Assessment of the "State" of the demersal fish communities in OSPAR Regions II, III, IV and V[1,2]

1 Introduction and Methods

OSPAR is developing an ecosystem approach for the management of marine natural resources. Ecological Quality Objectives have been developed as tools to support the application of such an approach. Ten Ecological Quality Issues have been identified, with the intention of setting Ecological Quality Objectives (EcoQOs) for each issue. This scheme has been developed and piloted in the North Sea Since 2000 (i.e. during the reporting period for QSR 2010),. Fish Communities is the fifth in the list of Ecological Quality Issues, and is considered to be one of the three community-level issues. In addressing concerns regarding anthropogenically induced change in fish communities therefore, a community-level approach has been widely adopted. This has generally involved the application of uni-variate metrics to groundfish survey data to quantify change in various aspects of the community's composition, structure and function. The element of Ecological Quality for the North Sea fish community focuses on "changes in the proportion of large fish and hence the average weight and average maximum length of the fish community", thus clearly identifying the need for a community size composition metric as the "indicator" on which to base an EcoQO for the "fish community" Ecological Quality Issue. The chosen metric, the Large Fish Indicator (LFI) was eventually defined as "the proportion by weight of fish greater than 40 cm in length", based on ICES first quarter (Q1) International Bottom Trawl Survey (IBTS) data.

The LFI was intended to be an indicator of the "general health" of the demersal fish community. However, other aspects of the composition, structure and functioning of fish communities, such as abundance, biomass, productivity, species richness, species diversity and mean life-history trait composition, can also be summarised using univariate metrics. Any one, or all, of these alternative metrics might also be considered to be indicative of the "health" of fish communities. The LFI was chosen ahead of these alternative metrics because it was believed to be particularly sensitive to variation in fishing pressure, and therefore to indicate directly the effect of fishing on state of the fish community. However, this raises the question as to whether one indicator is sufficient to inform on the general health of the demersal fish community, or is a suite of indicators necessary in order to provide information on various different aspects of a community's composition, structure and function? In this assessment of the state of the demersal community in OSPAR Regions II to V, fifteen uni-variate metrics are applied to groundfish survey data to quantify changes in five main aspects of community composition, structure and function: abundance/biomass/productivity; size composition; species richness; species diversity; and life-history trait composition (Annex 2).

Bottom trawl surveys have been carried out as part of the traditional annual fisheries management process for several decades. These surveys routinely provide point estimates of the abundance at

[1] This analysis was undertaken based on data accessed by the co-authors of this section who were Simon Greenstreet, Helen Fraser, John Cotter and John Pinnegar. This did not include data from OSPAR Region I
[2] Note: All tables presented in this text are included at the end of the text.

length of each species sampled; therefore providing the ideal data sets for the application of univariate community metrics. Many of these surveys have run for two or three decades now, providing ideal time series with which to evaluate changes in the composition, structure and function of fish communities. Furthermore, most coastal European nations have been involved in survey activity, providing data from most of the continental shelf waters in the OSPAR area. In this assessment, otter trawl survey data is analysed to assess changes in the fish communities present in OSPAR Regions II to V (Figure 6.1).

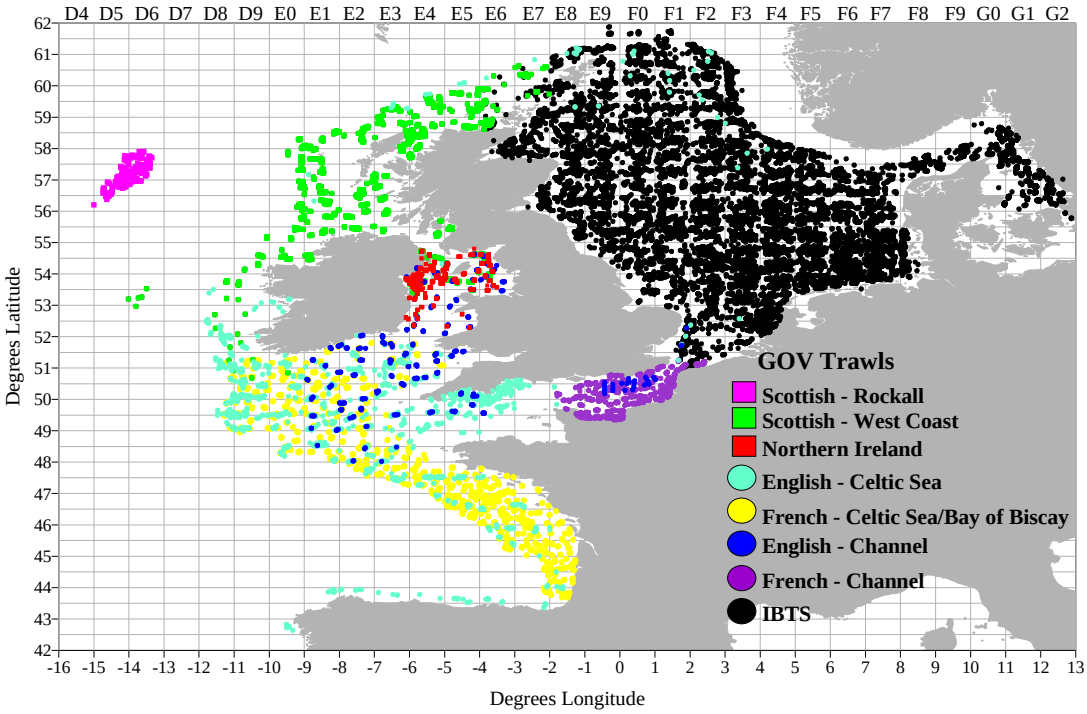

Figure 6.1: *Chart showing positions of otter trawl survey samples available for analysis.*

To assess the state of the demersal fish community in OSPAR Regions, II, III, IV and V, and make a judgement on the changes observed, it was necessary to decide what constituted "beneficial" and "detrimental" change. Emphasis is generally placed on conserving and restoring biodiversity; implying that declines in species diversity (both richness and evenness) are detrimental. The converse was therefore also assumed to hold. The life-history trait composition responses of populations and communities to anthropogenically raised levels of mortality have recently received considerable attention. Declines in population age and length at maturity, decreased community average ultimate body length, and increased in community average growth rate are all considered to be detrimental consequences. Improved management would therefore be expected to induce the opposite, beneficial trends.

Established population dynamics theory predicts that size-related fishing mortality reduces the mean size and proportion of large fish in exploited populations (including non-target species taken as by-catch). This concept underpins development of the LFI as the basis for the OSPAR North Sea Fish Community EcoQO. Reductions in LFI are therefore considered detrimental. Changes in LFI were generally inversely correlated with changes in the abundance, biomass and (growth) productivity of the fish community. The von Bertalanffy growth equation makes it clear that larger fish, closer to their

ultimate body length (L∞), have lower daily specific growth rates. Large fish exert a strong predation loading on small fish abundance. Since trophic transfer efficiency is around 10%, every kg of production by larger fish requires 10 kg of production in their smaller prey fish populations. Specific growth rates among smaller fish are approximately twice that of larger fish, so 5 kg of prey fish are required to support every kg of larger fish. Reductions in the abundance of larger fish, with the consequent reduction in predation loading on smaller prey fish, would therefore tend to result in a rapid increase in the abundance and biomass of small fish; a typical trophic cascade effect.

In assessing of the state of the demersal fish community in four of the OSPAR Regions, two questions were addressed. Firstly, how has the state of the community changed over the last decade, from 1999 to 2008; the period of particular interest to the current QSR. Secondly, how does the state of the community over the period 2004 to 2008 (i.e. now) compare with that prevalent during the eight-year period when data were first available for analysis. Detrimental trends were assigned a “red” colour code and beneficial trends “green”. Where no discernable trend was apparent, an “orange” colour code was applied. Five separate aspects of composition, structure and function of the demersal fish community were considered, and a judgement was made based on the trends observed in the 15 uni-variate community metrics applied to the groundfish survey data. Linear regression was used to make an assessment of metric trends over the last decade. In comparing the current situation with the earlier “reference period”, mean metric values over the period 2004 to 2008 were determined and the assessment was scored red or green depending on whether the recent mean value differed by more than one standard deviation either side of the mean value determined for the “reference period”.

In OSPAR Regions IV and V, only single data sets were available for analysis, each covering only a fraction of the whole Region concerned. For these Regions therefore, assessment was straightforward. In OSPAR Region II, data sets were available that covered almost the entire Region, allowing a single “analytical” assessment to be made based on all the data from throughout the Region. In OSPAR Region III, data were available that more or less covered the entire Region, but from several different surveys, not a single co-ordinated survey. This necessitated the division of the Region into seven sub-regions, with each sub-region assessed individually. To determine an overall regional assessment, weighted averages were then calculated. Red cells were given a value of 1, orange a value of 2, and green a value of 3, and cells were then weighted by the number of ICES statistical rectangles in the sub-regions. For the final regional assessment, weighted average scores greater than 2.35 were considered good and assigned a “green” code; scores of less than 1.65 were considered poor and assigned a “red” cod; while scores of 1.65 to 2.35 were deemed to indicate little change and assigned an “orange” code. This analysis revealed considerable variation between sub-regions in the way that the different aspects of the composition, structure and functioning of the fish community in OSPAR Region III had varied over time. So the same approach was applied to OSPAR Region II to determine whether the single “analytical” assessment had masked similar sub-regional variation. This had two benefits. Firstly, it allowed sub-regions, such as the English Channel, part of OSPAR Region II, but not covered by the single co-ordinated survey, to be included in the regional assessment. Secondly, it provided a comparison of the “analytical” and “weighted average” approaches.

2 Regional Assessments

OSPAR Region II – "Analytical" assessment

Figure 6.2 illustrates the development of the LFI and provides an explanation for the EcoQO indicator target of 0.3. From the early 1980s, the Large Fish Indicator (LFI) declined from around 0.3 to its lowest point of less than 0.05 in 2001, since when it has recovered to around 0.22 in 2008.

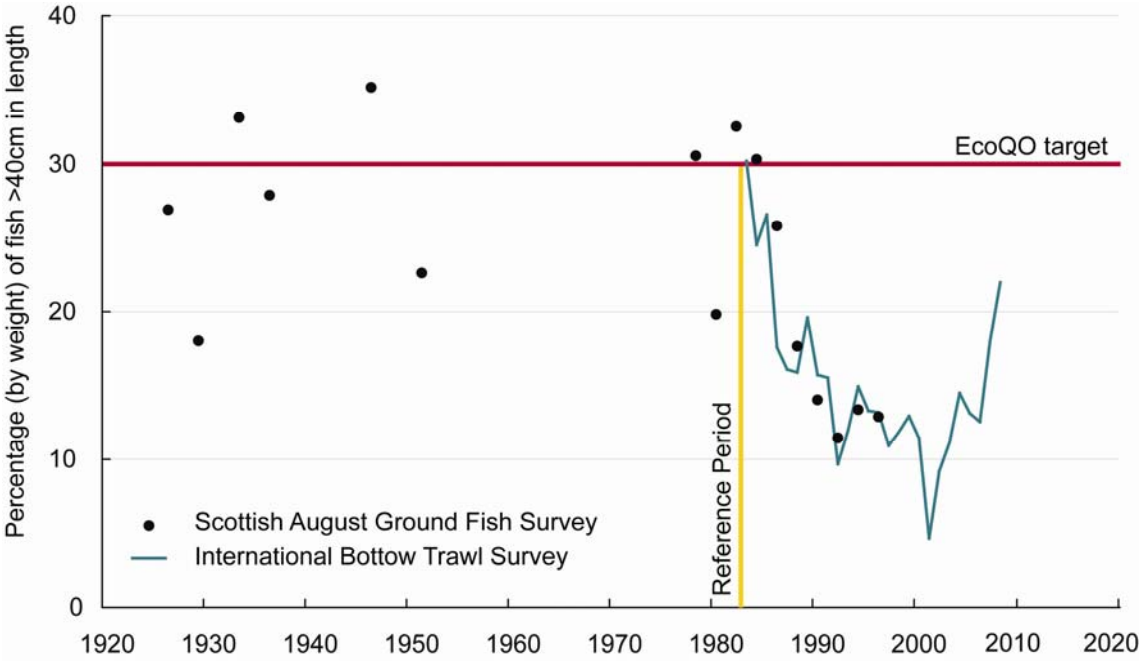

Figure 6.2: *Variation in the LFI, which is based on the Q1 International Bottom Trawl Survey (IBTS). Stock assessments in the early 1980s suggested that stocks were not being over-exploited at that time and that therefore fishing was at sustainable levels. The early 1980s were therefore considered to be a "reference" period, and the LFI recorded at that time deemed to be an appropriate level for fisheries managers to aspire to. The EcoQO is therefore 0.3; an LFI value consistent with individual stock conservation and preservation of the integrity of the wider demersal fish community, and yet a level that should still allow an economically viable fishing industry to persist. Analysis of the Scottish August Groundfish Survey (SAGFS), which stopped in 1997, confirms that an LFI value of 0.3 is an appropriate target for management. The SAGFS LFI tracks the IBTS Q1 index remarkably well over the period that the two surveys coincided, whilst the earlier index values varied around 0.29.*

Figure 6.3 indicates trends in all 15 uni-variate metrics. Increases in species richness were apparent since 1990, while species evenness oscillated, but was generally higher in the later part of the time-series than in the earlier. Concomitant with the recent trend towards larger fish in the community, total abundance, biomass and productivity all appear to have declined. Average life-history trait composition has also oscillated over the full time period, but clear trends were not obvious, except for a possible increase in the average age-at-maturity among demersal fish in the North Sea.

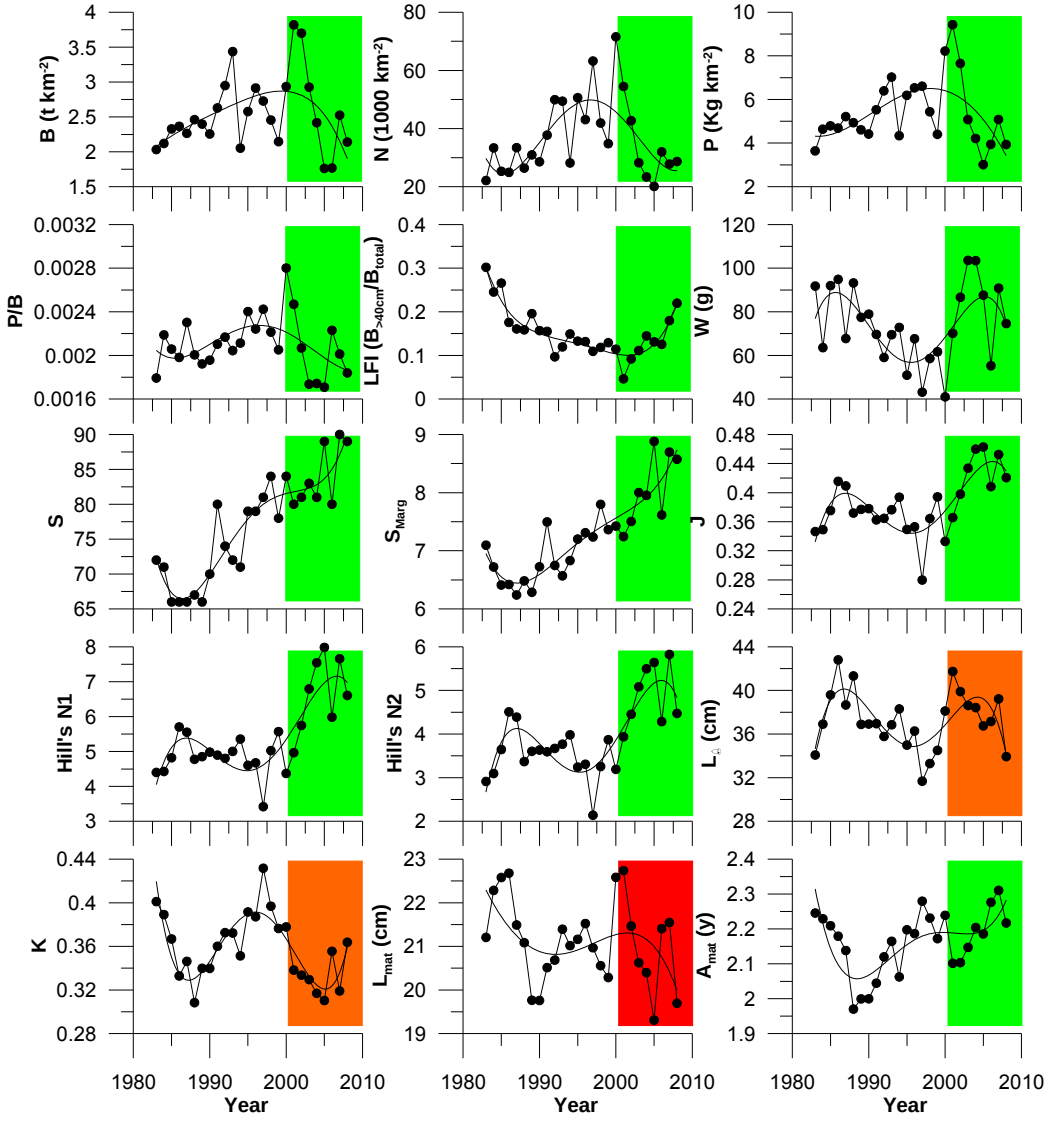

Figure 6.3: *Trends in fifteen indicator metrics applied to the IBTS Q1 groundfish survey data for the whole North Sea (OSPAR Region II). The metrics used are indicated on the plot y axes, these are: B - Biomass; N - Abundance; P - Daily growth production; P/B - Daily production to biomass ratio; LFI - Large fish indicator; W - Mean weight of fish; S - Species count; S_{Marg} - Margalef's species richness; J - Pielou's evenness; N1 - Hill's N1 diversity; N2 - Hill's N2 dominance; L_{∞} - Mean ultimate body length; K - Mean growth coefficient; L_{mat} - Mean length at maturity; A_{mat} - Mean age at maturity. Colour bars indicate whether the metric trend since 2000 suggests that state of the demersal fish community in North Sea is improving (green), deteriorating (red), or where the data are inconclusive (orange).*

Table 6.2 provides the "analytical" regional assessment of these trends. Most aspects of the composition, structure and functioning of the Greater North Sea demersal fish community have improved over the last decade, such that the state of the community is now on a parity with, or better than, the situation observed in the early to mid 1980s. The exception to this is the size composition of the community, which is the basis of the OSPAR EcoQO. Here the data suggest that the situation is improving, but that there is still a little way to go.

In the following sections, all the sub-regional and regional assessments were based on similar sets of plots to those shown in Figure 6.3. These can be accessed in the supplementary material annexes referred to at the end of each section.

Table 6.2: *Assessment of changes in the composition, structure and function of the demersal fish community in the Greater North Sea, OSPAR Region II. Green cells indicate beneficial changes. Red cells indicate detrimental changes. Where no discernable trend is apparent, cells are coded orange. Regional "reference periods" are indicated in the lower half of the table.*

Aspect of Fish Community Composition, Structure and Function	**Abundance, Biomass and Productivity**	**Size Composition**	**Species Richness**	**Species Evenness**	**Life-history Trait Composition**
Assessment of Trend Since 1999					
Greater North Sea (Region II)					
Comparison of State of Fish Community in Last Five-year Period with First Eight-year Period in Time Series					
Greater North Sea (Region II)	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990

OSPAR Region II - "Weighted average" assessment

Sub-regional analysis (Table 6.3) confirmed that changes in the composition, structure, and function of the demersal fish community were not consistent across the entire OSPAR Region II. In the recent decade, however, most aspects of the community's composition, structure, and function had improved, or at least shown no obvious decline; the exception to this being a deterioration in species evenness and life-history trait composition in the Northwestern Basin and a deterioration in the abundance/biomass/productivity and size composition aspects in the Eastern Central Basin. Comparison of the current situation with the situation prevailing when data were first available highlights size composition as the aspect of fish community composition, structure and function over which there should be greatest concern. In seven of the ten sub-regions the situation now is worse than it was in the early to late 1980s. In contrast, species richness is now higher in seven of the ten sub-regions than it was previously.

Generally, the sub-regional weighted average approach to providing a regional assessment of the state of the composition, structure and function of the demersal fish community in the entire OSPAR Region II provided similar results to the overall analytical assessment (compare Tables 6.2 and 6.3). Results were identical in the assessments of recent trends and in the comparison of the current situation with the earliest date period, only the assessment for the species evenness aspect differed: this was scored as an improvement in the analytical assessment (Table 6.2), and as no change in the weighted average assessment (Table 6.3).

Supplementary Material Annexes 2.1 and 2.2 provide further details of the data sets available and the results of all the analyses undertaken.

Table 6.3: *Assessment of changes in the composition, structure and function of the demersal fish community in each sub-region of OSPAR Region II and overall assessment for the entire Region. Green cells indicate beneficial changes. Red cells indicate detrimental changes. Where no discernable trend is apparent, cells are coded orange. Sub-regional "reference periods" are indicated in the lower half of the table. Values in the overall regional assessment rows indicate weighted average scores. Two assessments for the Northwestern Continental Shelf are shown; east refers to the IBTS based assessment documented in the Supplementary Material Annex 2.1. The assessment labelled (west) show the results of the assessment based on the Scottish West Coast Groundfish Survey, which along with the English Channel assessment, is documented in Supplementary Material Annex 2.2.*

Aspect of Fish Community Composition, Structure and Function	**Abundance, Biomass and Productivity**	**Size Composition**	**Species Richness**	**Species Evenness**	**Life-history Trait Composition**
Assessment of Trend Since 1999					
Northwestern Continental Shelf (east)					
Northwestern Basin					
Northeastern Basin					
Norwegian Deeps					
Kattegat and Skagerrak					
Western Central Basin					
Eastern Central Basin					
Southern Basin					
English Channel					
Northwestern Continental Shelf (west)					
OSPAR REGION II ASSESSMENT	**2.39**	**2.36**	**2.90**	**2.44**	**2.12**
Comparison of State of Fish Community in Last Five-year Period with First Eight-year Period in Time Series					
Northwestern Continental Shelf (east)	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990
Northwestern Basin	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990
Northeastern Basin	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990
Norwegian Deeps	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990
Kattegat and Skagerrak	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990
Western Central Basin	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990
Eastern Central Basin	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990
Southern Basin	1983-1990	1983-1990	1983-1990	1983-1990	1983-1990
English Channel	1986-1993	1986-1993	1986-1993	1986-1993	1986-1993
Northwestern Continental Shelf (west)	1988-1995	1988-1995	1988-1995	1988-1995	1988-1995
OSPAR REGION II ASSESSMENT	**2.20**	**1.30**	**2.65**	**2.08**	**1.69**

OSPAR Region III

In all sub-regions of OSPAR Region III, the fish community is currently in a poorer or similar state to that prevalent at the start of each of the sub-regional time series (Table 6.4). In all cases, however, recent trends indicate an improving situation. These improvements are most marked in the more northerly sub-regions. The overall regional assessment reflects a similar pattern. Nearly all aspects of the composition, structure and functioning of the demersal fish community in OSPAR Region III have improved over the last decade, such that, in many respects, the community is in a similar state to the one observed when data were first available. The aspects of most concern at the present time relate to the size structure, abundance, biomass and productivity of the community.

Supplementary Material Annex 2.3 provides further details of the data sets available and the results of all the analyses undertaken.

Table 6.4: *Assessment of changes in the composition, structure and function of the demersal fish community in each sub-region of OSPAR Region III and overall assessment for the entire Region. Green cells indicate beneficial changes. Red cells indicate detrimental changes. Where no discernable trend is apparent, cells are coded orange. Paler coloured cells indicate instances where confidence in the assessment is low. Sub-regional "reference periods" are indicated in the lower half of the table. Values in the overall regional assessment rows indicate weighted average scores.*

Aspect of Fish Community Composition, Structure and Function	**Abundance, Biomass and Productivity**	**Size Composition**	**Species Richness**	**Species Evenness**	**Life-history Trait Composition**
Assessment of Trend Since 1999					
Hebridean Continental Shelf					
Minches and Western Scotland					
Northwestern Irish Continental Shelf					
Southwestern Irish Continental Shelf					
Irish Sea					
Northern Celtic Sea					
Southern Celtic Sea					
OSPAR REGION III ASSESSMENT	2.25	2.40	2.36	2.68	2.69
Comparison of State of Fish Community in Last Five-year Period with First Eight-year Period in Time Series					
Hebridean Continental Shelf	1986-1993	1986-1993	1986-1993	1986-1993	1986-1993
Minches and Western Scotland	1986-1993	1986-1993	1986-1993	1986-1993	1986-1993
Northwestern Irish Continental Shelf	1986-1993	1986-1993	1986-1993	1986-1993	1986-1993
Southwestern Irish Continental Shelf	1984-1991	1984-1991	1984-1991	1984-1991	1984-1991
Irish Sea	1992-1998	1992-1998	1992-1998	1992-1998	1992-1998
Northern Celtic Sea	1984-1991	1984-1991	1984-1991	1984-1991	1984-1991
Southern Celtic Sea	1984-1991	1984-1991	1984-1991	1984-1991	1984-1991
OSPAR REGION III ASSESSMENT	1.55	1.55	1.91	2.23	2.25

OSPAR Region IV

Data were only available for French continental shelf waters within OSPAR Region IV. Over the recent decade, improvements in the life-history trait composition and species richness of the Bay of Biscay demersal fish community were noted (Table 6.5), however, little change was apparent in the other three aspects of community composition, structure and functioning. Over the longer term, size composition, species evenness, and abundance/biomass/productivity aspects were all considered to be in poorer state now than in the mid to late 1980s, while little change was apparent in the species richness and life-history trait composition of the community.

Supplementary Material Annex 2.4 provides further details of the data sets available and the results of all the analyses undertaken.

Table 6.5: *Assessment of changes in the composition, structure and function of the demersal fish community in the French Bay of Biscay sub-region of OSPAR Region IV. Green cells indicate beneficial changes. Red cells indicate detrimental changes. Where no discernable trend is apparent, cells are coded orange. Paler coloured cells indicate instances where confidence in the assessment is low. Sub-regional "reference periods" are indicated in the lower half of the table.*

Aspect of Fish Community Composition, Structure and Function	**Abundance, Biomass and Productivity**	**Size Composition**	**Species Richness**	**Species Evenness**	**Life-history Trait Composition**
Assessment of Trend Since 1999					
Bay of Biscay (French coast)					
Comparison of State of Fish Community in Last Five-year Period with First Eight-year Period in Time Series					
Bay of Biscay (French coast)	1984-1991	1984-1991	1984-1991	1984-1991	1984-1991

OSPAR Region V

Data were only available for the Rockall Bank Plateau area within OSPAR Region V. Metric trends over the last decade impart a mixed message (Table 6.6). The species diversity and size composition of the Rockall Bank demersal fish community has improved, whilst abundance/biomass/productivity appears little changed. However, the life-history trait composition metrics suggest a decrease in "climax community" species and an increase in the abundance of "opportunistic" species. A similar story emerges with regard to longer-term change in the composition, structure and function of the Rockall Bank demersal fish community, except that recent changes in size composition have simply achieved parity with the earlier data. Given the scarcity of data, particularly the gap between 1986 and the start of the systematic surveys in 2001, confidence in these assessments is low.

Supplementary Material Annex 2.5 provides further details of the data sets available and the results of all the analyses undertaken.

Table 6.6: *Assessment of changes in the composition, structure and function of the demersal fish community in the Rockall Bank Plateau sub-region of OSPAR Region V. Green cells indicate beneficial changes. Red cells indicate detrimental changes. Where no discernable trend is apparent, cells are coded orange. Paler coloured cells indicate instances where confidence in the assessment is low. Sub-regional "reference periods" are indicated in the lower half of the table.*

Aspect of Fish Community Composition, Structure and Function	**Abundance, Biomass and Productivity**	**Size Composition**	**Species Richness**	**Species Evenness**	**Life-history Trait Composition**
Assessment of Trend Since 1999					
Rockall Bank Plateau					
Comparison of State of Fish Community in Last Five-year Period with First Eight-year Period in Time Series					
Rockall Bank Plateau	1986	1986	1986	1986	1986

3 Overall Regional Summary

Examination of the summary assessment for each of Regions II, III, IV and V shows that, in general the trends since 1999 have been positive with beneficial changes in the majority of the metrics in Regions II, III and V (Figure 6.4). Where there has been no improvement in the metric, in all but one case (life-history trait composition in Region V) there is no discernable trend. Thus, based on this particular analysis, over the last decade the situation with respect to the demersal fish community has either remained unchanged or improved. However, the status over the period 2004 – 2008 is generally not as good as determined for a reference period which was generally the early 1980s to early 1990s.

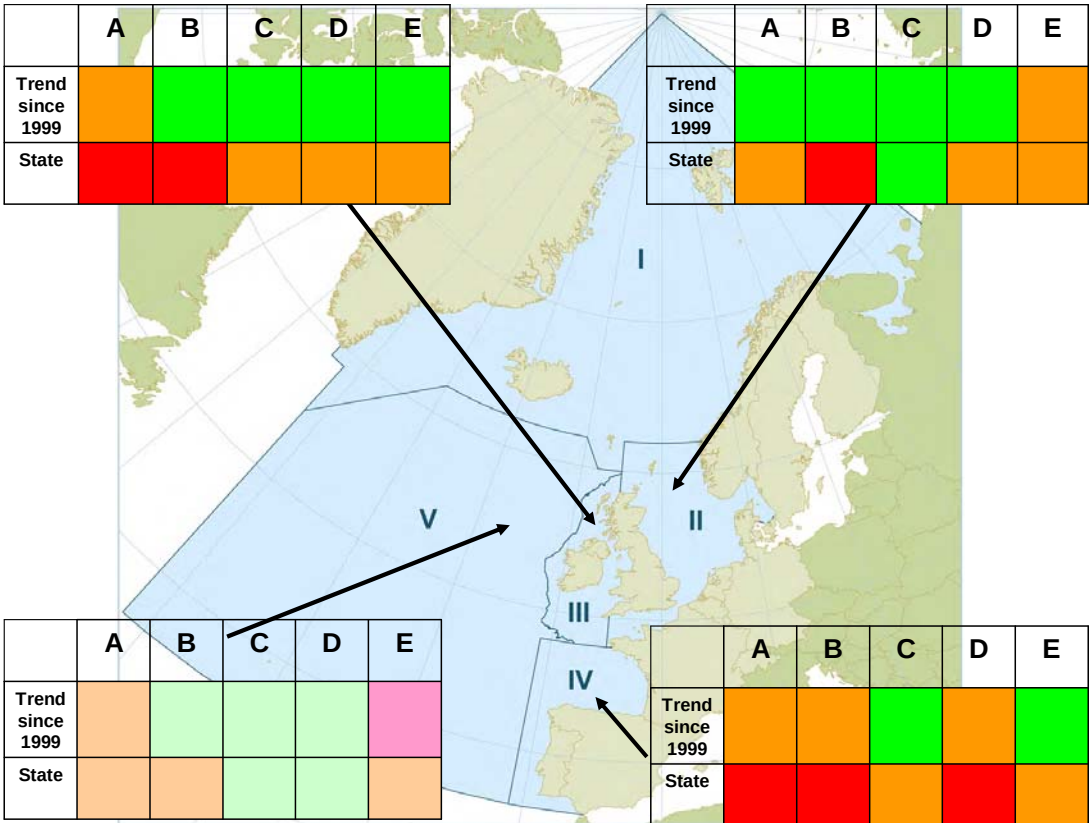

Figure 6.4: *Summary of the individual regional assessments of the demersal fish community for Regions II, III, IV and V. The assessment is based on the Quarter 1 International Bottom Trawl Survey (IBTS) data and National Bottom Trawl Surevy (NBTS) data. This data was used to assess a range of aspects of fish community composition, structure and function including A. Abundance/Biomass/Productivity, B. Size Composition, C. Species Richness, D. Species Evenness and E. Life-History Trait Composition. An improvement has been observed in several aspects of the demersal fish community's composition, structure and function in the four Regions analysed over the last decade. Only the life-history trait composition in Region V has shown a detrimental change. However, the 'mean' state over the period 2004 – 2008 relative to a reference period, which was generally the early 1980s to early 1990s, is generally poorer with detrimental changes apparent for several aspects of the demersal fish composition, structure and function in each Regions III and IV. The paler clours used to present the data in Region V indicate a lower confidence in the analysis. Green cells indicate beneficial changes; Red cells indicate detrimental changes. Orange cells show where there has been no discernable trend or change. OSPAR countries are highlighted in tan on the map. The Roman numerals are the Regions.*

Across the OSPAR Regions considered here (Regions II, III, IV and V), the overall assessment suggests that over the last decade, size composition, species richness and species evenness aspects of the composition, structure and function of the demersal fish community have all improved, whilst there has been little change in the life-history trait composition and abundance/biomass/productivity aspects (Table 6.7). Four of the five aspects are currently on parity with the situation prevailing when data in each Region were first available; the exception being the size composition of the community. Here the assessment indicates that, despite recent improvements, a full recovery to earlier conditions has yet to be achieved.

Table 6.7: *Assessment of changes in the composition, structure and function of the demersal fish community in each OSPAR Region and overall assessment across the four Regions. Green cells indicate beneficial changes. Red cells indicate detrimental changes. Where no discernable trend is apparent, cells are coded orange. Cell values indicate weighted average scores. Overall assessment is based on the "weighted average" assessment of OSPAR Region II. Paler coloured cells indicate instances where confidence in the assessment is low.*

Aspect of Fish Community Composition, Structure and Function	**Abundance, Biomass and Productivity**	**Size Composition**	**Species Richness**	**Species Evenness**	**Life-history Trait Composition**
Assessment of Trend Since 1999					
OSPAR Region II (analytical)					
OSPAR Region II (weighted average)	2.39	2.36	2.90	2.44	2.12
OSPAR Region III (weighted average)	2.25	2.40	2.36	2.68	2.69
OSPAR Region IV					
OSPAR Region V					
OVERALL ASSESSMENT	**2.27**	**2.42**	**2.76**	**2.54**	**2.24**
Comparison of State of Fish Community in Last Five-year Period with First Eight-year Period in Time Series					
OSPAR Region II (analytical)					
OSPAR Region II (weighted average)	2.20	1.30	2.65	2.08	1.69
OSPAR Region III (weighted average)	1.55	1.55	1.91	2.23	2.25
OSPAR Region IV					
OSPAR Region V					
OVERALL ASSESSMENT	**1.87**	**1.43**	**2.41**	**2.14**	**1.81**

➥*Go to full QSR assessment report on environmental impact of fishing (publication number 465/2009)*