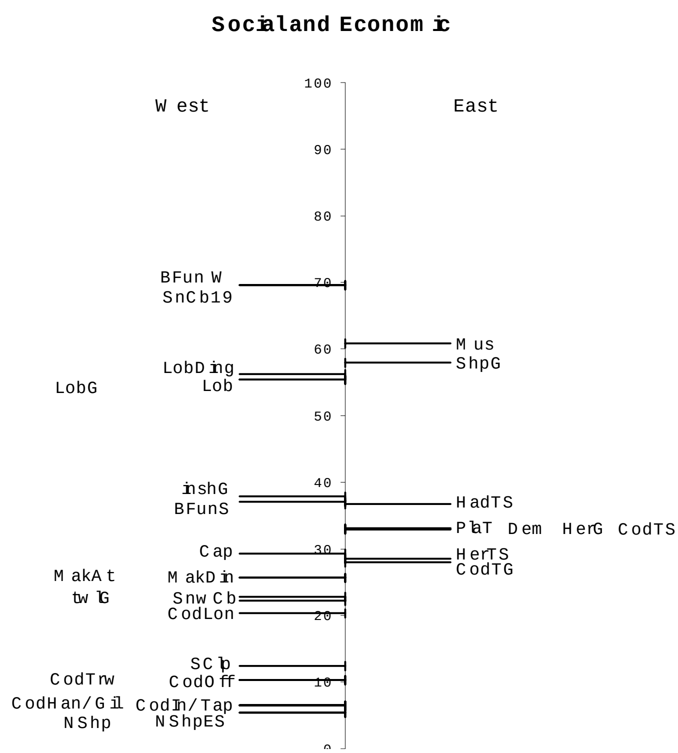

Figure 14. One dimensional ordination North Atlantic social and economic compliance scores.

and technological aspects of fisheries management and sustainability.

The performance criteria (indicators) and guideposts are based on these three principles, and usually more than one indicator is used to measure compliance with a principle. Within a single indicator the elements to be considered in an evaluation are also detailed so that the MSC Certifier can score a particular indicator. Each element is scored by consensus among the certifying team. Once the fishery is scored (as a percent) 'a normalised weight average score' for each principle and criteria category is calculated between 0 and 100% (MSC 1998b). This enables the team to assess how the fishery scores relative to the "full attainment (appropriate to the size and scale of the fishery) of a sustainable fishery (MSC 1998 p.17)".

The Western Australia Rock Lobster Fishery, which was the first fishery to be accredited, gives an indication of the scope and nature of the criteria and guideposts. In this fishery 5 indicators were defined and scored for Principle 1, 7 for Principle 2 and 5 for Principle 3 (MSC 1999). The element necessary for a 100% and an 80% score were provided for the certifiers.

The MSC Accreditation approach and the RAPFISH approach both score fisheries according to a well defined set of criteria. The scaling differs substantially as well as the number and scope of criteria with the RAPFISH approach using an interval scale for a number of criteria (nearly 90, see Appendix 2 for a list) and MCS using a percent scale for fewer criteria (17 for the WA Lobster Fishery (MSC 1999)). The RAPFISH approach enable managers to visually see how the fisheries has changed in terms of sustainability by the plots produced, and more importantly the kite diagrams are able to integrate the various aspects of sustainability into a single entity allowing managers to assess which areas of management need attention. The aggregating approach in MSC results in considerable loss of information while RAPFISH, which uses MDS, is able to retain much of the information as well as estimate the robustness of the assessment using Monte Carlo simulations and sensitivity analysis. The MSC approach requires accredited certifiers and requires a team of highly trained professionals which for the most part will be paid by the client who is seeking accreditation. The MSC guidelines indicate that a typical fishery requires 40 person days for establishing the accreditation and 12 person days each year to maintain the accreditation (MSC 1998). This requirement may limit its use in developing countries or for fisheries where profit margins are not exceedingly high. There are no such requirements with RAPFISH which can be undertaken by a range of stakeholders after minimal training.

Fisheries Assessment (FA) Framework (Australia)

The Bureau of Rural Science in Australia has developed a 'framework to assess fisheries with respect to ecologically sustainable development'. The framework focuses on providing a structure and process that can be used to meet the unique needs of each fisheries. The framework is based on the effects of fishing that are examined in terms of impact on ecological processes and the total quality of life. The direct effects of fishing on human society and the effects of fishing on the environment are included. The effects on human society and the environment are further subdivided in a hierarchical fashion. The structure can be adapted to the specific circumstances of any fishery through further subdivision to whatever level is desirable (Chesson & Clayton 1997). Criteria are developed within the framework and once developed a multicriteria analysis through time is used to assess the sustainability of the fisheries studied. This approach does not necessarily provide common measures or indicators for sustainability and is quite different to RAPFISH. However, once measures or indicators are developed within the framework RAPFISH can be used to assist in assessing the fishery.

Sustainable Development Reference Systems (SDRF)

The system is based on the FAO Code of Conduct and recognises the need to take a multi-disciplinary approach to assess sustainable development. SDRS sets objectives, related indicators and their respective reference points (FAO 1999) and includes economic, social, ecological and governance aspects as well as the FAO Code of Conduct. The indicators can be defined for the scale of the fisheries so that it can be used in a range of situations. The system also considers the aggregation and presentation of the information obtained. The system, however, is developed on a fishery by fishery basis.

Again the approach is similar to RAPFISH since indicators are scored according to a set criteria. However, the FAO guidelines also set reference points to indicate how the fishery is preforming for the specified criteria. The approach can also use kite diagrams to illustrate how well a particular fishery is preforming for a subset of indicators, however, there is no facility to integrate or include other fisheries (FAO 1999). The approach focuses on a fishery by fishery analysis and therefore no measures of error are possible and comparisons are limited between fisheries if separate criteria are developed for each fishery.

Use of Rapfish

Rapfish is a new and non-traditional approach to fisheries management. Consequently in some fisheries sectors scepticism has been expressed especially on the lack of uncertainty estimates and the dominance of attributes. This study of a total of 117 fisheries spanning several centuries in some fisheries, a range of gear and species, covering both sides of the North Atlantic has demonstrated that reasonable uncertainty estimates can be derived in both dimensions. Monte Carlo has been used in the past in MDS to investigate the uncertainty associated with STRESS estimates (Spence and Young 1978). The STRESS values obtained in this study were within a narrow range (0.02). The Monte Carlo simulations for all five-evaluation fields had similar results in not just STRESS values, but also in the confidence intervals as shown in Figure 6. In all evaluation fields the 95% confidence intervals were wider in the second dimension compared to the first. This is a consequence of the second dimension accounting for the non-sustainability component of the attributes.

Bootstrapping was not used in this analysis to investigate uncertainty with the scores because the resampling strategy allows for duplications that many statistical programs do not allow. In addition, analysis with duplicate (tied) data will result in higher STRESS values and therefore potentially give misleading results.

The sensitivity analysis results are quite comparable to previous sensitivity analysis (Pitcher 1999) where the standard error of the sustainability dimension (as a % score) was generally less than 14% for any attribute. There is no single attribute that dominates the Rapfish ordinations. As in the Monte Carlo study, the uncertainty of attributes in the second dimension was higher, but not substantially. This study and previous studies (Pitcher 1999) have shown that the attributes listed are effective in defining sustainability. The sensitivity analysis is also a useful tool when new attributes are proposed since their influence can be assessed.

The analysis of 117 fisheries has highlighted the need to determine a set of reference points so that fisheries from different MDS analysis can be compared, especially when the number of fisheries exceeds 100 (the limit for many statistical programs). In this analysis the three fisheries could not be combined since the total number of fisheries exceeded 100. Confirmatory analysis, however, may provide the basis for allowing for comparisons (Young and Arabie 1998). This aspect needs further investigation.

This study has clearly shown that Rapfish is based on proven multidimensional scaling theory and approaches within the broad subject of multivariate analysis. This basis combined with previous analysis and the analysis of the 117 fisheries in this study confirms Rapfish as an appropriate method to assess the sustainability of fisheries and compliance with the FAO Code of Conduct for Responsible Fisheries. The ability of Rapfish to express the uncertainty associated with the analysis further strengthens its appropriateness when compared to current approaches and traditional fisheries management approaches.

This study has also demonstrated how Rapfish can be used to undertake hierarchical analysis of fisheries as demonstrated in the east-west comparison analysis of North Atlantic fisheries. Rapfish enables managers to make comparisons between gear sector, time, fishing scale and geographic location at a very broad level or in considerable detail. There are also a number of options to illustrate these comparisons from 2-dimensional ordination plots to kite diagrams depending on the required analysis.

The strength of Rapfish lies in its ability to integrate a range of attributes into a single analysis and the visualisation of these results. All stakeholders easily understand the graphs and plots used to express the two-dimensional Rapfish analysis. Rapfish therefore provides a refreshing change for stakeholders to objectively come to grips with the issue of fisheries sustainability.

Other possible points for further discussion - Hierarchical use, scalability, enanbling comparisons by gear sector, by year and size scale /country. comparisons with compliance with international treaties.

Acknowledgements

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References

Arabie, P. (1973) Concerning Monte Carlo evaluations of nonmetric multidimensional scaling algorithms. *Psychometrika,* 38(4).

Buckingham-Hatfield, S. and Evans, B. (1996) Achieving sustainability through environmental planning. Environmental Planning and Sustainability. In: S. Buckingham-Hatfield and B. Evans, Wiley, Chichester, UK. 1-18.

Carroll, J. D. and Arabie, P. (1998) Multidimensional Scaling. Measurement, Judgement, and Decision Making. (ed. M. Birnbaum), San Diego, Academic Press.

Chesson, J. and Clayton, H. (1997) A framework for assessing fisheries with respect to ecologically sustainable development. Bureau of Resource Sciences Fisheries Resources Branch, Canberra, Australia.

Clark, K. R. and Warwick, R. M. (1997) Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. Plymouth: Plymouth Marine Laboratory, 144 pp.

Davison, M. L. (1983) Multidimensional Scaling. USA, John Wiley & Sons, Inc.

FAO (1999) The development and use of indicators for sustainable development of marine capture fisheries.

FAO Technical Guidelines for Responsible Fisheries No. 8, Rome.

Green, P. E., Carmone, F. J. Jr., and Smith, S. M. (1989) Multidimensional Scaling: Concepts and Applications. Massachusetts, Allyn and Bacon.

Jacoby, W. G. (1991) Data Theory and Dimensional Analysis. Newbury Park, Sage Publications, Inc.

Kruskal, J. B. and Wish, M. (1978) Multidimensional Scaling. Beverly Hills, Sage Publications.

Leeuw, J. de. and Meulman, J. (1986) A special jacknife for multidimensional scaling. *Journal of Classification,* 3(1), 97-112.

Manly, B. F. J. (1994) Multivariate Statistical Methods: A Primer. London, International Thomas Publishing.

Marine Stewardship Counsel (1998a) Principles and Criteria for Sustainable Fishing.

Marine Stewardship Council (1998b) MSC Certification Methodology.

Marine Stewardship Council (1999) Performance Criteria and Scoring Guideposts Against the Marine Stewardship Council Principles and Criteria: Western Australian Rock Lobster Fishery Issue.

McGoodwin, J. (1990) Crisis in the World Fisheries: people problems and policies. Stanford Univ. Press. Stanford.

Palmer, M., (2000) Ordination Methods for Ecologists. http://www.olcstate.edu/artsci/botany/ordinate. [accessed 03/03/00]

Pitcher, T.J. (1999) RAPFISH, A Rapid Appraisal Technique For Fisheries, And Its Application To The Code Of Conduct For Responsible Fisheries. FAO Fisheries Circular No. FIRM/C: No. 947. 47 pp.

Pitcher, T.J. and Power, M.P. (2000) Fish Figures: Quantifying the Ethical Status of Canadian Fisheries, East and West. In: Coward, H., Ommer, R. and Pitcher, T.J. (eds). Just Fish: the ethics of Canadian fisheries. Institute of Social and Economic Research Press, St John's, Newfoundland, 225-253.

Pitcher T. J. and Preikshot, D. B. (2000) Rapfish: A Rapid Appraisal Technique to Evaluate the Sustainability Status of Fisheries. Fisheries Research (in press).

Pitcher, T.J., Bundy, A., Preikshot, D., Hutton, T. and Pauly, D. (1998) Measuring the unmeasurable: a multivariate interdisciplinary method for rapid appraisal of health of fisheries. In: Pitcher, T.J. Hart, P.J.B. and Pauly, D. (eds) Reinventing Fisheries Management Chapman and Hall, London, 31-54.

Pitcher, T.J., Mackinson, S., Vasconcellos, V., Nøttestad, L. and Preikshot, D. (1999) Rapid appraisal of the status of fisheries for small pelagics using multivariate, multidisciplinary ordination. In: Quinn, T.J. II, Funk, F., Heifetz, J., Ianelli, J.N., Powers, J.E., Schweigert, J.F., Sullivan, P.J., Zhang, C.I. (eds), Fishery Stock Assessment Models. Alaska Sea Grant, Fairbanks, 759-782.

Preikshot, D.B. (2000) An Interdisciplinary Assessment of Troical Small Scale Fisheries Using Multivariate Statitstics. Masters Thesis, Department of Zoology, Fisheries Centre. University of British Columbia. Vancouver, Canada.

Preikshot, D.B., Nsiku. E., Pitcher, T.J. and Pauly, D. (1998) An interdisciplinary evaluation of the status and health of African lake fisheries using a rapid appraisal technique. J. Fish Biol. 53 (Suppl A), 382-393.

Schiffman, S., Reynolds, M. L. and Young, F. W. (1981) Introduction to multidimensional scaling: theory, methods, and applications. Academic Press, London.

Smith, S. J. (1993) Risk Evaluation and biological reference points for fisheries management: A review. In: Kruse, G. Eggers, D.M., Marasco, R.J., Pautzke, C. Quinn, T.J., (eds) Management Strategies for Exploited Fish Populations. Alaska Sea Grant, Anchorage. 339-353.

Spence, I. and Young, F. W. (1978) Monte Carlo studies in nonmetric scaling. *Physicometrika*, 43(1).

Stalans, L.J. (1995) Multidimensional Scaling. In: Grimm, L.G. and Yarnold, P.R. (eds) Reading and Understanding Multivariate Statistics. American Psychological Association, Washington.

Statistica (2000) Multidimensional Scaling. http://www.statsoft.com/textbook/stmulsca.html. [accessed 11/03/00]

Walters, C.J. (1998) Designing fisheries management systems that do not depend on accurate stock assessment. In: Pitcher, T.J. Hart, P.J.B. and Pauly, D. (eds) Reinventing Fisheries Management Chapman & Hall, London, 279-288.

Weinberg, S. L., Carroll, J. D. and Cohen, H. S. (1984) Confidence regions for indscal using the jackknife and bootstrap techniques. *Psychometrika*, 49(4), 475-491.

Young, F. W. (1987) Multidimensional Scaling: History, Theory, and Applications. Hillsdale, Lawrence Erlbaum Associates.

Young, F. W. and Hamer, R. M. (1987) Multidimensional Scaling: History, Theory, and Applications. London, Lawrence Erlbaum Associates, Publishers.

APPENDIX 1
MULTIDIMENSIONAL SCALING AS THE ORDINATION ENGINE IN THE RAPFISH TECHNIQUE

MULTIVARIATE ALTERNATIVES TO MDS

Cluster Analysis

Cluster Analysis and MDS have some similarities – both can analyse proximity data and use distance models, and in either approach, the solution can be represented as coordinates in k-dimensions (Davison 1983). There are fundamental differences: cluster analysis can not express the relationship between the distance data as a linear or monotone function, distances in hierarchical cluster analysis are not spatial distances as in MDS, and the coordinate dimensions in MDS are continuous whereas in cluster analysis they are discrete (Davison 1983). Cluster analysis can complement MDS by identifying groups of similar points (fisheries) which may provide further analysis with respect to sustainability

Factor Analysis (FA)

FA is similar to MDS since it also measures the proximity of pairs of points expressed as angles between vectors (Davison 1983) and both use a Euclidean space (Schiffman et al. 1981). FA attempts to account for the variation in a number of original variables using a smaller number of vectors, and FA can be used to explore the relationships between different variables. The number of vectors used (10 or more) and expressing the distances as angles makes interpretation of the data difficult. MDS on the other hand explores the distances between the points and their relative positions in a few dimensions. FA is not appropriate where samples are small and cannot be replicated (Manly 1994), or where relationships are not linear.

Principal Component Analysis (PCA)

PCA allows researchers to investigate combinations of variables that reduce the number of variables so that data is simplified. PCA can not use distance or similarity matrices and more importantly the data should be approximately normally distributed. The normality requirement severely limits the use of Principal Component Analysis since the scored fisheries data are often not normally distributed. When data are normally distributed the output from a PCA are indices that are uncorrelated and represent different dimensions. The indices (principle components) are ordered such that the first accounts for the largest amount of variation (Manley 1994). The principal components, however, do not necessarily reflect sustainability as in RAPFISH.

Correspondence Analysis

Correspondence analysis examines the abundance of data, often in the form of frequency or contingency tables (Green et al. 1989). It can be used to spatially represent the frequency data, and therefore differs from MDS where distances or dissimilarities involving sustainability are spatially represented.

MULTIDIMENSIONAL SCALING

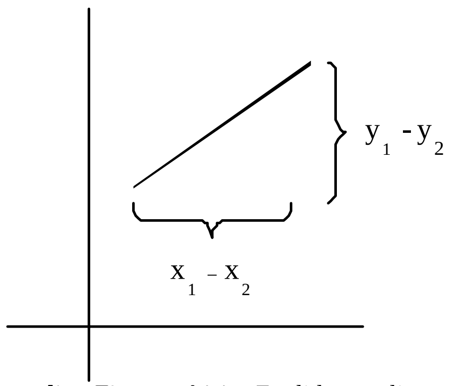
The Monte Carlo simulations indicated that scores are not necessarily normally distributed when a two dimensional analysis is undertaken and confidence intervals around the median values provide a robust indicator of the uncertainty. Monte Carlo runs to date indicate limited variation in the estimate of the median values in the first and second dimension. The sensitivity analysis (SA), based on jackknifing (without replacement) was used to investigate the influence of a specified attribute. Results in this study indicate that RAPFISH estimates are stable and not dominated by one particular attribute. Preliminary results comparing the distances between the original points and the SA points also found no significant differences.

Multi-attribute Utility Theory

Multi-attribute utility Theory (MAUT) has been suggested as an alternative to MDS within Rapfish. MAUT is often used to assist managers and stakeholder in deciding on the most appropriate option amongst several options. If fisheries are considered as options and the objectives was to decide which fishery is the most sustainable based on a defined set of criteria, then MAUT can be used. Applying this technique would require not only the table of scores against the various criteria but also weighting of the attributes as well as forming utility functions for each attribute by the stakeholders. In practice this would not be an easy task due to the diversity of stakeholder interests. Reviewers of Rapfish have questioned whether the methodology is already too complex for most stakeholders, defining the weightings and the utility functions add a layer of complexity to the current methodology. MAUT would limit the ability of managers to compare results with other fisheries since each weighting and utility function would be unique to the fishery or group of fisheries.

The Ordination Method

MDS is a distance based ordination method which seeks to map distances between 'objects' or points in a two or three dimension space as close as possible to the distances between the original (input) points in a multi-dimensional space. The ordination



Appendix Figure A1.1. Euclidean distance in 2 dimensional space.

technique approximates a configuration (ordination) of points in a t-dimensional space (usually 2 or 3 dimension) by using the Euclidean distances (Figure A1.1) between points in an initial configuration in the t-dimensional space and the distances between the original (input) points.

The Euclidean distance between points is calculated using Pythagorean Formula; in 2 dimensional space it is

$$d = \sqrt{|x_1 - x_2|^2 + |y_1 - y_2|^2}$$

In a n-dimensional space the Euclidean distance is

$$d = \sqrt{|x_1 - x_2|^2 + |y_1 - y_2|^2 + |z_1 - z_2|^2 + ...)}$$

A configuration is approximated by regressing the Euclidean distances in the initial or estimated configuration (d_{ij}) on the Euclidean distances between the original (input) points (δ_{ij}); this equation is then used to estimate the distances (disparities) of the original distances (δ_{ij}) scaled as close as possible to match the Euclidean distance (d_{ij}) in the configuration. The form of the regression equation will vary depending on whether it is linear, polynomial or monotonic (Manly 1994). An example of the regression and disparities are given:

$d_{ij} = a + b\delta_{ij} + e$ (an example of a linear equation)

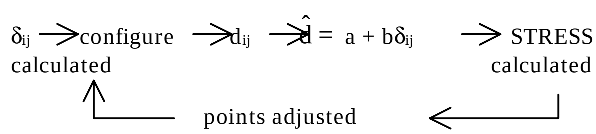
$\hat{d} = a + b\delta_{ij}$ (disparity)

where d_{ij} is the Euclidean distance, a is the intercept, b is the slope, e is the error term and $\hat{d}$ is the disparity .

When a linear or polynomial regression is used the MDS is metric, and when a simple monotonic regression is used the MDS is nonmetric (Kruskal and Wish 1978). In a nonmetric MDS the ordering of the data distances is therefore important (Manly 1994) and consequently maximises the rank-order correlation between distance measures and distance in the ordination [configuration] space (Palmer 2000).

Generally one of three methods is used to estimate the regression: least squares based on distances (KRYST), alternating least squares based on squared distances (ALSCAL) and maximum-likelihood-based procedure (MULTISCALE) (Schiffman et al. 1981; Carroll and Arabie 1998). Each method makes assumptions about the data to be analysed and generates different output. The KYST and ALSCAL can not estimate confidence levels directly, while the MULTISCALE approach can be used to estimate confidence regions. However, MULTISCALE has several strong assumptions about the distribution of the data and can only be used in metric MDS. Estimating confidence intervals is discussed below.

How well the configuration (ordination) of points reflects the original data is termed 'goodness of fit' or 'stress'. The stress is measured between the Euclidean distances and the disparities, if the stress is not reduced significantly, the coordinates of the points in the configuration are moved to reduce the stress. New Euclidean distances are calculated along with a new regression, disparity and stress when the points are moved. Most algorithms therefore evaluate different configurations iteratively with the goal of maximising the goodness of fit or minimising the stress Figure A1.2.



Kruskal's 'STRESS Formula 1' or STRESS1 is often used to measure stress. The general formula is (Manly 1994):

$$STRESS1 = \{\Sigma(d_{ij} - (\hat{d}_{ij})^2 / \Sigma \hat{d}_{ij}\}^{1/2}$$

In nonmetric MDS the configurations are evaluated

Appendix Figure A1.2: A generalised flow chart for computing MDS.

iteratively to minimise the stress which can be expressed as:

$$STRESS = \Sigma[d_{ij} - f(\delta_{ij})]^2$$

Where $f(\delta_{ij})$ is a nonmetric monotone function of the original distances (Statistica 1995).

A low stress value generally indicates a good fit when the analysis is in two or more dimensions. The actual value of the stress coefficient depends on the formula used, for Kruskal's STRESS 1 coefficient values greater than 0.10 in 2 dimension indicated a poor fit. If the data has high levels of measurement or sampling error then the stress value may exceed .10 (Kruskal and Wish 1978). However, for the same degree of fit, STRESS2 values are usually twice as much as for STRESS1 (Kruskal and Wish 1978).

Stress values close to zero, however, should be treated with caution since they may indicate a degenerate solution as discussed below. Similarly, large stress values may indicated that convergence to a solution was not reached.

There are a number of factors that affect stress, the most likely include:

- Introducing a distance matrix where the symmetrical points are significantly different from each other;
- Introducing replicates that are significantly different from each other; and
- The number of ties results in only a few distinct values (Kruskal and Wish 1978).

The ordination usually provides a set of points (coordinates) configured for either two or three dimensional space. Because the configuration represents the relative position of the points, rotating or reflecting the configuration and altering the scales will not change the relative positions of the points (Manly 1994). The final orientation of the axes and their corresponding scales are therefore subjective and generally based on which orientation is easily explained.

Appendix Table A1.1: Programs for computing MDS (based on Manly, 1994).

Algorithm (Metric - NonMetric)	**Source**	**Authors**
ALSCAL (both)	SPSS SAS	Young and Lewyckyj (1979) as cited in Manly 1994.
KYST (both)	Separate program available from Bell Laboratories.	Kruskal, Young and Seery (1973) as cited in Carroll and Arabie (1998).
MULTISCALE (metric)	Separate program available from International Education Services.	Ramsay (1989) as cited in Carroll and Arabie (1998).
MDSCAL (non-metric)	Primer.	Kruskal as cited in Clark and Warwick 1994.
NMDS (non-metric)	Written as a 'C' module which can be called by such programs as SPLUS.	Ludwig and Reynolds 1988 as cited in Manly 1994.

Clearly MDS is a computationally intensive method since calculating the Euclidean and regressed distance involves several calculations as well as the calculations required to derive the stress parameter. Current computer technology, however, makes this task much easier and faster so that several fisheries with a number of attributes can be analysed. There are a number of algorithms available to conduct a MDS analysis. Different programs use different algorithms (Table A1.1) and therefore do not give the same result (Manly 1994), however, the relative positions of the fisheries on the maps should be similar.

MDS Methodology Issues

Degenerate Solutions

Degenerating solutions are characterised by Stress values close to 0. They occur in MDS analysis when there is a relatively small amount of empirical data used to estimate a relatively large amount of information (Jacoby 1991) or there is clustering of the distances. Degenerate solutions can be avoided by increasing the amount of input data (Jacoby 1991) or by seeking a solution in a higher dimension (Davison 1983).

Sample sizes

The question of how many attributes to use and how many points (fisheries in the case of RAPFISH) to sample in a MDS analysis is raised irrespective of the nature of the project. Since the number of dimensions (K) that can be explored increases with the number of attributes (J), as many attributes as possible should be used (Schiffman et al 1981). When the analysis is focused in two dimensions the recommended number of attributes ranges between 9 (Kruskal and Wish 1978) and 12 (Schiffman et al. 1981). The general recommendation is:

$J - 1 >= 4xK ; K <= 3$

to achieve statitistical stability (Kruskal and Wish 1978).

The number of points (N) that should be sampled is also a function of the number of attributes. The more points sampled the better the fit of the data. Stalans (1995) recommends that three times as many points are sampled than the number of attributes:

Minimum $(N) = 3*J$.

Researchers are also interested in the impact of the attributes on the analysis, that is, do one or two attributes dominate the ordination? This dominance can be explored using multiple regression analysis (regression coefficients and canonical correlation) and sensitivity analysis (see below).

Significant regression coefficients in a multiple regression of the first and second dimensons indicate that one of the attributes may be dominating the analysis. However, the regression applies only to individual ordinations and does not necessarily identify which attribute. Canonical correlation coefficients can infer dominant attributes since high positive correlations indicate that a particular attribute score is likely to score high on an ordination axis. Negative correlations also imply that low attribute scores were associated with high values on an ordination axis (Pitcher and Preikshot in press). These correlations only infer or imply, because the MDS dimensions are jointly determined

Flipping

In an MDS analysis, points can "flip" from one iteration to another. This is due to the fact that the configurations always have a fair degree of randomness associated with them and therefore fitting the best solution may involve moving (or "flipping") nearby points. This phenomenon is likely related to the interdependence of nearby points, however, little information is available. Flipping in an analysis can be investigated by using sensitivity analysis (Kruskal and Wish 1978). Pitcher (1999) and Kavanagh (pers. comm.) found that 'flipping' could be minimised by the use of fixed anchor points – an extension of the anchor points system is currently under investigation.

Confidence Limits

MDS, like all multivariate methods, estimates the coordinates that are used to place the relative points on a map. Indeed, MDS is often described as a "arranging objects in a space with a particular number of dimensions" (Statsoft 2000 – URL). Because these coordinates are estimated, reported details of the error or degree of uncertainty associated with each coordinate would enhance the robustness of the MDS analysis. As discussed above most of the algorithms used to estimate the coordinates can not estimate uncertainty or confidence limits directly. The MULTISCALE approach can be used to estimate the standard error of the log likelihood estimate and the standard error of the coordinate estimates, however, it is a metric MDS and requires a large sample sizes and normally distributed data (Schiffman et al. 1981). This limits its use in RAPFISH since the data is often not normally distributed.

Confidence limits or levels of uncertainty can be estimated indirectly by using resampling methods such as Monte Carlo, Bootstrap or Jackknife (Weinberg et al. 1984). Monte Carol resampling maintains the attribute values for each fisheries, but randomly permutes them to estimate the test statistic or parameter. This permutation/parameter estimation process is repeated several times (minimum of 100 times) to obtain the distribution of the parameter. Confidence intervals can then be estimated based on the distribution of the data generated in the Monte Carlo simulations.

The bootstrap approach maintains not only the attribute values for each fishery, but does not permute the values. The resampled fisheries are generated by sampling randomly, with replacement, to obtain a data set the same size as the original set. MDS analysis is conducted on this new data set. This resampling/parameter estimation sequence is replicated many times and once completed the replicates are used to estimate the bias, mean and standard error for the parameter. It should be noted that in some bootstrap programs the resulting data set may have replicates (ties) and therefore the original data set should be large and preferably with few, if any ties.

The jackknife approach also maintains the attribute values for each fishery, but it leaves out one fishery and recalculates the parameters based on a sample size of n-1. Bias, mean and standard error are estimated but calculated differently to those in the bootstrap method. For analysis with a large number of points the perturbation will be very small (deLeeuw and Meulman 1986).

Which method is most appropriate to investigate uncertainty depends on which parameter is sought, the nature of the data and the program used (Table A1.2). Programs that prohibit ties can not be used for some bootstrap methods since some sample with replacement and therefore if the same point is sampled twice, the distances will be zero and the MDS program will fail. Because bootstrap and jackknife methods resample the input data directly, large sample sizes should be used with these methods.

Appendix Table A1.2: Summary of re-sampling Methods.

Resampling Method	Sampling Strategy	Estimates
Monte Carlo	Permutations	parameters
Bootstrap	Sampling with replacement	Bias, mean, standard error, percentile, sensitivity
Jackknife	Sample (n-1)	Bias, mean, standard error, percentile (calculations different to BS), sensitivity

Sensitivity Analysis

Sensitivity analysis enables researchers to examine the impact of an attribute or the appropriateness of the number of dimensions.

The jackknife and bootstrapping methods mentioned above are used to investigate the sensitivity of both points in the ordination, and the attributes used in a MDS (deLeeuw and Meulman 1986; Spence and Young 1978; Arabie 1973). If an analysis is stable then small perturbations in the data produce small changes in the solution (deLeeuw and Meulman 1986). In a jackknife or bootstrap analysis the difference between the sums of squares of full set of attributes and the generated set of attributes (one attribute missing in the case of a jackknife) can be compared. The difference can be expressed as a standard error for each attribute (Pitcher 1999). A sensitivity analysis enables researchers to investigate the appropriateness of the dimension specified by examining changes in the stress values in different dimensions, the stability of stress values and coordinates.

Hypothesis Testing/Confirmatory MDS

The strength of MDS lies in its ability to map points, however, MDS can also be used to evaluate a hypothesis about an ordination. Confirmatory MDS evaluates how well an ordination can be reproduced by an ordination that is hypothesised or where the ordination has been specified a priori. The prior points can be fixed to a previous value, proportional to another value or completely unconstrained (Young and Hammer 1987; Carroll and Arabie 1998). MDS approaches are also used to analyse the combined data set. Some or all of the coordinates are specified (hypothesised) and the remaining coordinates (unhypothesised) are estimated in some forms of confirmatory MDS approaches (Davison 1983). Confirmatory MDS allows researchers to constrain the ordination so that points in the ordination can be compared to known (hypothesised) points and in some cases allow for comparisons to be made between analysis where the same hypothesised points are used.

Ties/Clustering

When points in the map are at the same position, no information is available about the relationship between the two points since their distances are equal to zero. If there are numerous ties then the stress value can be high since the distances will be either clustered or take on only a few distinct values (Davison 1983; Schiffman et al. 1981). In MDS there are two approaches to handling ties. The primary approach breaks up the rank order of the ties so that the stress is minimised and the secondary approach replaces the ranks by their average (Schiffman et al. 1981). In analysis where there are a number of ties or “no differences” the results should be interpreted cautiously (Schiffman et al. 1981).

Missing data

The impact of missing values in MDS depends on how they are handled by the computer program. Incorporating missing values has the advantage of increasing the number of attributes and samples, and therefore allowing analysis in higher dimensions (Schiffman et al. 1981). Some programs omit those cases where the data is missing in one or more of the attributes, others estimate the missing value and substitute it into the analysis. Young and Hammer (1987) suggest that when data is discrete the optimal scaling process assigns a single number and when the data is continuous it assigns a continuum of numbers.

APPENDIX 2: ATTRIBUTES CURRENTLY USED IN RAPFISH ANALYSES FOR ECOLOGICAL, TECHNOLOGICAL, ECONOMIC, SOCIAL AND ETHICAL EVALUATION FIELDS. (Revised March 2000 by RAPFISH Group).

	Scoring	Good	Bad	Notes
Ecological analysis				
Exploitation status	0; 1; 2; 3	0	3	FAO-like scale: under- (0); fully- (1); heavily- (2); or over-exploited (3) [can consult FAO website for status]
Recruitment variability	0; 1; 2	0	2	COV: low <40% (0); medium 40-100% (1); or high >100% (2)
Change in trophic level	0; 1; 2	0	2	Is trophic level of fisheries sector decreasing: no (0), somewhat, slowly (1); rapidly (2).
Migratory range	0; 1; 2	0	2	# of jurisdictions encountered during migration (includes international waters): 1-2 (0); 3-4 (1); >4 (2)
Range collapse	0; 1; 2	0	2	Is there evidence of geographic range reduction: no (0); a little (1); a lot, rapid (2).
Size of fish caught	0; 1; 2	0	2	Has average fish size landed changed in past 5 years; no (0); yes, a gradual change (1); yes, a rapid large change (2).
Catch before maturity	0; 1; 2	0	2	percentage caught before maturity: none (0); some (>30%) (1); lots (>60%) (2)
Discarded by-catch	0; 1; 2	0	2	percentage of target catch: low 0-10% (0); medium 10-40% (1); high >40% (2)
Species caught	0; 1; 2	0	2	includes species caught as by-catch: low 1-10 (0); medium 10-100 (1); high >100 (2)
Primary production	0; 1; 2; 3	3	0	g C/m^2/year: low 0-50 (0); medium 50-90 (1); high 90-160 (2); very high >160 (3)
Economic analysis				
Profitability	0; 1; 2; 3; 4	4	0	Highly Profitable (0); marginally profitable (1); break even (2); losing money (3); big losses (4)
Fisheries in GDP	0; 1; 2	2	0	Importance of fisheries sector in national economy: low(0); medium (1); high(2)
Average wage	0; 1; 2; 3; 4	4	0	Do fishers make more or less than the average person? Much less (0); less (1); the same (2); more (3); much more (4)
Limited entry	0; 1; 2; 3; 4	4	0	includes informal limitations: Open Access (0); Almost none (1); very little (2); some (3); lots (4)
Marketable right	0; 1; 2	2	0	marketable right/quota/share? (0); some (1); mix (2); full ITQ, CTQ or other property rights (2)
Other income	0; 1; 2; 3	0	3	in this fishery, fishing is mainly: casual (0), part-time (1); seasonal (2); full-time (3)
Sector employment	0; 1; 2	0	2	employment in formal sector of this fishery: <10% (0); 10-20% (1); >20% (2)
Ownership/Transfer	0; 1; 2	0	2	profit from fishery mainly to: locals (0); mixed (1); foreigners (2)
Market	0; 1; 2	0	2	market is principally: local/national (0); national/regional (1); international (2)
Subsidy	0; 1; 2	0	2	Are subsidies (including hidden) provided to support the fishery?: no (o); somewhat (1); large subsidies (2).
Sociological analysis				
Socialization of fishing	0; 1; 2	2	0	fishers work as: individuals (0); families (1); community groups (2)
Fishing community growth	0; 1; 2	0	2	Growth over past ten years: <10% (0); 10-20% (1); >20% (2).
Fishing sector	0; 1; 2	0	2	households in fishing in the community: <1/3 (0); 1/3-2/3 (1); >2/3 (2)
Environmental knowledge	0; 1; 2	2	0	Level of knowledge about environmental issues and the fishery: none (0); some (1) ; lots (2)
Education level	0; 1; 2	2	0	education level compared to population average: below (0); at (1); above (2)
Conflict status	0; 1; 2	0	2	level of conflict with other sectors: none (0); some (1); lots (2)
Fisher influence	0; 1; 2	2	0	strength of direct fisher influence on actual fishery regulations: almost none (0); some (1); lots (2)
Fishing income	0; 1; 2	2	0	fishing income as % of total family income: <50%; 50-80%; >80%
Kin participation	0; 1; 2; 3; 4	4	0	do kin sell and/or process fish? None (0); very few relatives (1-2 people) (1); a few relatives (2); some relatives (3); many kin (4)
Technological analysis				
Trip length	days	Low	High	average days at sea per fishing trip
Landing sites	0; 1; 2; 3	0	3	are landing sites: dispersed (0); somewhat centralised (1); heavily centralised (2); distant (3)
Pre-sale processing	0; 1; 2	2	0	processing before sale, ex. gutting, filleting: none (0); some (1); lots (2)
Onboard handling	0; 1; 2; 3	3	0	none (0); some (ex. salting and boiling) (1); sophisticated (ex. flash freezing, champagne ice) (2); live tanks (3)

Gear	0; 1	0	1	gear is: passive (0); active (1)
Selective gear	0; 1; 2	2	0	device(s) in gear to increase selectivity? few (0); some (1); lots (2)
FADS	0; 0.5; 1	0	1	are FADS: not used (0); bait is used (0.5); used (1)
Vessel size	0; 1; 2; 3; 4	0	4	Average length of vessels: <5 m (0); 5-10 m (1); 10-15 (2); 15-20 (3); >20 (4)
Catching power	0; 1; 2: 3: 4	0		Have fishers altered gear and vessel to increase catching power over past 5 years?: No (0); very little (1); little (2); somewhat (3); a lot, rapid increase (4)
Gear side effects	0; 1; 2	0	2	Does gear have undesirable side effects (e.g. cyanide, dynamite, trawl); no (0); some (1); a lot (2).
Ethical analysis				
Adjacency and reliance	0; 1; 2; 3	3	0	geographical proximity & historical connection: not adjacent/no reliance (0); not adjacent/some reliance (1); adjacent/some reliance (2); adjacent/strong reliance (3)
Alternatives	0; 1; 2	2	0	alternatives to the fishery within community: none (0); some (1); lots (2)
Equity in entry to fishery	0; 1; 2	2	0	is entry based on traditional/historical access/harvests? not considered (0); considered (1); traditional indigenous fishery (2)
Just management	0; 1; 2; 3; 4	4	0	inclusion of fishers in management: none (0); consultations (1); co-mgmt/gov't leading (2); co-mgmt/comm. leading (3); genuine co-mgmt with all parties equal (4)
Influences – ethical formation	0; 1; 2; 3; 4	4	0	structures which could influence values: strong negative (0); some negative (1); neutral (2); some positive (3); strong positive (4)
Mitigation – habitat destruction	0; 1; 2; 3; 4	4	0	Attempts to mitigate damage to fish habitat: much damage (0); some damage (1); no ongoing damage or mitigation (2); some mitigation (3); much mitigation (4)
Mitigation – ecosystem depletion	0; 1; 2; 3; 4	4	0	Attempts to mitigate fisheries-induced ecosystem change: much damage (0); some damage (1); no damage or mitigation (2); some mitigation (3); much mitigation (4)
Illegal fishing	0; 1; 2	0	2	illegal catching/poaching/transshipments: none (0); some (1); lots (2)
Discards & wastes	0; 1; 2	0	2	discard and waste of fish: none (0); some (1); lots (2)

APPENDIX 3: SAMPLE SPSS OUTPUT FOR RAPFISH ORDINATION

Proximities

Case Processing Summary[a]

Cases					
Valid		Missing		Total	
N	Percent	N	Percent	N	Percent
99	100.0%	0	.0%	99	100.0%

a. Squared Euclidean Distance used

Alscal

ALSCAL is writing OUTFILE results to file:
C:\Rapfish\temp\alscout

Iteration history for the 2 dimensional solution (in squared distances)

Young's S-stress formula 1 is used.

Iteration	S-stress	Improvement
1	.43874	
2	.35340	.08534
3	.34529	.00812
4	.34481	.00048

Iterations stopped because
S-stress improvement is less than .001000

Stress and squared correlation (RSQ) in distances

RSQ values are the proportion of variance of the scaled data (disparities) in the partition (row, matrix, or entire data) which is accounted for by their corresponding distances.
Stress values are Kruskal's stress formula 1.

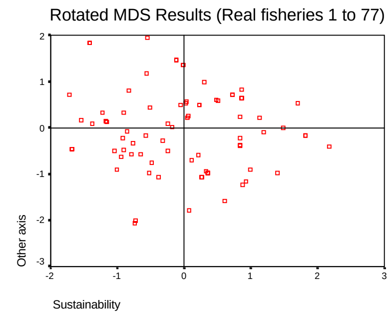
For matrix
Stress = .24497 RSQ = .74925

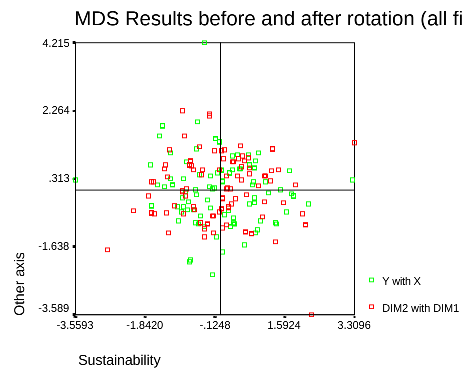
Configuration derived in 2 dimensions

Stimulus Coordinates

Dimension

Stimulus Number	Stimulus Name	1	2
1	VAR1	.7328	.4510
2	VAR2	-.9132	-.0464
3	VAR3	-.8484	-.1851
4	VAR4	1.1107	.4060
5	VAR5	-1.3288	-.6745
6	VAR6	-1.3430	.7122
7	VAR7	-2.1192	-.6137
8	VAR8	.2634	.0300
9	VAR9	1.0947	.4070
10	VAR10	.4392	.4027
11	VAR11	-.4590	.4404
12	VAR12	-.4227	.5774
13	VAR13	1.2377	.2693
14	VAR14	-.9040	-.7056
15	VAR15	-1.2747	-1.2420
16	VAR16	-.6371	-.5813
17	VAR17	-1.2541	1.1322
18	VAR18	.3200	.7986
19	VAR19	1.8551	.1502
20	VAR20	.0283	1.1151
21	VAR21	.5341	.6478
22	VAR22	-.1327	1.1255
23	VAR23	.0901	.8986
24	VAR24	.9535	.1179
25	VAR25	-.0115	.5624
26	VAR26	-.1852	-.7545
27	VAR27	.7216	.6218
28	VAR28	-.8689	1.5581
29	VAR29	.5617	.9803
30	VAR30	1.4437	.5591
31	VAR31	-.7128	.6923
32	VAR32	.1722	.0643
33	VAR33	-.7559	.7078
34	VAR34	-.7559	.7078
35	VAR35	.1566	.3967
36	VAR36	.2745	-.4177
37	VAR37	1.3747	-1.4877
38	VAR38	-1.1104	-.4554
....			
61	VAR61	1.2852	1.1762
62	VAR62	-.4799	-.9509
63	VAR63	-.4799	-.9509
64	VAR64	.6338	-1.2093
65	VAR65	.6338	-1.2093
66	VAR66	.7680	-1.2567
67	VAR67	.7680	-1.2567
68	VAR68	2.0983	-1.0014
69	VAR69	2.0983	-1.0014
70	VAR70	-.7168	.8288
71	VAR71	-.7168	.8288
72	VAR72	.1691	-1.0162
73	VAR73	-.1570	-.7535
74	VAR74	-.3199	-.9705





Appendix 4a: Historical Development and Description of the Gulf of Maine Fisheries

A general pattern in the division of catch in the Gulf of Maine emerged early. Offshore, commercial, full time sectors targeting groundfish developed first. This fishery used hooks and lines to catch such species as cod, haddock, halibut, and flatfish. Inshore, a small-scale, part time fishery emerged in which farmers and coastal townsfolk took advantage of seasonally abundant fish and invertebrates to supplement both diet and income (Table A4.1) . Through the 1900s the character of the offshore fishery changed as hook and line gave way to trawls. In the inshore fisheries also fewer part time fishers were involved so that full time fishers dominated both sectors. These trends can be seen for both Maine and Massachusetts, although the local regions differ in mix of species that were landed (Figures A4.1 and A4.2). Such differences are a function of population and biogeography. For example, the existence of large population centres with appropriate port and market infrastructure such as Boston, Gloucester, and Portland, determined where the offshore fisheries would be based. The presence of huge lobster populations in the near shore areas of Maine, and far away from large commercial centres, however, has seen this industry develop through small scale operators in almost every coastal town of that state.

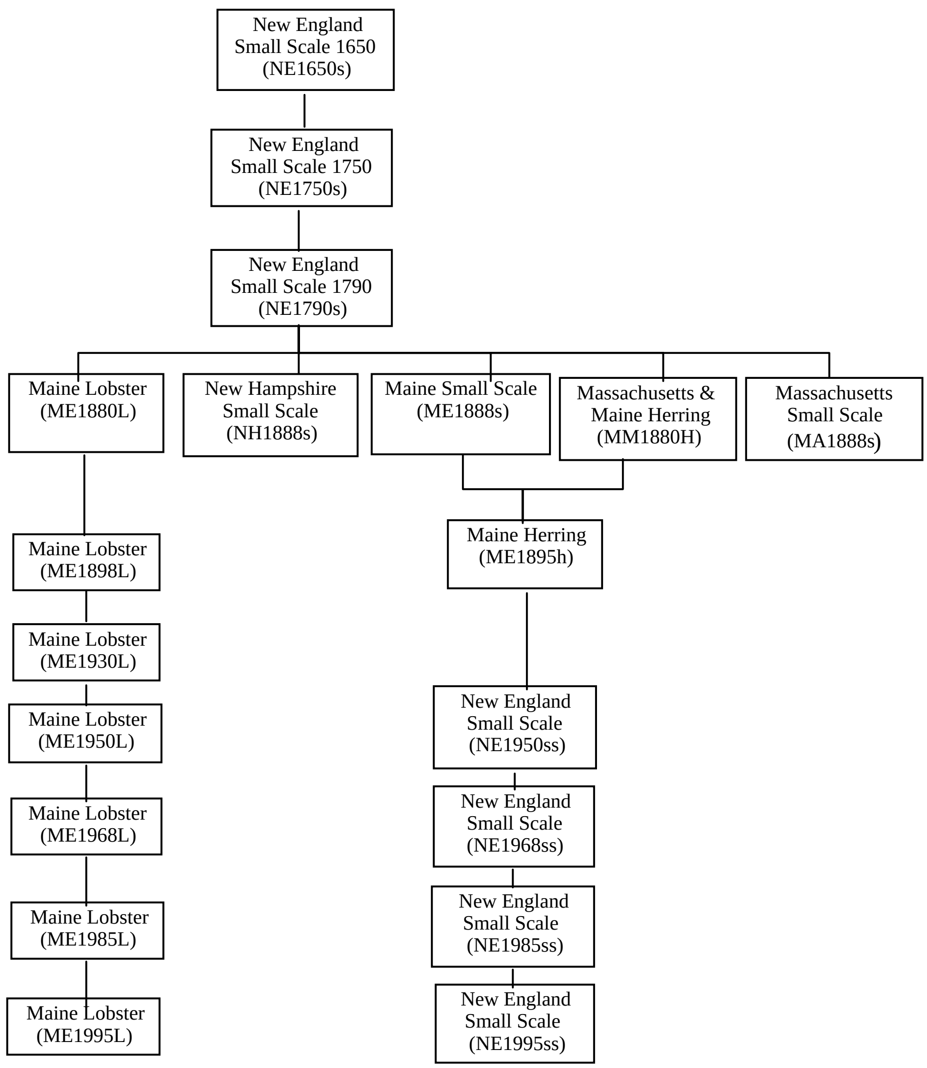


Figure A4.1. Historical development of the major small-scale Gulf of Maine fisheries used in the RAPFISH ordination.

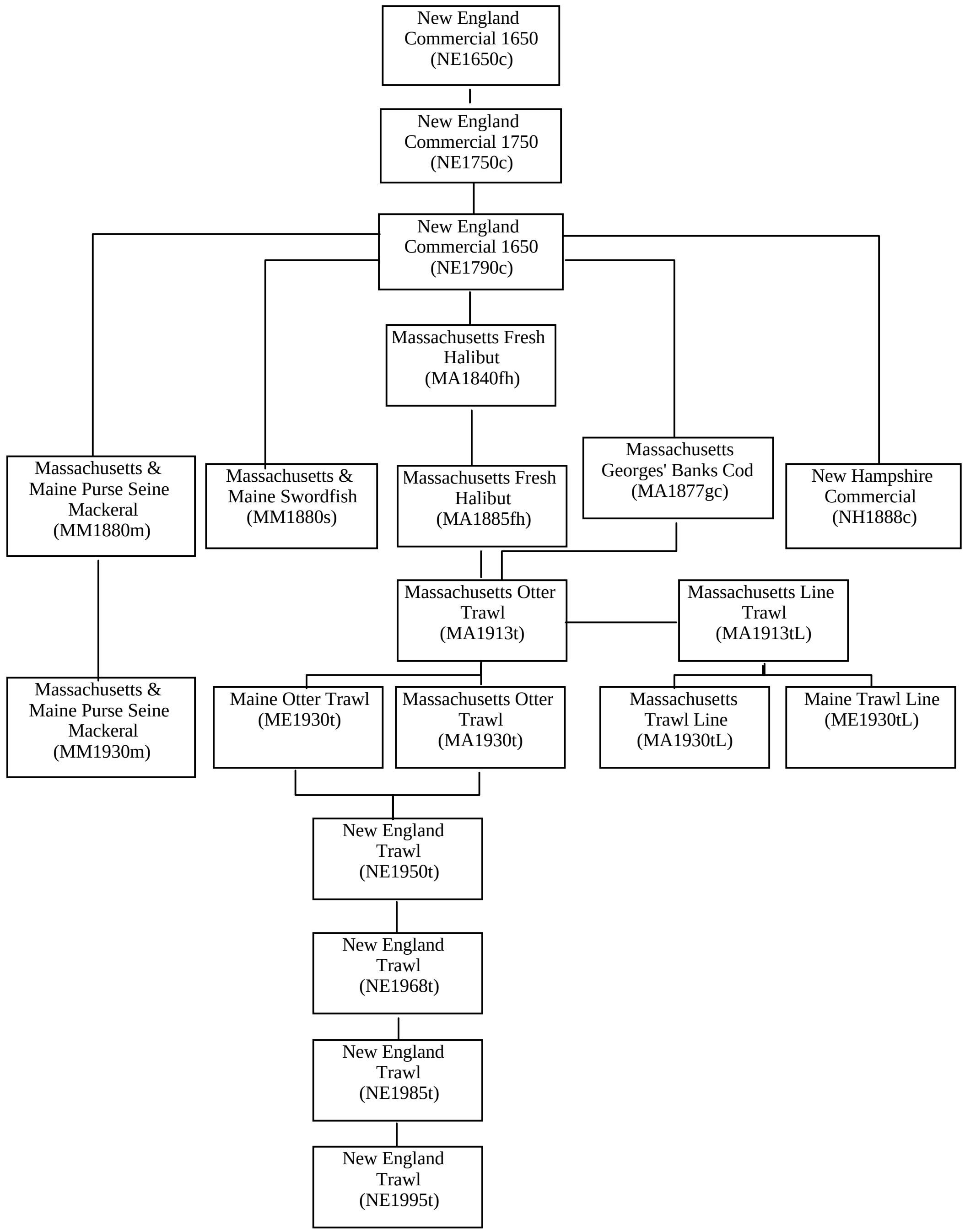


Figure A4.2: Historical development of the major large-scale commercial Gulf of Maine fisheries used in the RAPFISH ordination.

Table A4.1. Gulf of Maine fisheries in the RAPFISH ordination with their corresponding codes (as plotted on the figures) and brief notes on some of their features. Full details of the history and sources for these fisheries are provided in Appendix 4a and 5 respectively.

Definition	Description	Code
Small Scale & Inshore		
New England	Gleaning, net and line fishery on seasonally available stocks such as herring, salmon, clams and lobsters	
1650		NE1650s
1750		NE1750s
1790		NE1790s
New Hampshire 1888		NH1888s
Maine 1888		ME1888s
Massachusetts 1888		MA1888s
Main & Massachusetts Herring		
1880	Seasonal weir fishery on spawning adults	MM1880h
1895	Weir fishery on small fish for 'anchovy' canneries	ME1895h
New England	Dredging, net, and line fisheries for seasonally available stocks such as groundfish, herring and clams	
1950		NE1950ss
1968		NE1968ss
1985		NE1985ss
1995		NE1995ss
Maine Lobster	Pot trap fishery	
1880		ME1880L
1898		ME1898L
1930		ME1930L
1950		ME1950L
1968		ME1968L
1985		ME1985L
1995		ME1995L
Commercial & Offshore		
New England	Longline ground fishery off large rigged vessels targeting groundfish especially cod and haddock	
1650		NE1650c
1750		NE1750c
1790		NE1790c
New Hampshire 1880	Longline ground fishery from dories carried on large rigged vessels	NH1888c
Main & Massachusetts Swordfish 1880	Pelagic harpoon fishery from large rigged vessels, ceased to be important when the stocks were locally depleted. Fishing is now in international waters	MM1880s
Massachusetts Fresh Halibut	Longline ground fishery from dories carried on large rigged vessels	
1840		MA1840fh
1885		MA1885fh
Main & Massachusetts Purse Seine Mackerel 1880	Purse seine pelagic fishery from mid sized rigged vessels	MM1880m
1930	Purse seine pelagic fishery from mid sized motor vessels	MM1930m
Massachusetts Georges' Bank Cod 1877	Longline ground fishery from dories carried on large rigged vessels	MA1877gc
Massachusetts Line Trawl 1913		
1930	Longline ground fishery from dories carried on large rigged vessels targeting cod and haddock	MA1913tl MA1930tl
Maine Line Trawl 1930	Longline ground fishery from dories carried on large motor vessels catching cod and haddock	ME1930tl
Massachusetts Otter Trawl		
1913	Otter trawl pelagic fishery from mid sized motor vessels catching codd and haddock	MA1913t
1930		MA1930t
Maine Otter Trawl 1930	Otter trawl ground fishery from mid sized motor vessels catching cod and haddock	ME1930t
New England Trawl		
1950	Otter and sterntrawl ground fishery from mid sized motor vessels	NE1950t
1968	Otter and sterntrawl fishery from mid sized motor vessels	NE1968t
1985	Otter and sterntrawl ground fishery from mid sized motor vessels catching cod, haddock, flounder, skates, dogfish and redfish	NE1985t
1995		NE1995t

Appendix 4b: Historical Development of the German and United Kingdom Fisheries

The German fisheries in this study (Table A4.2) developed from fisheries that were established before the fourteenth century. Evolving from traditional small-scale deep-sea cutter fisheries targeting the same species, two offshore, commercial, full-time sectors catching pelagic and demersal fish were established. These fisheries used bottom and later mid-water trawls as well as long-lines to catch such species as cod, haddock, herring, and flatfish. Parallel to these and in increasingly heavier competition with the herring trawlers, a traditional lugger driftnet fishery for herring (salted directly onboard) operated in the Southern North Sea for centuries.

As the deep-sea fishery developed and expanded further offshore by improving boat and gear technology the species composition in the demersal fishery altered from cod and haddock to saithe and to some extent whiting and redfishes. Since the 1920s serial depletion forced German fisheries to spread out further and further and by 1975 most of the deep sea fleet was operating in distant waters and only a small proportion of all catches still stems from the North Sea. The catch was by saithe at that time. However, due to overexploitation of this species, today, the catch of Germany's deep-sea demersal fishery is made up of very small proportions of a variety of species with saithe only contributing 30% to the overall catch. Similarly, the proportion of herring in the catch of the pelagic trawling and the lugger fleet has declined steadily since the 1950s, when it made up more than 90% of the total catch. The economically struggling lugger fishery shifted to saithe in the 1970s, but was discontinued shortly after. Today, less than a third of the catches of the remaining pelagic trawling fleet are herring. Inshore, however, artisanal fisheries for oysters, shrimp, flatfish and herring were well established early this century but have since either ceased, declined or shifted to aquaculture production.

The traditional cutter deep-sea fleets once fished exclusively for flatfish, herring and sprat in the North Sea. Competition from large-scale commercial fisheries continuously diminished in importance of this fleet during the past century. The pelagic segment of this fishery temporarily experienced a revival when there was a huge expansion in the industrial fishing sector. By 1950 large numbers of juvenile herring and sprat were caught solely for the purpose of being processed into fishmeal. Due to the collapse of the herring stocks caused by recruitment overfishing, by 1975 this industrial cutter fishery was targeting mainly sand-eel and sprat and was discontinued around 1980. Although the deep-sea cutter fishery for flatfish and some demersal species is still on going, there is very little offshore fishing in the North Sea today.

The artisanal fisheries continued to develop into the nineteenth century and started to target mussel and hydrozoids (for ornaments) in addition to the traditional coastal species at the turn of the century. They diminished, however, greatly in importance with the onset of the industrialization and some fisheries ceased to operate (oysters and hydrozoid) or merged with the cutter deep-sea fleet targeting the same species (herring, sprat (in estuaries) and flatfish) between 1925 and 1950. The shrimp and mussel fisheries, formerly rather insignificant fisheries, are all that remain of the major coastal fisheries. In the 1950s and 1960s the shrimp fishery was threatened by serious recruitment over-fishing with 90% of the catch as juveniles processed into fish meal. Since then the focus has shifted back to mature shrimps caught for human consumption and today this fishery has been restored to highest valued fishery in Germany, surpassing the entire deep-sea fishing sector in economic importance. The current mussel fisheries have essentially turned into an aquaculture, which, however, still relies on the remaining wild mussel banks to harvest seedlings to be raised to maturity in mussel farms.

The United Kingdom fisheries in this study are commercial offshore fisheries and they have followed a similar trend to the German Fisheries. The English fisheries changes occurred at the same time as the German fisheries as boat and gear developed. Similar changes in the Scottish fisheries were delayed since the fishery was less centralised and more family based than the other countries. Today cod and haddock comprise much of the UK fisheries, however, there is concern with the sustainability of these fisheries. A beam trawl is used in this fishery today, the trawl produces a large amount of discards as well as catching juvenile plaice.

Table A4.2. German and United Kingdom North Sea fisheries evaluated using RAPFISH, together with their corresponding codes and brief notes on some of their features. Full details of the sources for these fisheries are provided in Appendix 4b and 5 respectively.

Fishery	Description	Code
GERMAN FISHERIES		
Deep Sea Demersal Fishery	initially cod, haddock and flatfishes primarily, used beam trawls and long-lines but changed to otter trawls in 1900s. Haddock and cod declined and whiting and saithe caught with otter trawls and long-lines. By 1950 mainly saithe, some herring and very little mackerel and cod caught. By 1975 fishing in distant waters and the catch is almost exclusively saithe. By 1997 redfish is an increasing component of the catch along with saithe, minor quantities of cod and haddock are taken. Today, these fisheries have decreased dramatically in importance.	GHS1880D, GHS1900D, GHS25D, GHS50D, GHS75D, GHS97D
Deep Sea Pelagic fishery	Primarily herring was found offshore in the North Sea using steamers with mid-water trawls. By 1975 the fishery moved mostly into distant waters. A decline of North Sea herring stocks resulted in a decrease of herring in the catch and by 1997 only 30% of the catch was herring, with mackerel (5%), horse mackerel (5%). Today, these fisheries have decreased dramatically in importance.	GHS25H, GHS50H, GHS75H, GHS97H
Cutter Deep Sea fishery - industrial	herring (including juvenile) and some sprat, full-time small scale fishers between the mainland and off-shore islands in the southern North Sea, Wadden sea and river estuaries used sailing cutters with specialised bottom trawls. By 1950 catch was primarily juvenile herring and some sprat, by trawling. Industrial fishing of "oil" herring commenced. By 1975 the catch was mainly sandeel and sprat with some juvenile herring. By 1997 these industrial fisheries are no longer operating.	CDS1880I, CDS1900I, CDS25I, CDS50I, CDS75I
Cutter Deep Sea fishery - flatfishes	mainly flounder, plaice, sole, lemon sole, etc between the mainland and off-shore islands in the southern North Sea, used sailing cutters with beam trawls. In 1900s demersals such as cod and haddock also caught in long-lines, otter trawls were also used. By 1925 most of the catch was plaice (over exploitation) with haddock, lemon sole and cod making up less than 12% of the catch. Long-lining for tuna occured during 1920s and by 1950s plaice declined with cod, whiting and tuna making up the rest of the catch. By 1975 the catch composition changed again with cod (50%), saithe (30%), haddock (7%) plaice(6%).	CDS1880F, CDS1900F, CDS25F, CDS50F, CDS75S, CDS97S
Lugger Herring Fishery	seasonal driftnet fishery targeted exclusively herring in the southern North Sea area, used sailing luggers, catch processed into the salt-herring. Until 1900s fishing grounds slowly expanded further out into the North Sea. With the start of the herring trawler fishery around the 1925, this fishery declined despite attempts to modernize the fleet.	GH1880S, GH1900S, GH25S, GH50S
Lugger Herring Fishery	evolved from the traditional lugger fishery in the 1950s, targeted fresh herring using mainly driftnets on a seasonal basis in the off-shore areas especially in the southern area of the North Sea. By 1975 most of the catch was saithe, The fishery continued to decline in profitability, and indeed ceased to exist a few years later.	GH50F, GH75F
Coastal fishery shrimps	Originally catching shrimps and some flatfish in passive weirs, on a casual basis. In 1900s and 1925 some full time fishing on a seasonal basis, immature shrimps were caught and small beam trawls dominated. By 1950 the fishers were full-time during the season, but over 90% of the catch was immature shrimp, this period corresponded to expansion of the fishery for juvenile shrimp for fish meal. With the decreasing profitability of the industrial fishery by 1975, fishery shifted back to focus on shrimps caught for human consumption, becoming in turn the most profitable of all German fisheries by 1997.	CF1880S, CF1900S, CF25S, CF50S, CF75S, CF97S
Coastal fishery mussels	originally on a casual basis in coastal and island areas in the Wadden Sea used manual dredges or collected at low tide. By 1925 larger fishing vessels with dredges were used and by 1950 fishing wass primarily full-time. By 1975 the industry was aquaculture based, and this fishery now collects juvenile animals for grow-out on farms.	CF1900M, CF25M, CF50M, CF75M, CF97M

Coastal fishery oysters	oysters, artisanal fishery on a seasonal basis, mainly inshore or off the islands areas in the Wadden sea fished used quite large fishing vessels with dredges. The fishery peaked in 1870s but due to over-exploitation the fishery ceased to exist after 1925.	CF1880O, CF1900O, CF25O
Coastal fishery hydrozoids	an ornamental artisinal fishery for hydrozaons and hydrallmania located in coastal or island areas in the Wadden Sea, used rakes and some set nets on a casual basis around 1880. Due to high profitability of fishery, fishing power expanded rapidly with larger dredge trawlers used. By 1925 the fishery declined and essentially ceased to exist around 1940.	CF1880H, CF1900H, CF25H
Coastal fishery estuary	an artisanal partially full-time mixed fishery for herring, sprat, sturgeon, salmon and eel located in coastal or river areas relying mainly on set nets and some small scale trawling gear. By the 1900s sturgeon and salmon depleted. By 1925 small scale trawls dominated and the focus shifted almost exclusively to herring and sprat (some eels).	CF1880R, CF1900R, CF25R
Coastal fishery flatfish	mainly flounder, plaice, sole, lemon sole, etc., artisanal fishers in inshore coastal areas and off-shore islands in the Wadden Sea and river estuaries, used small vessels with set nets, long-lines and beam trawls. By 1925 the fishery decreased in importance and most fishing was casual. By 1950 the fishery was no longer operating except offshore.	CF1880F, CF1900F, CF25F
UNITED KINGDOM		
1900s		
Scottish Line Fishery	haddock, cod, and plaice were caught in a local, small-scale fishery with strong family involvement. Eventually the fishery was out-competed by trawlers. After 1910 line fisheries faded in importance in Scotland.	SC10CL SC10PL SC10HAL
Scottish Trawl Fishery	trawl fleet catching cod, haddock, and plaice, with some boats fishing north of the North Sea to find less diminished stocks.	SC10CT SC10PT SC10HAT
Herring Drift Net Fishery	primarily herring especially in Scotland	SC10HD EN10HD
English Trawl Fishery	Primarily cod, haddock and plaice were caught	EN10CT EN10HAT EN10PT
1950s		
Herring Drift Net Fishery	The herring fishery had lost its importance and profitability in both England and Scotland by the 1950s.	SC55HD EN55HD
Trawl and Seine Net Fishery	World War II allowed the haddock, plaice, and cod stocks a brief recovery. By 1955, however, the catches had decreased to pre-war or close to pre-war levels.	EN55HATS SC55HATS EN55CTS SC55CTS EN55PTS SC55PTS
1990s		
Herring Pelagic Trawl and Purse Seine	Herring catches increased after the fishery closure (ending in the early 1980's) but were decreasing again by 1990. The herring fishery was of a lower importance, in the 1990s, due to industrial herring fisheries conducted by other countries.	EN90HTS SC90HTS
Trawl and Seine Fisheries	The cod and haddock stocks were severely over fished by the early 1990's. Cod and haddock comprised a large part of the UK fisheries.	EN90HATS SC90HATS EN90CTS SC90CTS
Plaice Beam Trawl Fishery	relatively efficient in catching plaice and other species, but a very destructive with a high level of by-catch. The plaice stock was not as depleted as that of the cod and haddock, but juvenile plaice were being caught and discarded	EN90PBT SC90PBT

APPENDIX 5(PART 1): ORIGINAL DATA USED FOR THE GULF OF MAINE FISHERIES IN THE FIVE 'RAPFISH' FIELDS. SOURCES OF SCORES ARE DOCUMENTED IN APPENDIX 11 AND DISCUSSED IN APPENDIX 4.

Fishery	Abbreviation	**SOCIAL**	socialisation of fishing	fishing community growth	fishing sector	environmental knowledge	education level	conflict status	fisher influence	fishing income	kin participation	**TECHNOLOGICAL**	trip length	landing sites	pre-sale processing	use of ice	gear	selective gear	power gear	FADS	Sonar	Average Boat Size	catching power	gear side effects	**ETHICAL**	Adjacency & Reliance	Alternatives	Equity in Entry	Just Management	Infl. in Ethical Formation	Mit. of Habitat Destruction	Mit. of Ecosystem Depl.	Illegal Fishing	Discards & wastes
New England mid 1600s small scale	NE1650s		1.0	2.0	2.0	0.0	0.0	1.0	2.0	1.0	1.0		0.5	1.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0		2.0	1.0	0.0	3.0	3.0	1.0	0.0	0.0	2.0
New England mid 1600s commercial	NE1650c		0.0	2.0	2.0	0.0	0.0	1.0	2.0	2.0	0.0		30.0	2.0	2.0	0.0	1.0	2.0	0.0	0.5	0.5	1.0	1.0	0.0		2.0	1.0	0.0	3.0	3.0	1.0	0.0	0.0	2.0
New England mid 1700s small scale	NE1750s		1.0	2.0	1.0	1.0	0.0	2.0	1.0	1.0	1.0		0.5	1.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	2.0	0.0		3.0	0.0	0.0	2.0	3.0	1.0	1.0	2.0	1.0
New England mid 1700s commercial	NE1750c		0.0	2.0	1.0	1.0	1.0	2.0	1.0	2.0	0.0		22.0	2.0	2.0	0.0	1.0	1.0	0.0	0.5	0.5	2.0	2.0	1.0		3.0	1.0	0.0	2.0	3.0	1.0	1.0	2.0	1.0
New England late 1700s small scale	NE1790s		1.0	2.0	1.0	1.0	0.0	2.0	2.0	1.0	1.0		0.5	1.0	2.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0		3.0	0.0	0.0	3.0	1.0	0.0	0.0	2.0	1.0
New England late 1700s commercial	NE1790c		0.0	2.0	1.0	1.0	0.0	2.0	2.0	2.0	0.0		22.0	2.0	2.0	0.0	1.0	1.0	0.0	0.5	0.5	2.0	1.0	1.0		3.0	0.0	0.0	3.0	2.0	0.0	0.0	1.0	1.0
Maine 1888 small scale	Me1888s		1.0	2.0	0.0	1.0	0.0	0.0	0.0	2.0	1.0		0.5	1.0	1.0	1.0	0.0	1.0	0.0	0.0	0.5	1.0	2.0	1.0		3.0	2.0	0.0	1.0	2.0	1.0	2.0	0.0	1.0
Massachussets 1888 small scale	Ma1888s		1.0	2.0	0.0	1.0	0.0	0.0	0.0	2.0	1.0		0.5	1.0	1.0	1.0	0.0	1.0	0.0	0.0	0.5	1.0	2.0	1.0		3.0	2.0	0.0	1.0	2.0	1.0	2.0	0.0	1.0
New Hampshire 1888 small scale	NH1888s		1.0	2.0	0.0	1.0	0.0	0.0	0.0	2.0	1.0		0.5	1.0	1.0	1.0	0.0	2.0	0.0	0.0	0.5	1.0	2.0	1.0		3.0	2.0	0.0	1.0	2.0	1.0	2.0	0.0	1.0
New Hampshire 1888 commercial	NH1888c		0.0	2.0	0.0	1.0	1.0	0.0	0.0	2.0	0.0		5.0	1.0	0.0	1.0	0.0	0.0	0.0	0.5	0.5	2.0	1.0	1.0		3.0	1.0	0.0	1.0	2.0	0.0	1.0	0.0	1.0
Massachusetts fresh halibut 1840	MA1840fh		0.0	2.0	0.0	1.0	1.0	0.0	0.0	2.0	0.0		5.0	2.0	0.5	1.0	0.0	1.0	0.0	0.5	0.5	1.0	2.0	0.0		3.0	2.0	0.0	1.0	2.0	2.0	0.0	0.0	1.0
Massachusetts fresh halibut 1885	MA1885fh		0.0	2.0	0.0	2.0	2.0	0.0	0.0	2.0	0.0		28.0	2.0	1.5	2.0	0.0	1.0	0.0	0.5	0.5	2.0	2.0	0.0		3.0	2.0	0.0	1.0	0.0	2.0	0.0	0.0	1.0
Massachusetts George's Bank cod late 1870's	MA1877gc		0.0	2.0	0.0	1.0	0.0	0.0	0.0	2.0	0.0		7.0	2.0	1.0	1.0	0.0	1.0	0.0	0.5	0.5	1.0	2.0	0.0		3.0	1.0	0.0	1.0	2.0	2.0	1.0	0.0	1.0
Massachusstets + Maine purse seine mackerel 1880	MM1880m		0.0	2.0	0.0	1.0	1.0	2.0	1.0	2.0	0.0		1.0	2.0	1.0	1.0	1.0	0.0	0.0	1.0	0.5	2.0	2.0	1.0		3.0	1.0	0.0	2.0	1.0	0.0	0.0	0.0	2.0
Massachussets + Maine swordfish 1880	MM1880s		0.0	2.0	0.0	2.0	1.0	0.0	0.0	2.0	0.0		12.0	2.0	0.5	0.0	1.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0		3.0	1.0	0.0	1.0	3.0	2.0	2.0	0.0	0.0
Massachussets + Maine herring 1880	MM1880h		2.0	2.0	0.0	1.0	0.0	1.0	0.0	2.0	0.0		0.5	0.0	0.5	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0		3.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
Maine 1895 herring	ME1895h		1.0	2.0	2.0	1.0	0.0	2.0	0.0	2.0	0.0		0.5	0.0	0.5	0.0	0.0	1.0	0.0	1.0	0.0	0.0	2.0	1.0		3.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0
Maine 1880 lobster	ME 1880l		1.0	2.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0		0.5	0.0	0.0	0.0	0.0	2.0	0.0	0.5	0.0	0.0	1.0	0.0		3.0	1.0	0.0	1.0	3.0	0.0	1.0	1.0	0.0
Maine 1898 lobster	ME 1898l		1.0	2.0	2.0	1.0	1.0	0.0	0.0	2.0	0.0		0.5	0.0	0.0	0.0	0.0	2.0	0.0	0.5	0.0	0.0	1.0	0.0		3.0	1.0	0.0	1.0	1.0	0.0	2.0	1.0	0.0
Massachusstets otter trawl fisheries 1913	MA1913t		0.0	1.0	0.0	1.0	1.0	2.0	1.0	2.0	0.0		5.0	2.0	0.5	2.0	1.0	0.0	1.0	0.0	0.5	2.0	2.0	2.0		2.0	2.0	0.0	1.0	1.0	0.0	0.0	0.0	2.0
Massachusetts trawl line fishery 1913	MA1913tl		0.0	1.0	0.0	1.0	1.0	2.0	0.0	2.0	0.0		7.0	2.0	1.0	1.0	0.0	1.0	0.0	0.5	0.5	2.0	1.0	1.0		3.0	2.0	1.0	2.0	2.0	2.0	2.0	0.0	1.0
Massachusetts + Maine purse seine mackerel 1930	MM1930m		0.0	1.0	0.0	1.0	1.0	1.0	0.0	2.0	0.0		1.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	1.0	0.0	1.0		2.0	2.0	0.0	1.0	2.0	1.0	1.0	0.0	1.0
Maine lobster 1930	ME1930l		1.0	1.0	1.0	2.0	1.0	0.0	1.0	2.0	1.0		0.5	0.0	0.0	0.0	0.0	2.0	0.0	0.5	0.5	0.0	0.0	0.0		3.0	1.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0
Maine trawl line 1930	ME1930tl		0.0	1.0	0.0	1.0	1.0	1.0	1.0	2.0	0.0		6.9	2.0	0.0	1.0	0.0	1.0	0.0	0.5	0.5	2.0	0.0	1.0		3.0	1.0	0.0	2.0	3.0	2.0	2.0	0.0	1.0
Maine otter trawl 1930	ME1930t		0.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	0.0		7.8	2.0	0.5	1.0	1.0	0.0	1.0	0.0	0.5	2.0	2.0	2.0		3.0	1.0	0.0	2.0	3.0	0.0	0.0	0.0	2.0
Massachusetts trawl line 1930	MA1930tl		0.0	1.0	0.0	1.0	1.0	1.0	1.0	2.0	0.0		6.9	2.0	0.0	1.0	0.0	1.0	0.0	0.5	0.5	2.0	0.0	1.0		3.0	2.0	0.0	2.0	3.0	2.0	2.0	0.0	1.0
Massachusetts otter trawl 1930	MA1930t		0.0	1.0	0.0	1.0	1.0	1.0	2.0	2.0	0.0		7.8	2.0	0.5	1.0	1.0	0.0	1.0	0.0	0.5	2.0	2.0	2.0		3.0	2.0	0.0	2.0	3.0	0.0	0.0	0.0	2.0
New England inshore 1950	NE1950ss		1.0	1.0	0.0	2.0	1.0	1.0	1.0	1.0	0.0		0.5	1.0	0.5	1.0	0.5	1.0	0.0	0.5	0.5	1.0	0.0	1.0		2.0	1.0	1.0	2.0	3.0	1.0	1.0	0.0	1.0
New England trawl 1950	NE1950t		0.0	1.0	0.0	1.0	1.0	1.0	2.0	2.0	0.0		8.0	2.0	0.5	2.0	1.0	0.0	1.0	0.0	2.0	2.0	1.0	2.0		2.0	2.0	0.0	2.0	1.0	0.0	0.0	0.0	2.0
Maine lobster 1950	ME1950l		1.0	1.0	1.0	2.0	1.0	0.0	1.0	2.0	0.0		0.5	0.0	0.0	1.0	0.0	2.0	1.0	0.5	1.0	1.0	1.0	0.0		3.0	2.0	1.0	2.0	4.0	2.0	3.0	0.0	0.0
New England inshore 1968	NE1968ss		1.0	1.0	0.0	2.0	1.0	2.0	2.0	1.0	0.0		0.5	1.0	0.5	1.0	0.5	1.0	0.0	0.5	0.5	1.0	0.0	1.0		2.0	1.0	1.0	2.0	3.0	1.0	2.0	0.0	1.0
New England Trawl 1968	NE1968t		0.0	1.0	0.0	1.0	1.0	2.0	2.0	2.0	0.0		8.0	2.0	0.5	2.0	1.0	0.0	1.0	0.0	2.0	2.0	1.0	2.0		1.0	2.0	0.0	3.0	0.0	0.0	0.0	0.0	2.0
Maine lobster 1968	ME1968l		1.0	1.0	1.0	2.0	1.0	1.0	2.0	2.0	0.0		0.5	0.0	0.0	1.0	0.0	2.0	1.0	0.5	1.0	1.0	0.0	0.0		2.0	2.0	1.0	3.0	4.0	2.0	3.0	0.0	0.0
New England inshore 1985	NE1985ss		0.0	1.0	0.0	2.0	1.0	2.0	2.0	2.0	0.0		0.5	1.0	1.0	1.0	0.5	2.0	1.0	0.5	1.0	1.0	2.0	2.0		1.0	2.0	1.0	3.0	4.0	2.0	3.0	0.0	0.0
New England Trawl 1985	NE1985t		0.0	1.0	0.0	1.0	2.0	2.0	2.0	2.0	0.0		8.0	2.0	1.0	2.0	1.0	0.0	1.0	0.0	1.0	1.0	2.0	2.0		1.0	2.0	1.0	3.0	3.0	0.0	3.0	0.0	1.0
Maine lobster 1985	ME1985l		0.0	1.0	1.0	2.0	1.0	0.0	2.0	2.0	0.0		0.5	0.0	0.0	1.0	0.0	2.0	1.0	0.5	1.0	1.0	1.0	0.0		2.0	1.0	1.0	2.0	3.0	2.0	2.0	0.0	0.0
New England inshore 1995	NE1995ss		0.0	0.0	0.0	2.0	1.0	2.0	1.0	2.0	0.0		0.5	2.0	1.0	1.0	0.5	2.0	1.0	0.5	1.0	1.0	1.0	2.0		1.0	2.0	1.0	2.0	4.0	2.0	4.0	0.0	0.0
New England Trawl 1995	NE1995t		0.0	0.0	0.0	2.0	2.0	2.0	1.0	2.0	0.0		8.0	2.0	1.0	2.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	2.0		1.0	2.0	1.0	2.0	3.0	3.0	4.0	0.0	1.0
Maine lobster 1995	ME1995l		0.0	0.0	1.0	2.0	1.0	0.0	2.0	2.0	0.0		0.5	0.0	0.0	1.0	0.0	2.0	1.0	0.5	1.0	1.0	0.0	0.0		2.0	1.0	1.0	4.0	3.0	3.0	2.0	0.0	0.0
Good	G		2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	4.0		0.5	0.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		3.0	2.0	2.0	4.0	4.0	4.0	4.0	0.0	0.0
Bad	B		0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0		30.0	3.0	0.0	0.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0

APPENDIX 5 (PART 2): ORIGINAL DATA USED FOR THE GULF OF MAINE FISHERIES IN THE FIVE 'RAPFISH' FIELDS.

Fishery	Abbreviation	ECOLOGICAL	exploitation status	recruitment variability	change in T level	migratory range	range collapse	size of fish caught	catch < maturity	discarded bycatch	species caught	primary production	ECONOMIC	Price	fisheries in GDP	relative income	limited entry	marketable right	other income	ownership	market	subsidy
land mid 1600s small scale	NE1650s		0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	3.0		0.0	1.0	1.0	1.0	0.0	2.0	1.0	0.0	0.0
land mid 1600s commercial	NE1650c		0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	3.0		1.0	1.0	1.0	1.0	0.0	3.0	2.0	2.0	0.0
land mid 1700s small scale	NE1750s		0.0	0.0	0.0	0.0	1.0	1.0	0.0	2.0	1.0	3.0		1.0	2.0	1.0	0.0	0.0	2.0	0.0	0.0	0.0
land mid 1700s commercial	NE1750c		3.0	2.0	0.0	0.0	1.0	1.0	1.0	2.0	0.0	3.0		2.0	2.0	1.0	1.0	0.0	3.0	0.0	2.0	2.0
land late 1700s small scale	NE1790s		1.0	0.0	2.0	0.0	1.0	1.0	2.0	1.0	1.0	3.0		1.0	2.0	1.0	0.0	0.0	2.0	0.0	1.0	0.0
land late 1700s commercial	NE1790c		2.0	2.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0	3.0		1.0	2.0	1.0	0.0	0.0	3.0	0.0	2.0	2.0
88 small scale	Me1888s		1.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	1.0	3.0		1.0	2.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
ssets 1888 small scale	Ma1888s		1.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	1.0	3.0		1.0	2.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
pshire 1888 small scale	NH1888s		1.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	1.0	3.0		1.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0
pshire 1888 commercial	NH1888c		1.0	2.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0	3.0		2.0	0.0	1.0	0.0	0.0	3.0	0.0	1.0	0.0
setts fresh halibut 1840	MA1840fh		0.0	2.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	3.0		1.0	2.0	2.0	1.0	0.0	3.0	0.0	0.0	0.0
setts fresh halibut 1885	MA1885fh		2.0	2.0	0.0	1.0	2.0	1.0	0.0	1.0	0.0	3.0		3.0	2.0	2.0	2.0	0.0	3.0	0.0	1.0	0.0
setts George's Bank cod late 1870's	MA1877gc		2.0	2.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	3.0		1.0	2.0	1.0	0.0	0.0	3.0	0.0	1.0	0.0
sstets + Maine purse seine mackerel 1880	MM1880m		2.0	2.0	0.0	1.0	1.0	0.0	0.0	2.0	0.0	3.0		2.0	2.0	1.0	0.0	0.0	3.0	0.0	1.0	0.0
ssets + Maine swordfish 1880	MM1880s		0.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	3.0		2.0	2.0	1.0	0.0	0.0	3.0	0.0	0.0	0.0
ssets + Maine herring 1880	MM1880h		3.0	2.0	0.0	1.0	1.0	1.0	2.0	1.0	0.0	3.0		2.0	2.0	1.0	1.0	0.0	3.0	0.0	0.0	0.0
95 herring	ME1895h		3.0	2.0	1.0	1.0	1.0	1.0	2.0	1.0	0.0	3.0		0.0	2.0	1.0	2.0	1.0	2.0	0.0	1.0	0.0
80 lobster	ME 1880l		2.0	2.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	3.0		1.0	2.0	1.0	1.0	0.0	2.0	0.0	1.0	0.0
98 lobster	ME 1898l		3.0	2.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	3.0		4.0	2.0	1.0	1.0	0.0	2.0	0.0	1.0	0.0
sstets otter trawl fisheries 1913	MA1913t		3.0	1.0	2.0	1.0	2.0	1.0	2.0	2.0	1.0	3.0		1.0	1.0	2.0	1.0	0.0	3.0	0.0	1.0	0.0
setts trawl line fishery 1913	MA1913tl		3.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	1.0	3.0		1.0	1.0	2.0	1.0	0.0	3.0	0.0	1.0	0.0
setts + Maine purse seine mackerel 1930	MM1930m		3.0	2.0	0.0	1.0	1.0	0.0	1.0	1.0	0.0	3.0		1.0	0.0	2.0	1.0	0.0	3.0	0.0	1.0	0.0
ster 1930	ME1930l		2.0	2.0	0.0	0.0	1.0	2.0	1.0	0.0	0.0	3.0		5.0	2.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0
wl line 1930	ME1930tl		2.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	3.0		1.0	1.0	2.0	2.0	0.0	3.0	0.0	1.0	0.0
er trawl 1930	ME1930t		3.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	3.0		1.0	1.0	2.0	1.0	0.0	3.0	0.0	1.0	0.0
setts trawl line 1930	MA1930tl		2.0	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	3.0		1.0	0.0	2.0	2.0	0.0	3.0	0.0	1.0	0.0
setts otter trawl 1930	MA1930t		3.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	3.0		1.0	0.0	2.0	1.0	0.0	3.0	0.0	1.0	0.0
land inshore 1950	NE1950ss		2.0	1.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	3.0		0.0	0.0	1.0	1.0	0.0	1.0	0.0	0.0	0.0
land trawl 1950	NE1950t		3.0	2.0	0.0	1.0	1.0	1.0	1.0	2.0	0.0	3.0		1.0	0.0	2.0	2.0	0.0	3.0	0.5	1.0	2.0
ster 1950	ME1950l		1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0		5.0	1.0	1.0	2.0	0.0	3.0	0.0	1.0	1.0
land inshore 1968	NE1968ss		3.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	3.0		2.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0
land Trawl 1968	NE1968t		3.0	2.0	2.0	1.0	2.0	1.0	1.0	2.0	0.0	3.0		2.0	0.0	1.0	2.0	1.0	3.0	0.5	1.0	2.0
ster 1968	ME1968l		2.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	3.0		5.0	1.0	1.0	2.0	1.0	3.0	0.0	1.0	2.0
land inshore 1985	NE1985ss		3.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	1.0	3.0		3.0	0.0	1.0	2.0	0.0	3.0	0.0	1.0	2.0
land Trawl 1985	NE1985t		3.0	2.0	1.0	1.0	2.0	2.0	2.0	2.0	0.0	3.0		3.0	0.0	1.0	2.0	0.0	3.0	0.0	1.0	2.0
ster 1985	ME1985l		1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0		5.0	1.0	1.0	1.0	0.0	3.0	0.0	1.0	1.0
land inshore 1995	NE1995ss		3.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	3.0		3.0	0.0	0.0	2.0	2.0	3.0	0.0	1.0	2.0
land Trawl 1995	NE1995t		3.0	2.0	2.0	1.0	0.0	1.0	1.0	1.0	0.0	3.0		3.0	0.0	0.0	2.0	2.0	3.0	0.0	1.0	2.0
ster 1995	ME1995l		2.0	2.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	3.0		5.0	1.0	0.0	2.0	2.0	3.0	0.0	1.0	1.0
	G		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0		5.0	2.0	4.0	2.0	2.0	0.0	0.0	0.0	0.0
	B		3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0		0.0	0.0	0.0	0.0	0.0	3.0	2.0	2.0	2.0

Appendix 6: Results of the MDS Rapfish ordination on the five evaluation fields for the 38 Gulf of Maine fisheries. Values for sustainability axes only, as percentage of the best possible.

Fishery	ethical	social	economic	technological	ecological
New England mid 1600s small scale	44.8	15.5	36.7	69.9	91.3
New England mid 1600s commercial	44.8	31.2	14.8	33.1	93.3
New England mid 1700s small scale	40.9	27.1	47.6	69.7	80.2
New England mid 1700s commercial	46.2	47.4	32.7	26.1	67.8
New England late 1700s small scale	29.1	31.5	43.3	69.5	61.5
New England late 1700s commercial	37.8	44.7	25.2	28.3	71.4
Maine 1888 small scale	48.8	27.7	40.0	61.0	85.6
Massachussets 1888 small scale	48.8	27.7	40.0	61.0	85.6
New Hampshire 1888 small scale	48.8	27.7	37.3	64.7	85.6
New Hampshire 1888 commercial	41.6	43.9	37.5	58.1	82.1
Massachusetts fresh halibut 1840	44.6	43.9	48.4	57.0	93.8
Massachusetts fresh halibut 1885	35.5	68.2	49.7	26.5	73.6
Massachusetts George's Bank cod late 1870s	45.9	35.4	38.3	55.5	83.7
Massachusstets + Maine purse seine mackerel 1880	34.9	50.5	40.1	32.6	79.2
Massachussets + Maine swordfish 1880	54.1	57.1	45.0	52.6	98.8
Massachussets + Maine herring 1880	42.7	32.1	47.2	75.0	64.4
Maine 1895 herring	32.6	28.3	52.5	76.4	63.1
Maine 1880 lobster	43.1	21.2	45.3	77.8	83.9
Maine 1898 lobster	37.9	34.2	51.2	77.8	77.9
Massachusstets otter trawl fisheries 1913	31.9	56.8	42.4	35.7	48.1
Massachusetts trawl line fishery 1913	57.8	53.0	42.4	51.3	57.2
Massachusetts + Maine purse seine mackerel 1930	45.6	52.4	39.8	64.0	75.1
Maine lobster 1930	47.7	63.2	63.4	79.6	75.8
Maine trawl line 1930	53.5	54.7	43.6	54.5	70.2
Maine otter trawl 1930	41.4	55.1	42.4	32.9	56.7
Massachusetts trawl line 1930	56.5	54.7	40.0	54.5	70.3
Massachusetts otter trawl 1930	44.5	58.7	39.8	32.9	56.7
New England inshore 1950	52.2	59.2	48.9	59.1	79.3
New England trawl 1950	35.2	58.7	34.4	31.5	65.4
Maine lobster 1950	70.3	60.7	47.8	72.9	93.1
New England inshore 1968	53.9	69.5	57.3	58.9	66.4
New England Trawl 1968	25.7	61.3	40.2	31.6	57.9
Maine lobster 1968	71.4	64.0	51.8	77.2	87.5
New England inshore 1985	72.9	70.1	38.2	52.6	55.1
New England Trawl 1985	64.7	73.4	38.2	35.9	48.4
Maine lobster 1985	58.7	64.2	45.7	72.7	93.1
New England inshore 1995	73.3	75.8	52.0	48.5	66.2
New England Trawl 1995	68.6	83.8	52.0	37.9	66.5
Maine lobster 1995	71.9	75.3	59.4	77.1	87.5

APPENDIX 7 (PART 1): ORIGINAL DATA USED FOR THE GERMAN NORTH SEA FISHERIES IN THE FIVE 'RAPFISH' FIELDS. SOURCES OF SCORES ARE DOCUMENTED IN APPENDIX 5 AND DISCUSSED IN APPENDIX 4.

Fishery	Abbreviation	**Ecological**	Exploitation status	Recruitment variability	Change in trophic level	Migratory range	Range collapse	Size of fish caught	Catch before maturity	Discarded by-catch	Species caught	Primary production	**Economic**	Profitability	Fisheries in GDP	Average Income	Management Regime	Other income	Sector employment	Ownership	Market	Subsidy
1880 Deep Sea Demersal Fishery	GHS1880D		3.0	1.0	0.0	2.0	1.0	1.5	1.5	1.0	0.5	1.5		4.0	0.0	3.5	0.5	3.0	0.0	1.0	2.0	0.5
1880 Lugger Herring Fishery (salted)	GH1880S		2.0	2.0	0.0	2.0	0.0	0.0	0.5	0.5	0.0	1.5		1.8	0.1	1.0	0.5	2.0	1.0	1.0	1.0	1.5
1880 Cutter Deep Sea Fishery - industrial	CDS1880I		1.5	2.0	0.0	2.0	0.0	0.0	1.0	0.5	1.5	1.5		1.5	0.2	1.0	0.5	2.5	1.0	0.0	1.0	0.0
1880 Cutter Deep Sea Fishery - flatfish	CDS1880F		3.0	1.0	0.0	2.0	1.5	2.0	1.5	1.0	1.5	1.5		1.5	0.2	1.0	0.5	2.5	1.0	0.0	2.0	0.0
1880 Coastal Fishery - shrimps	CF1880S		0.5	2.0	0.0	0.8	0.5	0.0	0.5	0.0	0.5	1.5		2.0	0.0	0.5	0.5	0.5	0.5	0.0	0.0	0.0
1880 Coastal Fishery - oysters	CF1880O		3.0	2.0	0.0	0.5	2.0	0.0	0.0	0.0	0.0	1.5		0.0	0.1	3.0	2.0	3.0	0.5	0.5	2.0	0.0
1880 Coastal Fishery - hydrozoids	CF1800H		0.0	2.0	0.0	0.5	0.0	0.0	0.0	0.5	0.0	1.5		1.0	0.0	3.0	0.0	0.0	0.0	0.0	2.0	0.0
1880 Coastal Fishery - estuary	CF1880R		2.5	1.5	0.0	2.0	1.0	1.5	1.0	0.5	1.5	1.5		1.5	0.1	1.0	1.0	2.0	1.0	0.0	0.0	0.5
1880 Coastal Fishery -flatfish	CF1880F		3.0	1.0	0.0	2.0	1.5	2.0	1.5	1.0	1.5	1.5		1.0	0.1	1.0	3.0	1.5	1.0	0.0	0.0	0.5
1900 Deep Sea Demersal Fishery	GHS1900D		3.0	1.0	0.0	2.0	2.0	1.5	1.5	1.0	0.5	1.5		2.5	0.3	3.0	0.5	3.0	2.0	1.0	2.0	2.0
1900 Lugger Herring Fishery (salted)	GH1900S		2.5	2.0	0.0	2.0	1.5	1.0	0.5	0.5	0.0	1.5		2.0	0.2	1.0	0.5	2.0	1.0	1.0	1.0	1.5
1900 Cutter Deep Sea Fishery - industrial	CDS1900I		2.5	2.0	0.0	2.0	1.8	1.0	1.0	0.5	1.0	1.5		3.0	0.1	1.0	0.5	2.8	0.8	0.0	1.0	1.0
1900 Cutter Deep Sea Fishery - flatfish	CDSH1900F		3.0	1.0	0.0	2.0	1.5	2.0	2.0	1.0	1.0	1.5		3.0	0.1	1.0	0.5	2.8	0.8	0.0	2.0	1.0
1900 Coastal Fishery - shrimps	CF1900S		1.5	2.0	0.0	0.8	1.5	0.0	0.0	0.5	0.8	1.5		2.0	0.1	0.5	0.5	1.5	0.5	0.0	0.5	1.0
1900 Coastal Fishery - mussels	CF1900M		0.0	2.0	0.0	0.5	0.0	0.0	1.0	0.0	1.0	1.5		2.0	0.0	0.0	0.0	0.2	0.0	0.0	2.0	0.0
1900 Coastal Fishery - oysters	CF1900O		3.0	2.0	0.0	0.5	1.5	0.0	0.0	1.0	1.0	1.5		2.0	0.0	2.0	2.0	2.0	0.0	0.5	2.0	0.0
1900 Coastal Fishery - hydrozoids	CF1900H		2.0	2.0	0.0	0.5	2.0	2.0	0.0	1.0	0.0	1.5		1.5	0.0	2.0	0.0	2.0	0.1	0.0	2.0	0.0
1900 Coastal Fishery - estuary	CF1900R		2.5	2.0	0.0	2.0	2.0	1.8	1.0	0.5	1.0	1.5		3.0	0.1	0.5	1.0	2.3	0.8	0.0	0.0	0.5
1900 Coastal Fishery -flatfish	CF1900F		3.0	1.0	0.0	2.0	2.0	2.0	2.0	1.0	1.3	1.5		3.0	0.1	0.5	3.0	1.5	0.8	0.0	0.0	0.5
1925 Deep Sea Pelagic Fishery	GHS25H		2.5	2.0	0.5	2.0	2.0	2.0	1.0	0.0	0.0	1.5		1.5	0.5	2.5	0.5	3.0	2.0	1.0	1.0	2.0
1925 Deep Sea Demersal Fishery	GHS25D		3.0	1.0	0.5	2.0	1.5	1.5	1.5	1.5	1.0	1.5		3.0	0.4	2.5	1.5	3.0	2.0	1.0	1.0	2.0
1925 Lugger Herring Fishery (salted)	GH25S		2.5	2.0	0.5	2.0	1.5	1.5	0.5	0.5	0.0	1.5		3.0	0.1	1.5	0.5	2.0	1.0	1.0	1.0	1.3
1925 Cutter Deep Sea Fishery - industrial	CDS25I		2.5	2.0	0.5	2.0	1.8	2.0	1.5	0.5	0.5	1.5		2.0	0.0	1.5	0.5	3.0	0.5	0.5	1.0	1.0
1925 Cutter Deep Sea Fishery - flatfish	CDSH25F		3.0	1.0	0.5	2.0	1.5	2.0	2.0	1.0	1.0	1.5		1.8	0.0	1.5	1.5	3.0	0.5	0.5	0.5	1.0
1925 Coastal Fishery - shrimps	CF25S		2.0	2.0	0.5	0.8	1.5	1.0	1.0	1.0	1.0	1.5		3.0	0.1	1.0	0.5	2.0	1.0	0.0	0.5	1.0
1925 Coastal Fishery - mussels	CF25M		1.0	2.0	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.5		2.0	0.0	0.0	0.8	0.1	0.0	0.0	2.0	0.0
1925 Coastal Fishery - oysters	CF25O		3.0	2.0	0.5	0.5	2.0	2.0	1.0	1.0	1.0	1.5		4.0	0.0	0.0	2.0	0.5	0.0	0.0	2.0	0.0
1925 Coastal Fishery - hydrozoids	CF25H		3.0	2.0	0.5	0.5	2.0	2.0	0.0	1.0	0.0	1.5		3.0	0.0	0.0	1.5	3.0	0.1	0.0	2.0	0.0
1925 Coastal Fishery - estuary	CF25R		2.5	2.0	0.5	2.0	2.0	2.0	2.0	0.5	0.5	1.5		2.5	0.0	1.0	0.5	2.5	0.5	0.0	1.0	1.0
1925 Coastal Fishery -flatfish	CF25F		3.0	1.0	0.5	2.0	2.0	2.0	2.0	1.0	1.3	1.5		3.0	0.0	1.0	2.0	2.0	0.5	0.0	0.5	1.0
1950 Deep Sea Pelagic Fishery	GHS50H		2.8	2.0	0.5	2.0	2.0	1.5	1.0	0.3	0.0	1.5		1.5	0.5	2.0	1.0	3.0	2.0	1.3	1.0	2.0
1950 Deep Sea Demersal Fishery	GHS50D		2.8	1.0	0.5	2.0	1.3	1.5	1.0	2.0	1.0	1.5		3.5	0.0	2.0	2.0	3.0	2.0	1.3	1.0	2.0
1950 Lugger Herring Fishery (salted)	GH50S		2.8	2.0	0.5	2.0	1.5	1.0	0.5	0.5	0.0	1.5		3.0	0.1	1.5	1.0	2.0	0.5	1.0	1.0	0.8
1950 Lugger Herring Fishery (fresh)	GH50F		2.8	2.0	0.5	2.0	1.5	1.0	0.5	0.5	0.0	1.5		3.0	0.0	1.5	1.0	2.0	0.0	1.0	1.0	0.0
1950 Cutter Deep Sea Fishery - industrial	CDS50I		2.8	2.0	0.5	2.0	2.0	1.0	2.0	0.5	0.5	1.5		2.0	0.0	1.5	1.0	3.0	0.5	0.8	1.0	0.8
1950 Cutter Deep Sea Fishery - flatfish	CDS50F		2.8	1.0	0.5	2.0	1.8	1.5	1.5	2.0	1.5	1.5		3.0	0.0	1.0	2.0	3.0	0.5	0.6	1.0	0.8
1950 Coastal Fishery - shrimps	CF50S		2.5	2.0	0.5	0.8	0.5	2.0	2.0	1.5	1.0	1.5		1.5	0.1	1.0	1.5	2.5	1.5	0.6	1.0	1.0
1950 Coastal Fishery - mussels	CF50M		1.0	2.0	0.5	0.5	1.0	0.0	1.0	0.5	0.5	1.5		1.3	0.0	1.0	1.5	1.0	0.0	0.7	2.0	0.0
1975 Deep Sea Pelagic Fishery	GHS75H		3.0	2.0	0.5	2.0	2.0	1.0	2.0	0.3	0.5	2.0		4.0	0.0	2.0	3.0	3.0	2.0	1.0	1.3	2.0
1975 Deep Sea Demersal Fishery	GHS75D		3.0	1.0	0.5	2.0	1.5	1.0	0.5	0.5	0.0	2.0		2.5	0.0	2.0	2.5	3.0	2.0	1.0	1.5	2.0
1975 Lugger Herring Fishery (fresh)	GH75F		3.0	1.0	0.5	2.0	2.0	1.0	0.5	0.5	0.0	2.0		4.0	0.0	1.5	2.5	3.0	0.0	1.0	1.3	1.0
1975 Cutter Deep Sea Fishery - industrial	CDS75I		3.0	2.0	0.5	2.0	2.0	0.0	1.5	0.5	1.0	2.5		2.5	0.0	2.0	0.5	3.0	0.0	0.8	1.3	1.0
1975 Cutter Deep Sea Fishery - flatfish	CDS75F		3.0	1.5	0.5	2.0	2.0	1.0	1.0	2.0	1.5	2.5		2.5	0.0	1.5	2.5	3.0	0.0	0.8	1.5	1.0
1975 Coastal Fishery - shrimps	CF75S		2.0	2.0	0.5	0.8	1.5	1.0	2.0	2.0	1.0	2.5		1.5	0.0	2.0	1.5	2.5	2.0	0.8	1.8	1.0
1975 Coastal Fishery - mussels	CF75M		1.5	2.0	0.5	0.5	0.5	0.0	0.0	0.0	0.0	2.5		1.8	0.0	3.0	1.5	2.5	0.8	0.5	1.8	1.5
1997 Deep Sea Pelagic Fishery	GHS97H		2.5	2.0	0.0	2.0	1.0	0.0	1.0	0.3	0.5	2.5		1.5	0.0	2.0	2.5	3.0	2.0	1.0	1.3	1.5
1997 Deep Sea Demersal Fishery	GHS97D		3.0	1.0	0.0	2.0	2.0	1.0	0.6	0.6	0.5	2.5		4.0	0.0	2.0	2.5	3.0	1.5	1.0	1.5	1.5
1997 Cutter Deep Sea Fishery - flatfish	CDS97F		3.0	1.0	0.0	2.0	2.0	0.0	1.0	2.0	1.0	3.0		3.0	0.0	2.0	2.5	3.0	0.5	0.5	1.5	1.8
1997 Coastal Fishery - shrimps	CF97S		2.0	2.0	0.0	0.8	0.5	0.5	0.5	1.5	1.0	3.0		1.8	0.0	2.0	2.0	3.0	2.0	0.5	1.8	1.8
1997 Coastal Fishery - mussels	CF97M		3.0	2.0	0.0	0.5	1.0	2.0	0.0	0.0	0.0	3.0		1.0	0.0	3.0	2.0	3.0	1.5	1.0	1.8	1.8
Good	G		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0		5.0	2.0	4.0	2.0	2.0	0.0	0.0	0.0	0.0
Bad	B		3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0		0.0	0.0	0.0	0.0	0.0	3.0	2.0	2.0	2.0

Appendix 7 (part 2): Original data used for the German North Sea fisheries in the five 'Rapfish' fields.

Fishery	Abbreviation	Social	Socialization of fishing	Fishing community growth	Fishing sector	Environmental knowledge	Education level	Conflict status	Fisher influence	Fishing income	Kin participation	Technological	Trip length	Landing sites	Pre-sale processing	Onboard Harvest Handling	Gear	Selective gear	FADS	Vessel size	Catching power	Gear side effects	Ethical	Adjacency and reliance	Alternatives	Equity in entry to Fishery	Just management	Influences – ethical formation	Mitigation – habitat destruction	Mitigation – ecosystem depletion	Illegal fishing	Discards & wastes
1880 Deep Sea Demersal Fishery	GHS1880D		0.5	0.0	0.0	0.3	0.0	1.5	1.0	2.0	0.5		12.0	2.0	1.0	2.0	1.0	0.0	0.3	4.0	0.0	1.5		1.0	1.3	0.0	2.0	3.0	0.5	1.5	0.0	1.0
1880 Lugger Herring Fishery (salted)	GH1880S		0.5	2.0	0.0	0.3	0.0	1.5	1.0	1.0	0.0		30.0	2.0	1.5	1.0	0.5	1.5	0.0	4.0	4.0	0.5		1.5	1.0	1.5	2.0	3.0	2.0	2.0	0.0	0.0
1880 Cutter Deep Sea Fishery - industrial	CDS1880I		1.0	2.0	2.0	0.3	0.0	1.5	1.0	2.0	2.0		13.0	2.5	1.0	1.5	1.0	0.0	0.0	3.0	3.0	0.5		3.0	0.0	1.5	1.8	3.0	1.8	2.0	0.0	1.0
1880 Cutter Deep Sea Fishery - flatfish	CDS1880F		1.0	2.0	2.0	0.3	0.0	1.5	1.0	2.0	2.0		13.0	2.5	0.0	3.0	1.0	0.0	0.0	3.0	3.0	0.8		3.0	0.0	1.5	1.8	3.0	1.0	1.5	0.0	1.0
1880 Coastal Fishery - shrimps	CF1880S		1.0	0.0	1.0	0.3	0.0	0.0	0.5	0.0	2.5		1.0	0.0	0.0	0.0	0.3	0.5	0.0	0.0	1.0	0.0		2.0	1.0	1.5	1.5	3.0	2.0	2.0	0.0	0.0
1880 Coastal Fishery - oysters	CF1880O		1.0	0.0	1.0	0.3	0.0	1.0	0.5	2.0	2.0		1.0	2.0	0.5	0.5	1.0	1.0	0.0	3.5	1.0	2.0		2.0	0.5	2.0	1.5	3.0	0.5	0.5	1.0	0.0
1880 Coastal Fishery - hydrozoids	CF1800H		1.0	0.0	1.0	0.3	0.0	0.0	0.5	0.0	0.5		1.0	2.0	0.5	0.0	0.0	2.0	0.0	0.0	0.0	0.0		0.0	1.0	1.5	1.5	3.0	2.0	2.0	0.0	0.0
1880 Coastal Fishery - estuary	CF1880R		1.0	0.0	1.5	0.3	0.0	0.5	0.5	2.0	2.0		1.0	0.5	0.0	3.0	0.5	0.5	0.0	0.0	0.0	0.5		3.0	0.0	1.5	1.5	3.0	2.0	2.0	0.0	0.0
1880 Coastal Fishery -flatfish	CF1880F		2.0	0.0	1.3	0.3	0.0	0.5	0.5	1.5	2.0		1.0	0.0	0.0	3.0	0.5	0.5	0.5	0.0	0.0	0.8		2.5	0.3	2.5	1.5	3.0	2.0	1.0	0.0	1.0
1900 Deep Sea Demersal Fishery	GHS1900D		0.0	2.0	0.0	0.3	1.0	1.5	1.0	2.0	0.5		12.0	2.5	1.0	2.0	1.0	0.0	0.0	4.0	4.0	0.5		1.0	1.5	0.0	2.0	3.5	0.5	0.8	0.0	1.0
1900 Lugger Herring Fishery (salted)	GH1900S		0.5	2.0	0.0	0.3	0.5	1.5	1.0	1.0	0.0		30.0	2.0	1.5	1.0	0.5	1.5	0.0	4.0	4.0	0.5		1.5	1.0	1.5	2.0	3.5	2.0	2.0	0.0	0.0
1900 Cutter Deep Sea Fishery - industrial	CDS1900I		0.8	0.5	2.0	0.3	0.5	1.5	1.0	2.0	2.0		13.0	2.0	1.0	2.0	1.0	0.0	0.0	3.5	2.0	0.5		3.0	0.0	1.5	1.8	3.5	1.8	1.0	0.0	1.0
1900 Cutter Deep Sea Fishery - flatfish	CDSH1900F		1.0	0.5	2.0	0.3	0.5	1.5	1.0	2.0	2.0		13.0	2.0	0.0	3.0	1.0	0.0	0.0	3.5	2.0	1.5		3.0	0.0	1.5	1.8	3.5	0.5	0.5	0.0	1.0
1900 Coastal Fishery - shrimps	CF1900S		1.0	2.0	1.0	0.3	0.0	0.5	1.0	1.0	2.0		1.0	0.0	1.0	1.0	1.0	1.0	0.0	1.0	2.0	1.0		2.5	0.8	1.5	1.5	3.5	0.5	2.0	0.0	1.0
1900 Coastal Fishery - mussels	CF1900M		1.0	0.0	1.0	0.3	0.0	0.0	1.0	0.0	2.0		1.0	0.0	1.0	0.5	1.0	1.0	0.0	1.0	0.0	1.5		1.0	1.0	1.5	1.5	3.5	1.0	2.0	0.0	0.5
1900 Coastal Fishery - oysters	CF1900O		1.0	0.0	1.0	0.3	0.0	1.0	1.0	0.0	2.0		1.0	2.0	0.5	0.5	1.0	1.0	0.0	3.5	1.5	2.0		2.0	1.0	2.0	1.5	3.0	0.5	0.5	0.0	0.5
1900 Coastal Fishery - hydrozoids	CF1900H		1.0	2.0	1.0	0.3	0.0	1.0	1.0	1.0	0.5		1.0	2.0	0.5	0.5	1.0	2.0	0.0	1.0	4.0	1.0		1.0	1.0	1.5	1.5	3.0	1.0	2.0	0.0	1.0
1900 Coastal Fishery - estuary	CF1900R		1.0	2.0	1.5	0.3	0.0	0.8	1.0	2.0	2.0		1.0	0.5	0.5	3.0	0.8	0.5	0.0	1.0	3.0	0.5		3.0	0.0	1.5	1.5	3.0	2.0	2.0	0.0	0.0
1900 Coastal Fishery -flatfish	CF1900F		2.0	2.0	1.3	0.3	0.0	0.8	1.0	1.5	2.0		1.0	0.0	0.0	3.0	0.5	0.5	0.3	0.5	2.0	1.0		2.5	0.3	2.5	1.5	3.0	1.8	1.0	0.0	1.0
1925 Deep Sea Pelagic Fishery	GHS25H		0.0	0.0	0.0	0.5	1.0	2.0	1.0	2.0	0.5		12.0	2.3	2.0	2.0	1.0	0.5	0.0	4.0	4.0	0.5		1.0	1.3	0.0	2.0	3.8	1.3	2.0	0.0	0.5
1925 Deep Sea Demersal Fishery	GHS25D		0.0	0.0	0.0	0.5	1.0	2.0	1.0	2.0	0.5		12.0	2.3	1.0	2.0	1.0	0.0	0.0	4.0	3.5	0.5		1.0	1.3	0.0	2.0	3.8	0.8	0.5	0.0	1.5
1925 Lugger Herring Fishery (salted)	GH25S		0.5	0.0	0.0	0.5	1.0	1.5	1.0	1.0	0.0		30.0	2.0	1.5	1.0	0.5	1.5	0.0	4.0	2.0	0.5		1.5	0.8	1.5	2.0	3.5	2.0	2.0	0.0	0.0
1925 Cutter Deep Sea Fishery - industrial	CDS25I		0.8	0.5	1.0	0.5	0.5	2.0	1.0	2.0	2.0		6.0	2.0	1.0	2.0	1.0	0.0	0.0	3.5	2.5	0.0		2.5	0.8	1.5	1.8	3.5	2.0	1.0	0.0	1.0
1925 Cutter Deep Sea Fishery - flatfish	CDSH25F		1.0	0.5	1.0	0.5	0.5	2.0	1.0	2.0	2.0		6.0	2.0	0.0	2.5	1.0	0.0	0.0	3.5	2.5	1.3		2.5	0.8	1.5	1.8	3.5	0.5	0.5	0.0	1.0
1925 Coastal Fishery - shrimps	CF25S		2.0	1.0	1.0	0.5	0.5	0.5	1.0	1.5	2.0		1.0	0.3	1.0	1.0	1.0	0.0	0.0	1.0	1.0	1.5		2.8	0.5	1.5	1.5	3.5	0.5	1.5	0.0	1.0
1925 Coastal Fishery - mussels	CF25M		1.0	0.0	1.0	0.5	0.0	0.0	1.0	0.0	2.0		1.0	1.0	1.0	0.5	1.0	1.0	0.0	3.0	2.0	1.5		1.5	0.8	1.5	1.5	3.5	0.5	2.0	0.0	1.0
1925 Coastal Fishery - oysters	CF25O		1.0	0.0	1.0	0.5	0.0	1.0	1.0	0.0	2.0		1.0	2.0	0.5	0.5	1.0	1.0	0.0	3.5	0.0	2.0		2.0	0.8	2.0	1.5	3.5	0.5	0.5	0.0	0.5
1925 Coastal Fishery - hydrozoids	CF25H		1.0	0.0	1.0	0.5	0.0	1.0	1.0	1.5	0.5		1.0	2.0	0.5	0.5	1.0	2.0	0.0	3.5	4.0	1.0		1.0	0.8	1.5	1.5	3.5	1.0	2.0	0.0	1.0
1925 Coastal Fishery - estuary	CF25R		2.0	1.0	1.5	0.5	0.5	1.5	1.0	1.8	2.0		4.0	0.5	0.5	2.5	0.8	0.3	0.0	1.5	3.0	0.0		3.0	0.0	1.5	1.5	3.5	2.0	1.0	0.0	0.5
1925 Coastal Fishery -flatfish	CF25F		2.0	1.0	1.3	0.5	0.5	1.5	1.0	1.8	2.0		6.0	0.3	0.0	2.5	0.8	0.5	0.0	0.5	3.0	1.0		2.5	0.0	1.5	1.5	3.5	1.5	1.0	0.0	1.0
1950 Deep Sea Pelagic Fishery	GHS50H		0.0	0.0	0.0	0.5	1.0	2.0	1.0	2.0	0.0		13.1	2.3	2.0	2.0	1.0	1.0	0.0	4.0	4.0	0.0		1.0	1.5	0.0	2.0	3.5	1.5	2.0	0.0	0.5
1950 Deep Sea Demersal Fishery	GHS50D		0.0	0.0	0.0	0.5	1.0	2.0	1.0	2.0	0.0		13.2	2.3	1.5	2.0	1.0	1.0	0.0	4.0	4.0	0.5		1.0	1.5	0.0	2.0	3.5	0.8	0.5	0.0	2.0
1950 Lugger Herring Fishery (salted)	GH50S		0.5	0.0	0.0	0.5	1.0	2.0	1.0	1.0	0.0		26.5	2.0	1.5	1.0	0.8	1.5	0.0	4.0	0.5	1.0		1.5	0.9	0.5	2.0	3.5	1.5	2.0	0.0	0.3
1950 Lugger Herring Fishery (fresh)	GH50F		0.5	0.0	0.0	0.5	1.0	2.0	1.0	0.0	0.0		26.5	2.0	0.0	2.0	0.8	1.5	0.0	4.0	0.5	1.0		1.5	0.9	0.5	2.0	3.5	1.5	2.0	0.0	0.3
1950 Cutter Deep Sea Fishery - industrial	CDS50I		0.8	0.5	0.1	0.5	1.0	2.0	1.0	2.0	0.0		7.0	2.0	0.5	0.5	1.0	0.0	0.0	3.0	2.0	0.0		2.3	1.0	0.5	1.8	3.5	2.0	0.5	0.0	0.5
1950 Cutter Deep Sea Fishery - flatfish	CDS50F		1.0	0.5	0.1	0.5	1.0	2.0	1.0	2.0	1.0		11.0	1.5	0.5	2.5	0.9	0.0	0.2	3.0	0.5	1.0		2.3	1.0	0.5	1.8	3.5	0.5	0.5	0.0	2.0
1950 Coastal Fishery - shrimps	CF50S		1.5	0.1	1.0	0.5	1.0	1.0	1.0	1.8	1.5		1.0	0.5	1.5	1.0	1.0	0.0	0.0	2.0	2.0	1.5		2.8	0.5	0.5	1.5	3.5	0.5	1.0	0.0	2.0
1950 Coastal Fishery - mussels	CF50M		1.0	0.5	0.5	0.5	1.0	0.5	1.0	1.0	1.0		1.0	1.0	1.0	0.5	1.0	1.0	0.0	3.0	1.0	1.3		1.5	1.0	0.5	1.5	3.5	1.5	1.8	0.0	0.8
1975 Deep Sea Pelagic Fishery	GHS75H		0.0	0.0	0.0	1.0	1.0	2.0	1.0	2.0	0.0		110.0	3.0	2.0	2.0	1.0	1.5	0.0	4.0	0.5	0.0		1.0	2.0	0.0	2.0	3.5	1.5	1.5	1.5	0.5
1975 Deep Sea Demersal Fishery	GHS75D		0.0	0.0	0.0	1.0	1.0	2.0	1.0	2.0	0.0		110.0	3.0	2.0	2.5	1.0	1.5	0.0	4.0	0.5	0.5		1.0	2.0	0.0	2.0	3.5	1.0	1.3	1.5	2.0
1975 Lugger Herring Fishery (fresh)	GH75F		0.0	0.0	0.0	1.0	1.0	2.0	1.0	2.0	0.0		15.0	3.0	0.0	2.0	0.8	1.5	0.0	4.0	0.0	1.5		1.5	1.5	0.5	2.0	3.5	2.0	1.5	1.5	0.3
1975 Cutter Deep Sea Fishery - industrial	CDS75I		0.8	0.0	0.0	1.0	1.0	2.0	1.0	2.0	0.0		15.0	2.0	0.5	0.5	1.0	0.0	0.0	4.0	0.3	0.0		1.0	1.0	0.5	2.0	3.5	2.0	0.5	1.5	0.5
1975 Cutter Deep Sea Fishery - flatfish	CDS75F		1.0	0.0	0.0	1.0	1.0	2.0	1.0	2.0	0.3		15.0	2.5	0.0	2.0	0.8	0.0	0.2	4.0	0.3	1.0		1.0	1.0	0.5	2.0	3.5	1.5	1.3	1.5	2.0
1975 Coastal Fishery - shrimps	CF75S		1.5	0.1	0.2	1.0	1.0	1.0	1.0	2.0	1.0		1.0	0.8	1.0	1.0	1.0	1.0	0.0	2.5	0.5	1.3		2.0	0.8	0.5	1.8	3.5	1.5	1.5	1.5	2.0
1975 Coastal Fishery - mussels	CF75M		1.0	0.5	0.2	1.0	1.0	1.0	1.0	2.0	0.5		1.0	1.0	0.5	0.5	1.0	1.5	0.0	4.0	2.0	0.8		2.0	0.8	0.5	1.8	3.5	4.0	1.8	1.5	0.0
1997 Deep Sea Pelagic Fishery	GHS97H		0.0	0.0	0.0	1.0	1.0	2.0	1.5	2.0	0.0		110.0	3.0	2.0	2.0	1.0	1.5	0.0	4.0	0.0	0.0		1.0	2.0	0.0	2.0	4.0	2.0	1.8	1.5	0.5
1997 Deep Sea Demersal Fishery	GHS97D		0.0	0.0	0.0	1.0	1.0	2.0	1.5	2.0	0.0		110.0	3.0	1.5	2.0	1.0	1.5	0.0	4.0	0.0	0.5		1.0	2.0	0.0	2.0	4.0	1.5	1.5	1.5	2.0
1997 Cutter Deep Sea Fishery - flatfish	CDS97F		1.0	0.0	0.0	1.0	1.0	2.0	1.0	2.0	0.3		15.0	2.5	1.0	2.0	0.8	0.0	0.0	4.0	0.1	1.0		0.5	1.0	0.5	2.0	4.0	1.8	1.5	1.5	2.0
1997 Coastal Fishery - shrimps	CF97S		1.0	0.0	0.2	1.0	1.0	1.0	1.0	2.0	0.5		1.0	0.8	1.5	1.0	1.0	1.0	0.0	2.5	0.3	1.3		1.5	1.0	0.5	2.0	4.0	1.8	1.8	1.5	2.0
1997Coastal Fishery - mussels	CF97M		0.5	0.0	0.2	1.0	1.0	1.0	1.0	2.0	0.5		1.0	1.0	1.0	0.5	1.0	1.5	0.0	4.0	0.3	0.8		1.5	1.0	0.5	2.0	4.0	4.0	1.9	1.5	0.0
Good	G		2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	4.0		0.5	0.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0		3.0	2.0	2.0	4.0	4.0	4.0	4.0	0.0	0.0
Bad	B		0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0		30.0	3.0	0.0	0.0	1.0	1.0	1.0	2.0	2.0	2.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0

APPENDIX 7 (PART 3): ORIGINAL DATA USED FOR THE UK NORTH SEA FISHERIES IN THE FIVE 'RAPFISH' FIELDS. SOURCES OF SCORES ARE DOCUMENTED IN ANNEX TABLE X AND DISCUSSED IN THE TEXT.

Fishery	Abbreviation	**Ecological**	Exploitation status	Recruitment variability	Change in trophic level	Migratory range	Range collapse	Size of fish caught	Catch before maturity	Discarded by-catch	Species caught	Primary production	**Economic**	Profitability	Fisheries in GDP	Average Income	Management Regime	Other income	Sector employment	Ownership	Market	Subsidy
1910 Herring English-drift net	EN10HD		0.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0		0.0	0.0	3.0	1.0	2.0	1.0	1.0	2.0	1.0
1910 Herring-Scottish drift net	SC10HD		0.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0		0.0	1.0	3.0	0.0	2.0	2.0	0.0	2.0	1.0
1910 Haddock-English trawl	EN10HAT		1.0	2.0	0.0	2.0	2.0	0.0	1.0	1.0	1.0	1.0		1.0	0.0	3.0	1.0	2.0	2.0	1.0	1.0	1.0
1910 Haddock-Scottish line	SC10HAL		1.0	2.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	1.0		1.5	0.0	2.0	0.0	2.0	0.0	0.0	0.0	1.0
1910 Cod-English trawl	EN10CT		1.0	1.0	0.0	2.0	2.0	0.0	1.0	1.0	1.0	1.0		1.0	0.0	3.0	1.0	2.0	2.0	1.0	1.0	1.0
1910 Cod Scottish line	SC10CL		1.0	1.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	1.0		1.5	0.0	2.0	0.0	2.0	0.0	0.0	0.0	1.0
1910 Plaice English trawl	EN10PT		2.0	1.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0		1.0	0.0	3.0	1.0	2.0	2.0	1.0	1.0	1.0
1910 Plaice Scottish line	SC10PL		2.0	1.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	1.0		1.5	0.0	2.0	0.0	2.0	0.0	0.0	0.0	1.0
1910 Haddock Scottish trawl	SC10HAT		1.0	2.0	0.0	2.0	2.0	0.0	1.0	1.0	1.0	1.0		1.0	0.5	3.0	0.0	2.0	1.0	0.0	1.0	1.0
1910 Cod Scottish trawl	SC10CT		1.0	1.0	0.0	2.0	2.0	0.0	1.0	1.0	1.0	1.0		1.0	0.5	3.0	0.0	2.0	1.0	0.0	1.0	1.0
1910 Plaice Scottish trawl	SC10PT		2.0	1.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0		1.0	0.5	3.0	0.0	2.0	1.0	0.0	1.0	1.0
1990 Herring-English pel.trawl+purse seine	EN90HTS		2.0	1.0	0.0	2.0	0.0	0.0	0.0	1.0	1.0	3.0		1.0	0.0	3.0	2.0	2.0	1.0	0.0	1.5	2.0
1990 Herring-Scottish pel.trawl+purse seine	SC90HTS		2.0	1.0	0.0	2.0	0.0	0.0	0.0	1.0	1.0	3.0		1.0	0.0	3.0	2.0	2.0	1.0	0.0	1.5	2.0
1990 Haddock-English trawl+seine	EN90HATS		3.0	2.0	0.0	2.0	0.0	0.0	1.0	2.0	1.0	3.0		1.0	0.0	3.0	2.0	2.0	0.0	0.0	1.0	2.0
1990 Haddock-Scottish trawl+seine	SC90HATS		3.0	2.0	0.0	2.0	0.0	0.0	1.0	2.0	1.0	3.0		1.0	0.0	3.0	2.0	2.0	0.0	0.0	1.0	2.0
1990 Cod-English trawl+seine	EN90CTS		3.0	1.0	0.0	2.0	0.0	0.0	1.0	2.0	1.0	3.0		1.0	0.0	3.0	2.0	2.0	1.0	0.0	1.0	2.0
1990 Cod--Scottish trawl+seine	SC90CTS		3.0	1.0	0.0	2.0	0.0	0.0	1.0	2.0	1.0	3.0		1.0	0.0	3.0	2.0	2.0	1.0	0.0	1.0	2.0
1990 Plaice-English beam trawl	EN90PBT		2.0	1.0	1.0	2.0	0.0	1.0	2.0	2.0	2.0	3.0		1.0	0.0	3.0	2.0	2.0	1.0	0.0	1.0	2.0
1990 Plaice-Scottish beam trawl	SC90PBT		2.0	1.0	1.0	2.0	0.0	1.0	2.0	2.0	2.0	3.0		1.0	0.0	3.0	2.0	2.0	1.0	0.0	1.0	2.0
1955 Herring-English -drift	EN55HD		3.0	1.0	1.0	2.0	0.0	1.0	0.0	0.0	0.0	1.0		3.0	0.0	3.0	0.0	2.5	1.0	1.0	1.5	2.0
1955 Herring-Scottish-drift	SC55HD		3.0	1.0	1.0	2.0	0.0	1.0	0.0	0.0	0.0	1.0		3.0	0.0	3.0	0.0	2.5	1.0	0.0	1.5	2.0
1955 Haddock-English trawl+seine	EN55HATS		1.0	2.0	0.0	2.0	0.0	0.0	2.0	1.0	1.0	1.0		1.5	0.0	3.0	0.0	2.5	1.0	1.0	1.0	2.0
1955 Haddock-Scottish trawl+seine	SC55HATS		1.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0	1.0	1.0		1.5	0.0	3.0	0.0	2.5	1.0	0.0	1.0	2.0
1955 Cod-English trawl+seine	EN55CTS		1.0	1.0	0.0	2.0	0.0	0.0	0.0	1.0	1.0	1.0		1.5	0.0	3.0	0.0	2.5	2.0	1.0	1.0	2.0
1955 Cod--Scottish trawl+seine	SC55CTS		1.0	1.0	0.0	2.0	0.0	0.0	0.0	1.0	1.0	1.0		1.5	0.0	3.0	0.0	2.5	2.0	0.0	1.0	2.0
1955 Plaice-English trawl+seine	EN55PTS		1.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0	1.0	1.0		1.5	0.0	3.0	0.0	2.5	0.0	1.0	1.0	2.0
1955 Plaice-Scottish trawl+seine	SC55PTS		1.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0	1.0	1.0		1.5	0.0	3.0	0.0	2.5	0.0	0.0	1.0	2.0
Good	G		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0		5.0	2.0	4.0	2.0	2.0	0.0	0.0	0.0	0.0
Bad	B		3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0		0.0	0.0	0.0	0.0	0.0	3.0	2.0	2.0	2.0

APPENDIX 7 (PART 4): ORIGINAL DATA USED FOR THE UK NORTH SEA FISHERIES IN THE FIVE 'RAPFISH' FIELDS.

Fishery	Abbreviation	**Social**	Socialization of fishing	Fishing community growth	Fishing sector	Environmental knowledge	Education level	Conflict status	Fisher influence	Fishing income	Kin participation	**Technological**	Trip length	Landing sites	Pre-sale processing	Onboard Harvest Handling	Gear	Selective gear	FADS	Vessel size	Catching power	Gear side effects	**Ethical**	Adjacency and reliance	Alternatives	Equity in entry to Fishery	Just management	Influences – ethical formation	Mitigation – habitat destruction	Mitigation – ecosystem depletion	Illegal fishing	Discards & wastes
1910 Herring English-drift net	EN10HD		0.0	2.0	1.0	0.5	0.0	0.0	0.0	1.0	0.0		2.0	1.0	2.0	1.0	0.0	1.0	0.0	4.0	4.0	0.0		3.0	1.0	1.0	0.0	2.0	2.0	1.0	0.0	0.0
1910 Herring-Scottish drift net	SC10HD		2.0	2.0	2.0	0.5	0.0	0.0	0.0	1.0	0.0		2.0	1.0	2.0	1.0	0.0	1.0	0.0	4.0	4.0	0.0		3.0	0.0	1.0	0.5	2.0	2.0	1.0	0.0	0.0
1910 Haddock-English trawl	EN10HAT		0.0	2.0	2.0	0.5	0.0	1.0	0.0	1.0	0.0		8.0	1.0	1.0	1.0	1.0	0.0	0.0	4.0	4.0	1.0		3.0	1.0	1.0	0.0	2.0	1.0	1.0	0.0	1.0
1910 Haddock-Scottish line	SC10HAL		1.5	0.0	0.0	0.5	0.0	0.0	0.5	1.0	0.5		5.0	1.0	1.0	1.0	0.0	1.0	0.5	4.0	3.5	0.0		3.0	0.0	1.0	0.5	2.0	2.0	2.0	0.0	0.0
1910 Cod-English trawl	EN10CT		0.0	2.0	2.0	0.5	0.0	1.0	0.0	1.0	0.0		8.0	1.0	1.0	1.0	1.0	0.0	0.0	4.0	4.0	1.0		3.0	1.0	1.0	0.0	2.0	1.0	1.0	0.0	1.0
1910 Cod Scottish line	SC10CL		1.5	0.0	0.0	0.5	0.0	0.0	0.5	1.0	0.5		5.0	1.0	1.0	1.0	0.0	1.0	0.5	4.0	3.5	0.0		3.0	0.0	1.0	0.5	2.0	2.0	2.0	0.0	0.0
1910 Plaice English trawl	EN10PT		0.0	2.0	2.0	0.5	0.0	1.0	0.0	1.0	0.0		8.0	1.0	1.0	1.0	1.0	0.0	0.0	4.0	4.0	1.0		3.0	1.0	1.0	0.0	2.0	1.0	1.0	0.0	1.0
1910 Plaice Scottish line	SC10PL		1.5	0.0	0.0	0.5	0.0	0.0	0.5	1.0	0.5		5.0	1.0	1.0	1.0	0.0	1.0	0.5	4.0	3.5	0.0		3.0	0.0	1.0	0.5	2.0	2.0	2.0	0.0	0.0
1910 Haddock Scottish trawl	SC10HAT		0.0	2.0	1.0	0.5	0.0	1.0	0.0	1.0	0.0		5.0	2.0	1.0	1.0	1.0	0.0	0.0	4.0	4.0	1.0		3.0	0.0	1.0	0.0	2.0	1.0	1.0	0.0	1.0
1910 Cod Scottish trawl	SC10CT		0.0	2.0	1.0	0.5	0.0	1.0	0.0	1.0	0.0		5.0	2.0	1.0	1.0	1.0	0.0	0.0	4.0	4.0	1.0		3.0	0.0	1.0	0.0	2.0	1.0	1.0	0.0	1.0
1910 Plaice Scottish trawl	SC10PT		0.0	2.0	1.0	0.5	0.0	1.0	0.0	1.0	0.0		5.0	2.0	1.0	1.0	1.0	0.0	0.0	4.0	4.0	1.0		3.0	0.0	1.0	0.0	2.0	1.0	1.0	0.0	1.0
1990 Herring-English pel.trawl+purse seine	EN90HTS		0.0	0.0	0.0	2.0	1.0	2.0	1.0	1.0	0.0		7.0	1.0	1.0	1.0	1.0	1.0	0.0	4.0	2.0	0.0		3.0	2.0	1.0	2.0	2.0	2.0	3.0	2.0	2.0
1990 Herring-Scottish pel.trawl+purse seine	SC90HTS		0.5	0.0	0.0	2.0	1.0	2.0	1.0	1.0	1.0		5.0	1.0	1.0	1.0	1.0	1.0	0.0	4.0	2.0	0.0		3.0	1.0	1.0	2.0	2.0	2.0	3.0	2.0	2.0
1990 Haddock-English trawl+seine	EN90HATS		0.0	0.0	0.0	2.0	1.0	2.0	1.0	1.0	0.0		7.0	1.0	1.0	1.0	1.0	0.5	0.0	4.0	2.0	1.0		3.0	2.0	1.0	2.0	2.0	1.5	3.0	2.0	2.0
1990 Haddock-Scottish trawl+seine	SC90HATS		0.5	0.0	0.0	2.0	1.0	2.0	1.0	1.0	1.0		5.0	1.0	1.0	1.0	1.0	0.5	0.0	4.0	2.0	1.0		3.0	1.0	1.0	2.0	2.0	1.5	3.0	2.0	2.0
1990 Cod-English trawl+seine	EN90CTS		0.0	0.0	0.0	2.0	1.0	2.0	1.0	1.0	0.0		7.0	1.0	1.0	1.0	1.0	0.5	0.0	4.0	2.0	1.0		3.0	2.0	1.0	2.0	2.0	1.5	3.0	2.0	2.0
1990 Cod--Scottish trawl+seine	SC90CTS		0.5	0.0	0.0	2.0	1.0	2.0	1.0	1.0	1.0		5.0	1.0	1.0	1.0	1.0	0.5	0.0	4.0	2.0	1.0		3.0	1.0	1.0	2.0	2.0	1.5	3.0	2.0	2.0
1990 Plaice-English beam trawl	EN90PBT		0.0	0.0	0.0	2.0	1.0	2.0	1.0	1.0	0.0		7.0	1.0	1.0	1.0	1.0	0.5	0.0	4.0	2.0	1.0		3.0	2.0	1.0	2.0	2.0	1.0	3.0	2.0	2.0
1990 Plaice-Scottish beam trawl	SC90PBT		0.5	0.0	0.0	2.0	1.0	2.0	1.0	1.0	1.0		5.0	1.0	1.0	1.0	1.0	0.5	0.0	4.0	2.0	1.0		3.0	1.0	1.0	2.0	2.0	1.0	3.0	2.0	2.0
1955 Herring-English -drift	EN55HD		0.0	0.0	0.0	1.0	1.0	1.0	0.5	1.0	0.0		3.0	1.0	1.5	1.0	0.0	1.0	0.0	3.5	3.0	0.0		3.0	0.5	0.0	0.0	1.0	2.0	0.0	0.0	0.0
1955 Herring-Scottish-drift	SC55HD		0.5	0.0	0.0	1.0	1.0	1.0	0.5	1.0	0.5		3.0	1.0	1.5	1.0	0.0	1.0	0.0	3.5	3.0	0.0		3.0	0.5	0.0	0.0	1.0	2.0	0.0	0.0	0.0
1955 Haddock-English trawl+seine	EN55HATS		0.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.0		8.0	1.0	1.0	1.0	1.0	0.5	0.0	3.5	4.0	1.0		3.0	0.5	0.5	0.0	1.0	1.0	1.0	0.0	1.0
1955 Haddock-Scottish trawl+seine	SC55HATS		0.5	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.5		5.0	1.0	1.0	1.0	1.0	0.5	0.0	3.5	4.0	1.0		3.0	0.5	0.5	0.0	1.0	1.0	1.0	0.0	1.0
1955 Cod-English trawl+seine	EN55CTS		0.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.0		8.0	1.0	1.0	1.0	1.0	0.5	0.0	3.5	4.0	1.0		3.0	0.5	0.5	0.0	1.0	1.0	1.0	0.0	1.0
1955 Cod--Scottish trawl+seine	SC55CTS		0.5	1.0	1.0	1.0	1.0	1.0	0.5	1.0	0.5		5.0	1.0	1.0	1.0	1.0	0.5	0.0	3.5	4.0	1.0		3.0	0.5	0.5	0.0	1.0	1.0	1.0	0.0	1.0
1955 Plaice-English trawl+seine	EN55PTS		0.0	0.0	0.0	1.0	1.0	1.0	0.5	1.0	0.0		8.0	1.0	1.0	1.0	1.0	0.5	0.0	3.5	4.0	1.0		3.0	0.5	0.5	0.0	1.0	1.0	1.0	0.0	1.0
1955 Plaice-Scottish trawl+seine	SC55PTS		0.5	0.0	0.0	1.0	1.0	1.0	0.5	1.0	0.5		5.0	1.0	1.0	1.0	1.0	0.5	0.0	3.5	4.0	1.0		3.0	0.5	0.5	0.0	1.0	1.0	1.0	0.0	1.0
Good	G		2.0	2.0	2.0	2.0	2.0	0.0	2.0	2.0	4.0		0.5	0.0	2.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0		3.0	2.0	2.0	4.0	4.0	4.0	4.0	0.0	0.0
Bad	B		0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0		30.0	3.0	0.0	0.0	1.0	1.0	1.0	2.0	2.0	2.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0

APPENDIX 8: RESULTS OF THE MDS RAPFISH ORDINATION ON THE FIVE EVALUATION FIELDS FOR THE GERMAN AND UNITED KINGDOM FISHERIES. VALUES FOR SUSTAINABILITY AXES ONLY, AS PERCENTAGE OF THE BEST POSSIBLE.

Fishery	Ecological	Economic	Social	Technological	Ethical
1880 Deep Sea Demersal Fishery	45.9	17.2	39.0	40.7	39.9
1880 Deep Sea Demersal Fishery	63.2	33.3	24.8	57.6	54.0
1880Cutter Deep Sea fishery - industrial	58.9	36.6	34.4	48.8	50.3
1880 Cutter Deep Sea fishery - flatfish	38.0	33.2	34.4	38.3	43.3
1880 Coastal fishery - shrimps	69.9	44.0	24.8	51.4	52.4
1880 Coastal fishery - oysters	63.5	42.8	36.6	41.4	35.1
1880 Coastal fishery - hydrozoids	79.5	55.1	18.0	70.9	55.1
1880 Coastal fishery - estuary	47.0	39.6	35.1	54.8	51.9
1880 Coastal fishery -flatfish	38.2	49.1	36.6	23.2	50.3
1880 Deep Sea Demersal Fishery	41.1	25.0	39.7	45.6	37.0
1900 Lugger Herring Fishery (salted)	52.2	34.1	29.0	57.6	55.3
1900 Cutter Deep Sea fishery - industrial	46.9	29.3	41.4	49.9	46.3
1900 Cutter Deep Sea fishery - flatfish	37.1	26.1	42.1	35.3	33.3
1900 Coastal fishery - shrimps	62.6	36.9	32.7	52.0	46.0
1900 Coastal fishery - mussels	76.3	39.4	32.6	51.5	49.6
1900 Coastal fishery - oysters	62.1	37.6	33.5	41.2	37.4
1900 Coastal fishery - hydrozoids	56.1	35.7	29.1	53.5	47.4
1900 Coastal fishery - estuary	42.6	31.5	35.3	50.3	51.8
1900 Coastal fishery -flatfish	33.6	39.8	36.2	31.6	48.2
1925 Deep Sea Pelagic Fishery	42.7	33.1	44.6	53.6	52.3
1925 Deep Sea Demersal Fishery	40.0	29.0	44.6	47.0	36.0
1925 Lugger Herring Fishery (salted)	47.9	31.5	38.7	58.1	54.7
1925 Cutter Deep Sea fishery - industrial	40.3	30.3	43.5	51.2	48.8
1925 Cutter Deep Sea fishery - flatfish	35.7	32.7	44.1	38.6	39.1
1925 Coastal fishery - shrimps	49.5	31.8	43.4	42.6	42.6
1925 Coastal fishery - mussels	57.0	42.5	34.3	47.8	45.5
1925 Coastal fishery - oysters	37.0	31.5	35.1	42.4	36.7
1925 Coastal fishery - hydrozoids	45.5	22.8	36.5	51.4	47.8
1925 Coastal fishery - estuary	35.4	31.0	44.9	51.8	47.5
1925 Coastal fishery -flatfish	32.5	33.9	45.1	42.0	43.3
1950 Deep Sea Pelagic Fishery	44.0	32.2	42.3	60.2	53.7
1950 Deep Sea Demersal Fishery	41.1	19.6	42.3	53.7	35.3
1950 Lugger Herring Fishery (salted)	48.8	33.4	38.6	57.9	50.5
1950 Lugger Herring Fishery (fresh)	48.8	31.9	33.7	55.2	50.5
1950 Cutter Deep Sea fishery - industrial	39.3	30.8	42.6	49.1	46.0
1950 Cutter Deep Sea fishery - flatfish	35.3	27.9	45.8	43.3	36.3
1950 Coastal fishery - shrimps	39.9	33.6	45.1	43.5	36.0
1950 Coastal fishery - mussels	61.3	43.0	40.4	50.5	47.4
1975 Deep Sea Pelagic Fishery	38.4	16.4	43.9	78.3	52.9
1975 Deep Sea Demersal Fishery	49.9	24.0	43.9	75.5	44.0
1975 Lugger Herring Fishery (fresh)	47.6	20.7	43.9	52.3	53.6
1975 Cutter Deep Sea fishery - industrial	41.7	28.7	45.5	51.7	46.8
1975 Cutter Deep Sea fishery - flatfish	37.3	28.6	46.8	38.6	45.4
1975 Coastal fishery - shrimps	43.8	31.5	48.1	51.8	45.2
1975 Coastal fishery - mussels	72.6	34.5	44.2	51.4	66.5
1997 Deep Sea Pelagic Fishery	58.6	28.6	53.1	79.8	59.4
1997 Deep Sea Demersal Fishery	50.3	19.9	53.1	74.5	50.0
1997 Cutter Deep Sea fishery - flatfish	47.3	26.8	46.8	50.2	50.1
1997 Coastal fishery - shrimps	63.0	27.2	45.5	54.7	50.5
1997Coastal fishery - mussels	73.1	30.5	44.6	56.3	71.0
1910 Herring English-drift net	75.6	38.0	11.3	63.8	42.7
1910 Herring-Scottish drift net	75.6	50.7	7.5	63.8	41.0
1910 Haddock-English trawl	49.6	36.6	10.0	43.3	36.6
1910 Haddock-Scottish line	59.7	38.7	27.2	42.7	45.7
1910 Cod-English trawl	51.8	36.6	10.0	43.3	36.6
1910 Cod Scottish line	61.7	38.7	27.2	42.7	45.7
1910 Plaice English trawl	24.9	36.6	10.0	43.3	36.6
1910 Plaice Scottish line	34.7	38.7	27.2	42.7	45.7
1910 Haddock Scottish trawl	49.6	43.6	14.6	43.3	33.1
1910 Cod Scottish trawl	51.6	43.6	14.6	43.3	33.1
1910 Plaice Scottish trawl	24.9	43.6	14.6	43.3	33.1
1990 Herr-English pel.trawl+purse seine	65.7	39.0	42.2	55.0	63.2
1990 Herr-Scottish pel.trawl+purse seine	65.7	39.0	47.6	54.9	60.5
1990 Haddock-English trawl+seine	57.6	42.1	42.2	48.8	59.2
1990 Haddock-Scottish trawl+seine	57.6	42.1	47.6	48.6	56.8
1990 Cod-English trawl+seine	57.2	40.1	42.2	48.8	59.2
1990 Cod--Scottish trawl+seine	57.2	40.1	47.6	48.6	56.8
1990 Plaice-English beam trawl	39.2	40.1	42.2	48.8	55.1
1990 Plaice-Scottish beam trawl	39.2	40.1	47.6	48.6	52.4
1955 Herring-English -drift	52.9	25.0	33.2	60.8	29.0
1955 Herring-Scottish-drift	52.9	26.1	36.2	60.8	29.0
1955 Haddock-English trawl+seine	57.3	30.6	30.7	46.9	31.7
1955 Haddock-Scottish trawl+seine	59.1	32.2	33.8	46.5	31.7
1955 Cod-English trawl+seine	63.7	28.1	30.7	46.9	31.7
1955 Cod--Scottish trawl+seine	63.7	28.7	33.8	46.5	31.7
1955 Plaice-English trawl+seine	54.1	30.4	33.2	46.9	31.7
1955 Plaice-Scottish trawl+seine	54.1	33.5	36.2	46.5	31.7

APPENDIX 9: SCORES USED FOR FISHERIES IN THE CODE OF CONDUCT 'INTENTIONS' RAPFISH FIELD.

Fishery	Management	formal ref points	fleet capacity	small scale fisheries consider	biodiversity impacts allowed	restoring depleted stocks	human impacts on habitat	fish gear mandated to avoid impacts	explicit ecosystem linkages	explicit environmental influences
GOM Inshore		1	0	3	1	1	3	0	1	1
GOM Lobster		2	3	4	3	2	3	2	0.5	2.3
GOM Offshore commercial trawl		1.8	2.5	2.5	1	2	2	0	1	1
N.Sea-Eng Herring(trawl/purse seine)		2	1.5	2	0	0.5	1.5	1	0	0
N.Sea-Eng Plaice(beam trawl)		2	1.5	1	0	0.5	1.5	0	0	0
N.Sea-Eng Haddock(trawl/seine)		2	2.5	1	0.5	1	1.5	0	0	0
N.Sea-Eng Cod(trawl/seine)		2	2.5	1	0.5	0.8	1.5	0	0	0
N.Sea-Ger Deep sea herring pelagic		2	3	1	2	2	3	1.5	2	2
N.Sea-Ger Deep sea demersal		2	3	1	2	1.5	3	2	2	2
N.Sea-Ger Deep Sea flatfish		2	3	1	2	1	3	1.5	2	2
N.Sea-Ger Coastal Shrimp		1	2	2	1.5	1.5	3	1.5	3	2
N.Sea-Ger Coastal Mussel		1	2	2	2	0.5	3	0	2.5	2
GOOD		2	3	4	3	2	3	2	3	3
BAD		0	0	0	0	0	0	0	0	0

Fishery	Framework	removals accounted for	compatible management measures	long term objectives stated	stakeholders identified & considered	open & tranparent processees	timely & complete statisitics	social, econom & instit factors
GOM Inshore		2.5	2	2	4	3	4	2.3
GOM Lobster		3	2	2	4	4	4	3
GOM Offshore commercial trawl		2.5	2	2	3.5	3	4	1
N.Sea-Eng Herring(trawl/purse seine)		2	1.3	1.5	2	0	2	1
N.Sea-Eng Plaice(beam trawl)		1.5	1	1.5	1.5	0	2.5	1
N.Sea-Eng Haddock(trawl/seine)		2.5	1.3	1.5	1.5	0	2.5	2
N.Sea-Eng Cod(trawl/seine)		2.5	1.3	1.5	1.5	0	2.5	1
N.Sea-Ger Deep sea herring pelagic		3	3	2	4	2.5	4.5	1
N.Sea-Ger Deep sea demersal		3	3	2	4	2.5	4.5	1
N.Sea-Ger Deep Sea flatfish		3	3	2	3	2.5	4.5	2
N.Sea-Ger Coastal Shrimp		1.5	2	2	4	2.5	3	2.5
N.Sea-Ger Coastal Mussel		1.5	2	1.5	4	2.5	3	2.5
GOOD		3	2	2	4	4	5	4
BAD		0	0	0	0	0	0	0

Fishery	Precaution	PP enshrined in legislation	uncertainty quantified & used	stock-specific target reference points	stock-specific limit reference points	contingeny plans - env	contingeny plans - fishing	continuous management review	no-take areas sufficient & working	restrict fishing if spp threatened
GOM Inshore		1.5	2	2	1.5	1.5	2.5	3	2.5	2
GOM Lobster		2	3	3	3	1.3	3	3	2.5	2
GOM Offshore commercial trawl		2	2.5	2.5	3	1.5	3	3	5	2
N.Sea-Eng Herring(trawl/purse seine)		0	3	3	1	1	1	3	0.5	0.3
N.Sea-Eng Plaice(beam trawl)		0	3	3	1	1	0	3	2.5	0.5
N.Sea-Eng Haddock(trawl/seine)		0	3	3	1	1	0	3	0	0.3
N.Sea-Eng Cod(trawl/seine)		0	3	3	1	1	0	3	0	0.3
N.Sea-Ger Deep sea herring pelagic		2	2.5	3	3	1	3	3	0	1
N.Sea-Ger Deep sea demersal		2	2.5	1	3	1	0	3	0	1
N.Sea-Ger Deep Sea flatfish		2	2.5	3	3	1	0	3	3	1
N.Sea-Ger Coastal Shrimp		1	1	2	2	1	1.5	3	1.5	0
N.Sea-Ger Coastal Mussel		1	3	2	2	1	1	3	0	0
GOOD		2	3	3	3	3	3	3	5	3
BAD		0	0	0	0	0	0	0	0	0

	Stocks, Fleetts & Gear	reducing excess fleet cap	harmful methods	non-sp by-catch minimised	discards minimised	gear minimises ghost fishing	Safe levels of juv and spawners fishing	rebuilding depleted stocks
shore		0	0	2.5	1	0	0.25	1
bster		1	1	4	2	2	2	2.5
ffshore commercial trawl		1.5	0	1	1	1	0.5	2
ng Herring(trawl/purse seine)		0	0	1.5	0	2	1	1.5
ng Plaice(beam trawl)		2	0	1	0	2	0	1.25
ng Haddock(trawl/seine)		1	0	1	0	2	0.5	1
ng Cod(trawl/seine)		1	0	1	0	2	0.5	0
er Deep sea herring pelagic		3	0	3	3	2	3	2.5
er Deep sea demersal		3	0	3	3	2	2	2
er Deep Sea flatfish		3	0	3	2	2	1.5	1
er Coastal Shrimp		2	0	2.5	1.5	2	1.5	1.5
er Coastal Mussel		2	0	1	0	2	2	2.5
		3	2	5	3	2	3	3
		0	0	0	0	0	0	0

	Social & Economic	conflict minimised	local needs	cost-effective evaluation of change	social impact evaluated	cost recovery for res & MCS
shore		0	1	1	1.5	0
bster		1	2	2	1.5	0
ffshore commercial trawl		0	0	2	0	0
ng Herring(trawl/purse seine)		0	1	1	0	0
ng Plaice(beam trawl)		1	1	1	0	0
ng Haddock(trawl/seine)		1	1	1	0.5	0
ng Cod(trawl/seine)		1	1	1	0	0
er Deep sea herring pelagic		1.5	0	1.5	1	0
er Deep sea demersal		1.5	0	1.5	1	0
er Deep Sea flatfish		2	0	1.5	1	0
er Coastal Shrimp		2	1	2	2	0
er Coastal Mussel		2	1.5	2	2	0
		2	2	2	2	3
		0	0	0	0	0

	MCS	observer effectiveness	inspection effectiveness	vessel monitoring effectiveness	illegal non-flag fishing	effectiveness in stopping illegal fishing
shore		0	1	1	0	0.5
bster		2	4	3	1	4
ffshore commercial trawl		2.5	3.5	4	0	1
ng Herring(trawl/purse seine)		2	3	3	2	0
ng Plaice(beam trawl)		2	3	3	1	1
ng Haddock(trawl/seine)		2	3	3	1	1
ng Cod(trawl/seine)		2	3	3	1	0
er Deep sea herring pelagic		0	3	4	1.5	0.5
er Deep sea demersal		0	3	4	1.5	0.5
er Deep Sea flatfish		0	3	4	1.5	1
er Coastal Shrimp		0	2	2	0	4
er Coastal Mussel		0	2	2	0	4
		4	4	4	0	4
		0	0	0	4	0

APPENDIX 10: RESULTS OF THE MDS RAPFISH ORDINATION ON THE SIX EVALUATION FIELDS FOR THE GULF OF MAINE, GERMAN AND UNITED KINGDOM FISHERIES. VALUES FOR SUSTAINABILITY AXES ONLY, AS PERCENTAGE OF THE BEST POSSIBLE.

Fishery	management	framework	precaution	social & econ	stocks, fleet & gear	MCS
GOM Inshore	43.3	82.2	62.4	37.9	23.9	32.6
GOM Lobster	92.1	91.0	77.3	56.3	60.8	77.6
GOM Offshore commercial trawl	58.8	78.6	80.1	22.8	35.9	76.9
N.Sea-UK Herring(trawl/purse seine)	40.8	59.8	54.6	28.5	28.1	61.1
N.Sea-UK Plaice(beam trawl)	34.5	56.2	55.6	33.1	29.1	62.5
N.Sea-UK Haddock(trawl/seine)	43.7	60.7	51.4	36.7	28.4	62.5
N.Sea-UK Cod(trawl/seine)	41.9	59.3	51.4	33.1	21.2	62.9
N.Sea-Ger Deep sea herring pelagic	74.5	91.7	73.4	32.9	67.7	64.1
N.Sea-Ger Deep sea demersal	74.0	91.7	58.2	32.9	60.3	64.1
N.Sea-Ger Deep Sea flatfish	67.8	88.9	69.2	28.0	51.6	63.7
N.Sea-Ger Coastal Shrimp	67.3	78.3	54.9	58.0	45.2	53.1
N.Sea-Ger Coastal Mussel	54.5	73.8	58.0	60.9	41.1	53.1

Appendix 11: Sources of Information for Gulf of Maine, German and United Kingdom Fisheries

Gulf of Maine Fisheries

Acheson, J.M. and R.S. Steneck. 1997. Bust then boom in the Maine lobster industry: perspectives of fishers and biologists. N. Am. J. Fish. Mgt. 17: 826-847.

Alexander, A.B., H.F. Moore, and W.C. Kendall. 1914. Report on the otter trawl fishery. Report of the United States Commissioner of Fisheries for the Fiscal Year Ending June 30, 1914, Appendix VI: 97 p.

Clark, S.H. 1998. Status of the fishery resources off the Northeastern United States. NOAA Technical Memorandum NMFS-NE-115: 149 p.

Cobb, J.E. 1899. The lobster fishery of Maine. Bull. U.S. Fish Comm., 19: 241-265.

Collins, J.W. 1887. The gill-net cod fishery. In Goode, G.B. (ed.) The fisheries and fishery industry of the United States. United States Commission of Fish and Fisheries, Washington, pp. 226-233.

Collins, J.W. 1892. Statistical review of the coast fisheries of the United States. U.S. Comm. Fish and Fisheries, Part XVI, Report of the Commisioner For 1888, pp. 271-378.

Dewar, M.E. 1983. Industry in trouble: the federal government and the New England fisheries. Temple Univ. Press, Philadelphia: 252 p.

Earll, R.E. 1887. The herring fishery of the United States. In Goode, G.B. (ed.) The fisheries and fishery industry of the United States. United States Commission of Fish and Fisheries, Washington, pp. 419-439.

Fiedler, R.H. 1933. Fishery indusrties of the United States, 1931. Rept. U.S. Comm. Fisheries, 1932: pp. 97-440.

Goode, G.B. 1887. The swordfish fishery. In Goode, G.B. (ed.) The fisheries and fishery industry of the United States. United States Commission of Fish and Fisheries, Washington, pp. 317-326.

Goode, G.B. and J.W. Collins. 1887a. The fresh halibut fishery. In Goode, G.B. (ed.) The fisheries and fishery industry of the United States. United States Commission of Fish and Fisheries, Washington, pp. 3-89.

Goode, G.B. and J.W. Collins. 1887b. The George's bank cod fishery.In Goode, G.B. (ed.) The fisheries and fishery industry of the United States. United States Commission of Fish and Fisheries, Washington, pp. 187-198.

Goode, G.B. and J.W. Collins. 1887c. The hake fishery. In Goode, G.B. (ed.) The fisheries and fishery industry of the United States. United States Commission of Fish and Fisheries, Washington, pp. 241-243.

Goode, G.B. and J.W. Collins. 1887d. The mackerel fishery of the United States.In Goode, G.B. (ed.) The fisheries and fishery industry of the United States. United States Commission of Fish and Fisheries, Washington, pp. 247-313.

Hall, A. 1898. The herring fishery of the Passamaquoddy Bay region, Maine. U.S. Comm. Fish and Fisheries Report of the Commissioner. Government Printing Office, Washington: pp. 443-487.

Higgins, E. 1933. Progress in biological inquiries, 1931. Rept. U.S. Comm. Fisheries, 1932: pp. 441-529.

Hoy, D.L. and J.T. Gharrett. 1971. North Atlantic fisheries. In S. Shapiro (ed.). Our changing fisheries. United States Government Printing Office, Washington: pp. 168-183.

Moore, H.F. 1898. Observations upon the herring and herring fisheries of the northeast coast, with special reference to the vicinity of Passamaquoddy Bay. U.S. Comm. Fish and Fisheries Report of the Commissioner. Government Printing Office, Washington: pp. 387-442.

Pearson, J.C. (Editor). 1972. The fish and fisheries of colonial America: a documentary history of fishing resources of the United States and Canada, part II. The New England states. Dept of Interior. U.S. fish and wildlife service, Washington: pp. 178- 678

Sette, O.E. 1932. Outlook for the mackerel fishery in 1932. U.S. Dept. of Commerce Fish. Circ. 10: 25 pp.

Sette, O.E. and A.W.H. Needler. 1934. Statistics of the mackerel fishery off the east coast of North America 1804 to 1930. U.S. Dept. of Commerce Investig. Rept. 19: 48 pp.

German Fisheries

Anon. 1925. Berichte der deutschen wissenschaftlichen Kommission für Meeresforschung - Arbeiten der Jahre 1919-1923. Deutsche wissenschaftliche Kommission fr Meeresforschung, Berlin .

Bahr, K. 1954. Sportlicher Thunfischfang und die Entwicklung des Makrelenangelns seit 50 Jahren. Schriftenreihe des Verbands deutscher Sportfischer e.V. 11:1-23.

Bartz, F. 1964. Die grossen Fischraeume der Welt - Versuch einer regionalen Darstellung der Fischerei-Wirtschaft der Erde. Franz Steiner Verlag GmbH, Wiesbaden.

BFA. 1997. Jahresbericht 1997 - Annual Report 1997. Bundesforschungsanstal für Fischerei,

Blanke, W. 1956. Die Seefischerei Nordwest-Europas - Struktur und Probleme. Verlag - Kroegers Buchdruckerei, Hamburg-Blankenese.

BML. 1951. Jahresbericht über die deutsche Fischerei 1950. Bundesministerium für Ernaehrung, Landwirtschaft und Forsten,

BML. 1976. Jahresbericht ueber die deutsche Fischwirtschaft 1975/76. Bundesministerium für Ernaehrung, Landwirtschaft und Forsten, Report No.ISSN 0075-2851.

BML. 1998. Jahresbericht über die deutsche Fischwirtschaft 1998. Bundesministerium r Ernaehrung, Landwirtschaft und Forsten, Report No.ISSN 0075-2851.

Camphuysen, C. J., B. Calvo, J. Durnik, K. Ensor, A. Follestad, R. W. Furness, S. Garthe, G. Leaper, H. Skov, M. L. Tasker and C. J. N. Winter. 1995. Consumption of discards by seabirds in the North Sea. NIOZ, Rapport Report No.1995 -?

Coull, J. R. 1972. The Fisheries of Europe - an economic geography., G.Bells & Sons, LTD, London.

Cushing, D. H. 1988. The provident sea. Cambridge University Press, Cambridge.

Dankers, N., C. J. Smit and M. Scholl. 1992. Present and Future Conservation of the Wadden Sea - Proceedings of the 7th international Wadden Sea Symposium, Ameland 1990. DLO - Institute for Forestry and Nature Research -Texel, Report No.20 -1992.

Dethlefsen, V. 1973. Zur Frage des Fischvorkommens im Duennsaeureverklappungsgebiet nordwestlich Helgolands. Arch.FischWiss. 24:65-75.

Dittmer, R. 1902. Die deutsche Hochsee-, See- und Kuestenfischerei im 19. Jahrhundert und bis zum Jahre 1902. i.A. des deutschen Seefischereivereins,

Eichelbaum, E. 1913. Das Seemoos und seine Fischerei - Die Seemoosfischerei an der Kueste von Ostfriesland. Abhandlungen des deutschen Seefischerei-Vereins 12:94.

Eichelbaum, E. 1922. Herings-Schleppnetzfischerei. Abhandlungen des deutschen Seefischerei-Vereins 13:

Erdmann, W. 1937. Die deutsche grosse Heringsfischerei in den Jahren 1931 -1934. Berichte der deutschen wissenschaftlichen Kommission für Meeresforschung 8:23.

Goeben, H. 1974. Die Zukunftsaspekte der Kutterfischerei aus der Sicht des Landes Niedersachsen. Arbeiten des deutschen Fischerei-Verbandes 17:101 -111.

Hauke, M. 1974. Die Bedeutung der Kutterfischerei für die Seefischereimaerkte der Bundesrepublik Deutschland. Arbeiten des deutschen Fischerei-Verbandes 17:126 - 133.

Hempel, G. 1977. Fischerei in marinen Oekosystemen - Fishing in marine ecosystems. Verh.Dtsch. Zool. Ges. 67-85.

Hempel, G. 1978. Fisch frisst Fisch - Nahrungsketten und Fangerträge in der Nordsee. Umschau in Wissenschaft und Technik 78:271-277.

Hempel, G. and D. Sahrhage. 1959. Zur Berechnung des Anteils nicht angelandeter und untermassiger Fische im Gesamtfang. Arch.FischWiss. 10:58-67.

Kohl, H. 1954. Die Standortverteilung der Hochseefischerei der deutschen Hochseefischerei und ihre natürlichen Bedingungen. Deutscher Verlag der Wissenschaften, Berlin.

Lasch, R. 1974. Der Frischfischmarkt-Entwicklung und Bedeutung für die Kutterfischerei. Arbeiten des deutschen Fischerei-Verbandes 112-125.

Lenz, W. 1992. Die Ueberfischung der Nordsee - ein historischer Ueberblick des Konfliktes zwischen Politik und Wissenschaft. Pages 87- 108 In: W. Lenz and B. Watermann (eds.) Historisch-meereskundliches Jahrbuch. Dietrich Reimer Verlag, Berlin/Hamburg.

Lindeboom, H. J. and S. J. d. Groot. 1998. IMPACT II - The effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystems. NIOZ-Rapport 1998-1, RIVO-DLO -C003/98, NIOZ-Rapport 1998-1 Report No.C003/98.

Lissner, H. 1927. Die grosse Heringsfischerei in Deutschland. Berichte der deutschen wissenschaftlichen Kommission für Meeresforschung 3:

Meseck, G. 1972. Die Fischwirtschaft in der erweiterten Europaeischen Wirtschaftsgemeinschaft. Schriftenreihe der Schleswig-Holsteinischen Fischwirtschaft 11:9-18.

Meyer, H. A., K. Moebius, G. Karsten and V. Hensen. 1878. Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel für die Jahre 1874, 1875, 1876. Koenglich Preussischen Ministeriums für die landwirtschaftlichen Angelegenheiten,

Meyer-Waarden, P. F. 1957. Krebs- und Muscheltiere, 2.Teil: Muscheltiere. Arbeiten des deutschen Fischerei-Verbandes 9:1-68.

Nellen, W. 1978. Das Wattenmeer: Ökologische Kostbarkeit und Goldgrube für den Fischer. Umschau in Wissenschaft und Technik 78:163-169.

Nellen, W. 1979. Fischereiliche Bedeutung des Wattenmeeres. Arbeiten des Deutschen Fischerei-Verbandes (Probleme der Koexistenz von Fischerei und anderen Wirtschaftszweigen bei der Nutzung des Deutschen Festlandsockels der Nordsee) 27:1-16.

Nerdel, W. 1974. Die Kutterfischerei in der Nordsee, die Entwicklung in den letzten 15 Jahren und die Aussichten für die Zukunft. Arbeiten des deutschen Fischerei-Verbandes 17:93 - 100.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F. T. (Jr.). 1998. Fishing down marine food webs. Science 279:860-863.

Reitzenstein, F. 1913. Das Seemoos und seine Fischerei - Das Seemoos und das Korallenmoos, ihre Fischerei, ihre Lebensweise- und Wachstumsverhaeltnisse, speziell an der Küste von Schleswig-Holstein. Abhandlungen des deutschen Seefischerei-Vereins 12:94.

RML. 1925. Jahresbericht ueber die deutsche Fischerei 1925. Reichsministerium für Ernaehrung und Landwirtschaft,

RML. 1939. Jahresbericht über die deutsche Fischerei 1938. Reichsministerium für Ernährung und Landwirtschaft,

Sahrhage, D. 1987. Marine Fischbestandsforschung: ein Teil des Umwelt- und Naturschutzes. Naturwissenschaften 74:305-311.

Schnakenbeck, W. 1928. Die Nordseefischerei. E. Schweizerbart'sche Verlagsbuchhandlung (Erwin Naegele) Gmbh, Stuttgart.

Seefischerei-Verein. 1897. Abhandlungen des deutschen Seefischerei-Vereins. Deutscher Seefischerei-Verein, Berlin.

Tiews, K. 1974. Fischereiressourcen der Nordsee in ihrer Bedeutung für die deutsche Kutterfischerei. Arbeiten des deutschen Fischerei-Verbandes 17:1-19.

Tiews, K. 1990. 35-Jahres-Tend (1954-1988) der Häufigkeit von 25 Fisch- und Krebstierbestaenden an der deutschen Nordseekueste. Archiv für Fischerei Wissenschaften 40:39-48.

Tiews, K. and A. Schumacher. 1982. Assessment of brown shrimp stocks (*Crangon crangon*) off the German coast for the period of 1965-1978. Arch. FischWiss. 32:1-11.

Willer, A. 1945. Zoologisches aus der Deutschen Fischereistatistik. Archiv für Hydrobiologie 40:1063-1077.

Wolfff, W. J. 1983. Ecology of the Wadden Sea - Fishes and fisheries/Birds/Marine Mammals/Pollution. A.A.Balkema, Rotterdam.

United Kingdom

Aflalo, F.G. 1904. The Sea Fishing Industry of England and Wales. E. Stanford, London.

Aitkin, A., Mackie, I., & Windsor, M. 1982. Fish Handling and Processing. Ministry of Agriculture, Fisheries, and Food. HMSO, London. pp.28-115.

Anon. Report of the North Sea Roundfish Working Group. ICES Doc. C. M., 1981, G:8

Anon. Report of the Herring Assessment Working Group for the Area South of 62N. ICES Doc. C. M., 1988, 17.

Anon. Report of the North Sea Flatfish Working Group. ICES Doc. C. M., 1988, Assess:9.

Anon. Report of the Herring Assessment Working Group for the Area South of 62N. ICES Doc. C. M., 1990, Asses:14.

Anon. Report of the North Sea Roundfish Working Group. ICES Doc. C. M., 1990, Assess:7.

Anon. Report of the Herring Assessment Working Group for the Area South of 62N. ICES Doc. C. M., 1991, Assess:5.

Anon. Report of the North Sea Flatfish Working Group. ICES Doc. C. M., 1991, Assess:9.

Anon. Report of the North Sea Roundfish Working Group. ICES Doc. C. M., 1991, Assess:4.

Anon. Report of the North Sea Flatfish Working Group. ICES Doc. C. M., 1992, Assess:6.

Anon. Working Group on the Assessment of Demersal stocks in the North Sea and Skagerrak. ICES Doc. C. M., 1993, Assess:5.

Board of Agriculture and Fisheries. Sea Fisheries. Fishery Investigations, 1(1):2.

Board of Trade (Dep. of Labour Statistics). 1915. Great Britain Abstracts of Labour Statistics, 17-19. HMSO, London.

Burd, A. C. 1978. Long-term changes in North Sea herring stocks. Rapp. P. – V. Reun. CIEM, 172: pp.137-153.

Clarkson, L. 1990. British Trade Union and Labour history: A Compendium. The Economic history Society, London. 108p.

Coull, J. 1996. The Sea Fisheries of Scotland: A Historical Geography. John Donald Pub., Edinburgh. pp15-17,142-153.

Coull, J. R. 1972. The Fisheries of Europe. An Economic Geography. G.Bell and Sons Ltd., London.

Daan, N., Hessen, H. J. L., & Pope, J. G. 1994. Changes in the North Sea cod stock during the twentieth century. *ICES Marine Science Symposium*, 198:229-243

Daan, N., Richardson, K., & Pope, J.G. 1996. Changes in the North Sea ecosystem and their causes. *ICES Journal of Marine Science*, 53(6):879-883.

Dyson, J. 1977. Business in Great Waters. London, Angus and Robertson. pp.111-257.

Graham, M. 1956. Sea Fisheries: Their Investigations in the UK. E.Arnold, London.

Graham, M. 1939. Effect of fishing plaice in the North Sea. *Rapp. P.-v. Reun. Cons. int. Explor. Mer*, 110.

Graham, M. 1960-1963. The state of the northern stocks of cod. *Rapp.P.-v.Reun.Cons.int. Explor. Mer. Rapports*, 133-140.

Gray, M. 1978. The Fishing Industries of Scotland 1790-1914: A Study in Regional Adaptation. Oxford University Press, London.

Gulland, J. A. 1971. The Fish Resources of the Ocean. Rome, FAO. 15.

Hardy, A. 1959. The Open Sea II: Fish and Fisheries. Collins Press, London.

Hatcher, A. C. 1977. Producers organizations and developed fisheries management in the UK: Collective and individual quota systems. *Marine Policy*, 21(6):519-533.

Hempel, G. 1978. Synopsis of the symposium on North Sea fish stocks-recent changes and their causes. *Rapp. P.-v. Reun. Cons. Int. Explor. Mer*, 172:445-449.

Holden, M. J. 1978. Long term changes in landings of fish from the North Sea. *Rapp.P.-v. Reun.Cons.int.Explor.Mer*, 11-26.

Holden, M.J. 1981. Long term changes in landings from the North Sea with particular reference to the periods 1930-38 and 1960-69. Symposium on the Changes in North Sea Fish Stocks and their Cause. No. 15.

ICES 1910. Bulletin Statistique des peches maritimes des pays du nord de l'Europe: *Cons.int.Explor.Mer.*, 3-9.

ICES 1953-1955. Bulletin Statistique des peches maritimes des pays du nord de l'Europe: *Cons.int.Explor.Mer.*, 32-43.

Kondrashova, N.G. 1984. Shipboard refidgeration and fish processing equipment. Amerind Pub. Co. Pvt. Ltd., New Delhi. 222 p.

Meyers, R. A., Bridson, J, and Barrowman, N. J. 1995. Summary of worldwide stock and recruitment data. Can. Tech. Rep. Fish. Aquat. Aci., 2024: 274 p.

Ministry of Agriculture, Fisheries, and Food. 1994. Sea Fisheries Statistics:1991 and 1992. HMSO, London. pp. 3-63.

Organisation for European Economic Co-operation. 1960. Fisheries Policies in Western Europe and North America.

Parish,B. B. and Jones, R. 1952. State of the haddock stocks in the north sea: 1946-1950. *Marine Research*, 4.

Pope, J. G. 1978. An evaluation of the stock structure of North Sea cod, haddock, and whiting since 1920, together with a consideration of the impacts of fisheries and predation effects on their biomass and recruitment. ICES J. Mar. Sci, 53:1157-1169.

Posgay, J. A. Status of fisheries and research carried out in subarea 4 in 1971. ICNAF Res. Doc. 72/131. 5 p.

Report of the ICES Advisory Committee on Fishery Management, 1999. *ICES Coop.Res.Rep*, 236(1):234-292.

Ritchie, A. 1960. The Scottish seine net fishery:1921-1957. *Marine Research*, 3.

Rijnsdorp, A.D., Daan, N., Beek, F.A., and Heesen, H. J. L. 1991. Reproductive variability in North Sea plaice, sole, and cod. J. Cons. Int. Explor. Mer. 47:352-375.

Sahrhage, D. & Lundbeck, J. 1992. A History of Fishing. Springer-Verlag, Berlin.

Serchuk, F. M., Kirkegaard, E., & Daan, N. 1996. Status and trends of the major roundfish, flatfish, and pelagic fish stocks in the North Sea: Thirty year overview. *ICES Journal of Marine Science*, 53(6):1130-1145.

Starkley, D. J., & Jamieson A. 1998. Exploiting the Sea. Exeter, University of Exeter Press.

Steele, J. H. 1958. Plant production in the northern North Sea. *Marine Research*, 7.

Steele, J.H. 1961. The environment of a herring fishery. *Marine Research*, 6.

Symes, D. 1991. UK demersal fisheries and the North Sea: Problems in renewable resources management. *Geography*, 76(2):131-142.

Symes, D. 1998. Northern Waters: Management and Practice. Fishing New Books, London. pp.195-246.

The European Commision. The Common Fisheries Policy.

UK Sea Fisheries Statistics 1950. HMSO, London. 1951.

UK Sea Fisheries Statistics 1991 and 1992. HMSO, London. 1994

Varela, R.A., Cruzado, A., and Gabaldon, J.E. 1995. Modelling primary production in the North Sea. *Netherlands Journal of Sea Research*, 33:337-361.

Wimpenny, R. S. 1948-1951. The English plaice fishery in the southern North Sea and English Channel in 1948. *Annales Biologiques CPIEM*, 5-8.

Wren, C. 1988. Industrial Subsidies: The UK Experience. Macmilllan Press, London. pp.123-170.