

An indicator of sustainability for marine fin-fish stocks around the UK: 1990 - 2008

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March 2010

Summary

- This note updates the analysis adopted since July 2006 for evaluating trends in the proportion of fish stocks at full reproductive capacity and being harvested sustainably around the UK since 1990. This is required for the government PSA delivery agreement 28, Indicator 4(1): *Number of fish stocks around the UK at full reproductive capacity and harvested sustainability*
- The updated sustainability index is based on a consistent set of 18 stocks since 1991 and on a consistent set of 17 stocks between 1982 and 1990. The 18 stocks represent a wide range of different stocks and fisheries including demersal roundfish (cod, haddock, saithe, hake), flatfish (sole, plaice), pelagic (mackerel, herring) and widely dispersed (blue whiting). Many of these stocks are extremely valuable or have high conservation profile. The indicator is applicable only to these stocks.
- The number of stocks included in the index has reduced from 20 in last year's index to 18 in this year's index. This is due to difficulties with the assessments of Western Channel sole and Celtic Sea cod resulting in ICES no longer being able to evaluate the status of the stocks relative to biological reference points. A sensitivity analysis shows that excluding these two stocks shifts the value of the indicator upwards by 3 – 5 percentage points but otherwise does not affect the trend in the indicator in the 2000s.
- In 2008, 50% of the 18 assessed fish stocks around the UK were at full reproductive capacity and were being harvested sustainably. Since 2000, 20-40% of the fish stocks around the UK have been at full reproductive capacity and being harvested sustainably, compared to 5 – 15% in the years from 1990 to 1999.
- The proportion of the 18 stocks being harvested sustainably has increased from around 10% in the 1990s to between 25-45% (2000 – 2007) and 61% in 2008. In contrast, the proportion with full reproductive capacity has increased from 35% in 1999 to 61% in 2008.
- Although the proportion of stocks being harvested sustainably is increasing, fishing mortality in most of the stocks remains above values that may be considered as providing the maximum long-term yields or economic returns under the prevailing environmental conditions that affect stock productivity.
- The index is calculated only for finfish stocks in UK waters for which ICES is able to provide quantitative advice based on age-structured scientific assessments.

Background

The UK government comprehensive spending review CSR 2007 contains a new set of cross-government priorities or public service agreements (PSAs) replacing those agreed in the previous spending review (SR04). The Defra-led PSA Delivery Agreement 28 (*Secure a healthy natural environment for today and the future*¹) includes an indicator of the number of fish stocks around the UK at full reproductive capacity and harvested sustainability:

PSA Delivery Agreement 28: Secure a healthy natural environment for today and the future	
Indicator 4	Marine health – clean, healthy, safe, productive and biologically diverse oceans and seas as indicated by proxy measurements of fish stocks, sea pollution and plankton status.
Fish stock indicator	Number of fish stocks around the UK at full reproductive capacity and harvested sustainability.
Data provider	Defra, CEFAS, International Council for Exploration of the Sea (ICES).
Data set used	A time series of data on the status of finfish stocks around the UK, as identified by ICES. The data are derived from annual Advisory Committee on Management (ACOM) reports from May and October ACFM meetings, and are categorized according to the ICES definition of the state of the stock. Since 1998, the status of stocks has been defined by ICES using new biological reference points based on the precautionary approach.
Baseline	1990
Reporting frequency	Annual
Minimum movement required for performance assessment	Any change in number of fish stocks at full reproductive capacity and harvested sustainability.

The PSA indicators are available to the public in the Defra *Sustainable development indicators in your pocket* booklet².

What do we mean by sustainability of fish stocks?

The FAO report on the state of world fisheries in 2008³ indicated that the percentage of the world's fish stocks that are over-exploited, depleted or recovering from depletion increased rapidly in the 1970s and 1980s and has varied from 25%-30% since the mid 1990s. In the UK, we are particularly interested to know if fisheries management measures imposed through the EU Common Fisheries Policy and any additional national initiatives are being successful in improving the status of stocks that support our fisheries around the UK coast.

A long-term goal of fisheries management is to achieve rates of **fishing mortality** (F), a measure of the fraction of the stock that is removed each year by fishing, that provide the largest annual yields on a sustainable basis without reducing the spawning stock biomass (SSB) and recruitment of young fish to unproductive levels.

¹ http://www.hm-treasury.gov.uk/d/pbr_csr07_psa28.pdf

² http://www.defra.gov.uk/sustainable/government/progress/documents/SDIYP2009_a9.pdf

³ <http://www.fao.org/docrep/011/i0250e/i0250e00.htm>

Fishery Management Plans being developed in the EU for individual stocks aim to move fishing mortality progressively towards the value associated with the **Maximum Sustainable Yield** or **MSY**, as required by the agreements reached during the World Summit on Sustainable Development in 2002.

The **first step** towards achieving MSY is to ensure that the fishing mortality is sustainable – i.e. there is a low risk of depleting the reproductive capacity of the spawning stock to an unproductive state. The Precautionary Approach⁴ adopted by the International Council for the Exploration of the Seas (ICES: www.ices.dk) defines a limit reference point for spawning stock biomass (B_{lim}) below which a stock is considered as suffering reduced reproductive capacity. To maintain stocks above B_{lim} with high probability requires that the fishing mortality rate is less than the limit reference point F_{lim} . However, fishing mortality and spawning stock biomass cannot be measured exactly. If recent estimates of F from a stock assessment model are only slightly below F_{lim} , there is still a high probability that the true F could be above F_{lim} . To reduce the risk of this happening, additional “precautionary” (P_A) reference points B_{pa} and F_{pa} are defined. The difference between the limit and precautionary reference points represents a “buffer zone” to minimise the risk that would be associated with making fishery management decisions based on error-prone estimates of SSB and F in relation to limit reference points. If estimates of SSB or F are in the buffer zone, the stock is considered as being “at risk” of having reduced reproductive capacity or being harvested unsustainably (see Figure 1).

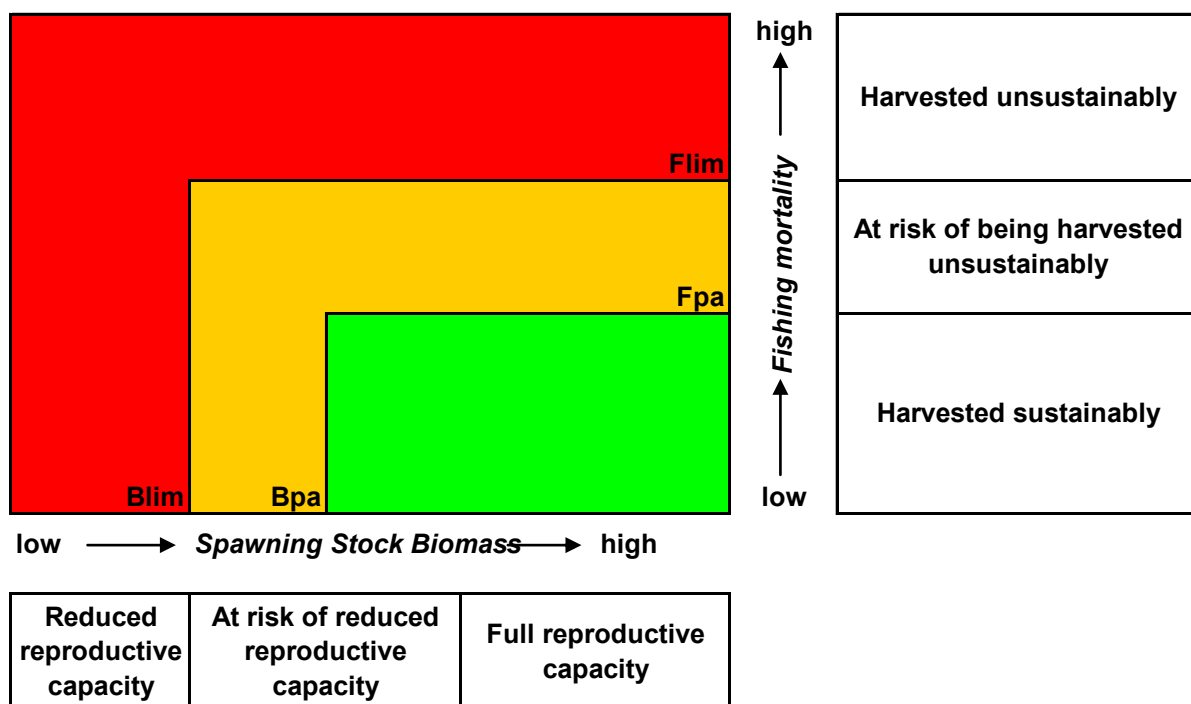


Figure 1. Classification of fish stocks by ICES according to fishing mortality and spawning stock biomass relative to limit (F_{lim} and B_{lim}) and precautionary (F_{pa} and B_{pa}) reference points.

⁴ <http://www.cefas.co.uk/data/fisheries-information/management-and-advice/overfishing-and-the-ices-precautionary-approach-to-management.aspx>

Developing an indicator of sustainability of fish stocks around the UK

The concept of precautionary reference points for spawning stock biomass and fishing mortality is adopted for calculating an indicator of sustainability of fish stocks around the UK. The indicator is calculated using time-series of estimates of F and SSB for each fin-fish stock given in the latest management advice from ICES⁵. The annual estimates of F and SSB in each time series are compared with the precautionary reference points F_{pa} and B_{pa} to determine if the stock had full reproductive capacity and was being harvested sustainably in each year. The proportion of stocks for which this condition holds is then calculated for each year. By including the criterion that both F and SSB are within sustainable limits, the indicator identifies stocks that may temporarily be above B_{pa} due to recent good recruitment, but continue to be harvested unsustainably. The method of calculating the indicator is given below:

1. The latest ICES advice was reviewed to identify those stocks occurring in UK waters for which advice was given based on a full analytical assessment of trends in F and spawning stock biomass SSB in relation to precautionary reference points.
2. For each stock, each year in the time-series given by the most recent assessment was examined to determine if the SSB of fish surviving to the end of the fishing year (i.e. the SSB at the start of the following year) was at or above B_{pa} and if F in the fishing year was below F_{pa} . This represents a change from the method adopted in providing the PSA index in previous years, in which the status of stocks in a given fishing year was evaluated relative to SSB at the start of the same year. This alteration was made to be in alignment with a change in the way that ICES has provided advice on stock status since 2008. In practice this allows the impact of fishing mortality on SSB to be detected a year earlier than in the previous PSA index, but otherwise has relatively small impact on trends in the indicator.
3. The annual status of each stock was tabulated, and the proportion of stocks with full reproductive capacity or being harvested sustainably, or both, was calculated for each year.
4. The total reported landings for stocks assessed for sustainability was calculated, from the values given by ICES in the stock summary tables (these may differ from the official reported landings in some cases).
5. The stock assessments reported by ICES in 2009 contain estimates of F only up to 2008. The sustainability index is therefore calculated to 2008 only.

Stock assessments rejected by ACOM due to poor data quality, conflicting signals in data, or use of inappropriate methods, have been excluded from the analysis.

⁵ <http://www.ices.dk/advice/icesadvice.asp>

Stocks included in the sustainability indicator

The indicator from 1991 to present is currently calculated for 18 fin-fish stocks in UK waters for which ICES gives quantitative advice on sustainability based on age-structured assessment models, and for which estimates of both F and SSB are available up to the most recent fishing year (Table 1). The 18 stocks represent a wide range of different species and fisheries including demersal roundfish (cod, haddock, saithe, hake), flatfish (sole, plaice), pelagic (mackerel, herring) and widely dispersed (blue whiting). Many of these stocks are extremely valuable or have high conservation profile. Equivalent time series of data are not available for any shellfish stocks.

From 1982 to 1990, 17 of these stocks had data. In 1980, 15 of the stocks had data and in 1970 only 9 of the stocks had data. It is therefore only possible to give a sustainability index for all 18 stocks from 1991 onwards. Using a baseline year of 1990 (as required for Defra Public Service Agreement indicators) results in only 17 stocks for 1990, but this makes only a small difference to the results.

ICES also provides results from analytical assessments for an additional 14 fin-fish stocks in UK waters, but either considers the state of the stocks as “unknown” due to problems with the assessment or is only able to give advice in relation to B_{pa} due to the absence of an F_{pa} value (Table 2). A slightly larger number of stocks (23) can therefore be evaluated against B_{pa} only.

The sustainability indicator only reflects trends in F and SSB for the 18 stocks with data and should not be considered as representing an “average” for all stocks. Many other fin-fish stocks occur in UK waters, for which ICES is not able to determine stock status relative to any precautionary reference points. These include stocks for which there are insufficient data to estimate stock trends (e.g. Celtic Sea cod, Rockall cod and whiting, West of Scotland megrim and sandeel, Channel sprat, northern anglerfish); the data are inadequate to define the current status although trends indicate low or declining stock size (e.g. Western Channel sole, Eastern Channel plaice, North Sea, Irish Sea and Celtic Sea whiting; west of Scotland herring stocks, Celtic Sea herring, Shetland sandeel); or the data are inadequate to define current stock status although trends indicate stock size is either stable or has recently been relatively high (e.g. Irish Sea and Celtic Sea haddock; Irish Sea herring, North Sea sprat, western anglerfish stocks, western megrim).

The latest ICES advice (2009) includes advice on six widely dispersed shark species. However it is not possible to determine precautionary reference points for both SSB and F for these stocks based on an analytical assessment and they are not included in the sustainability indicator. Of these species, basking sharks, porbeagle sharks, spurdogfish, Portuguese dogfish and leafscale gulper sharks are considered depleted whilst insufficient information is available on kitefin shark to evaluate trends. For skates and small sharks, ICES advice in 2008 indicated that of a total of 31 species/area combinations in the Celtic Seas and the North Sea & eastern Channel, 17 were stable or increasing, 6 were depleted or severely depleted (and one extirpated), and 8 were of uncertain status.

Table 1: Fin-fish Stocks around UK for which ICES currently gives advice on stock status in relation to P_A reference points, and which are included in the sustainability indicator. ICES areas/divisions are indicated.

	first year	last year	ref points available		ICES advice
North Sea/east channel cod (IV, VIId)	1963	2008	Bpa	Fpa	Y
West of Scotland cod (VIa)	1978	2008	Bpa	Fpa	Y
Irish Sea cod (VIIa)	1968	2008	Bpa	Fpa	Y
North Sea haddock (IV)	1963	2008	Bpa	Fpa	Y
West Scotland haddock (VIa)	1978	2008	Bpa	Fpa	Y
Rockall Haddock (VIb)	1991	2008	Bpa	Fpa	Y
North Sea plaice (IV)	1957	2008	Bpa	Fpa	Y
Irish Sea plaice (VIIa)	1964	2008	Bpa	Fpa	Y
West Channel plaice (VIIe)	1976	2008	Bpa	Fpa	Y
North Sea sole (IV)	1957	2008	Bpa	Fpa	Y
Irish Sea sole (VIIa)	1970	2008	Bpa	Fpa	Y
East Channel sole (VIId)	1982	2008	Bpa	Fpa	Y
Celtic Sea sole (VIIf&g)	1971	2008	Bpa	Fpa	Y
III, IV, VI saithe	1967	2008	Bpa	Fpa	Y
Northern hake	1978	2008	Bpa	Fpa	Y
Blue whiting	1981	2008	Bpa	Fpa	Y
North East Atlantic mackerel	1980	2008	Bpa	Fpa	Y
North Sea herring (III-IV)	1960	2008	Bpa	Fpa	Y

Table 2. Fin-fish stocks around the UK that have age-based assessments of SSB relative to B_{pa} but have no F_{pa} available, or the assessments are considered too unreliable to provide quantitative management advice.

	first year	last year	ref points available		ICES advice
Celtic Sea/west Channel cod (VIIe-k)	1971	2008	Bpa	Fpa	N
Celtic Sea whiting (VIIe-k)	1982	2008	Bpa	-	N
Celtic Sea plaice (VIIf&g)	1977	2008	Bpa	-	Y
West Channel sole (VIIe)	1969	2008	-	-	N
VII-VIII <i>Lophius budegassa</i>	1986	2008	Bpa	Fpa	N
VII-VIII <i>Lophius piscatorius</i>	1986	2008	Bpa	Fpa	N
VII-VIII megrim	1984	2008	Bpa	Fpa	N
Western horse mackerel	1982	2008	Bpa	-	Y
Irish Sea Herring (VIIa)	1987	2008	Bpa	-	N
West Scotland herring (VIa S)	1970	2008	Bpa	Fpa	N
West Scotland herring (VIa N)	1957	2008	-	-	N
Celtic Sea herring (VIIf&g)	1988	2008	Bpa	-	Y
North Sea sandeel (IV)	1983	2008	Bpa	-	Y
North Sea Norway pout (IV)	1983	2008	Bpa	-	Y

Changes in stocks included in the indicator since previous assessment

Any addition or deletion of stocks (e.g. if an assessment has improved and is now accepted, or has been rejected due to deteriorating data or if the methods are no longer considered reliable), will also cause the full time series of sustainability indices to alter. The following changes to stocks included in the index have been made since the revised index series was first produced in July 2006 based on ICES advice given in autumn 2005 and May 2006:

- Autumn 2006: VII/VIII megrim and VIaS herring removed; Rockall haddock added (22 stocks total)
- Autumn 2007: Area VII anglerfish (*Lophius piscatorius* and *Lophius Budegassa*) removed (20 stocks total)
- Autumn 2008: No changes.
- Autumn 2009: Celtic Sea/Western Channel cod (VIIe-k) and Western Channel sole (VIIe) removed. (18 stocks total)

Indicator trends

The proportion of the stocks being harvested sustainably declined to zero in the late 1980s but has since increased steadily to around 60% in 2008 (Fig. 2). This is based on the 18 stocks that have F_{pa} reference points. Note that the years on all the plots refer to the year for which F was estimated. The trends prior to the mid 1980s will be affected by the variable mix of stocks that have assessments extending further back in time (for a number of stocks, the assessment data only start in the 1980s).

There has been a long-term decline in the proportion of stocks with full reproductive capacity, with a levelling off in the 1990s (Fig. 2). The sharp dip in the 1970s is due to the collapse of several herring stocks. The results since 1991 are for a consistent set of 23 stocks that have B_{pa} reference points. Previous time series of the sustainability indicator have noted that the proportion of stocks with full reproductive capacity had levelled off in recent years but showed no sign of recovery despite the increase in proportion of stocks being harvested sustainably. The updated indicators show an increasing trend in the proportion of stocks with full reproductive capacity during the 1990s, which reflects the increase in proportion of stocks being harvested sustainably during the same period.

The proportion of stocks with full reproductive capacity and being harvested sustainably follows a generally similar pattern to the proportion being harvested sustainably (Fig. 2; Table 3). In 2008, 50% of the 18 assessed fish stocks around the UK were at full reproductive capacity and were being harvested sustainably. Between 2000 and 2007, 20 - 40% of the fish stocks around the UK were at full reproductive capacity and being harvested sustainably, compared to none in 1989 and generally 10 - 20% in the years from 1990 to 1999.

Although the proportion of stocks being harvested sustainably is increasing, fishing mortality in most of the stocks remains above values that may be considered as providing the maximum long-term yields or economic returns under the prevailing environmental conditions that affect stock productivity.

The total reported international landings for the 18 stocks appear to have increased since 1990 but show a large decrease in the last four years (Fig. 3). In recent years around half of this has comprised blue whiting, a very large stock that experienced strong recruitment resulting in *SSB* increasing to well above the B_{pa} reference point in the 2000s despite *F* having increased above F_{pa} . This stock is fished mainly along the shelf-edge to the west of the British Isles. Total international landings for the 17 stocks excluding blue whiting declined in the mid 1990s due largely to a reduction in North Sea herring landings and have fluctuated around this level since then (Fig. 3). The inclusion of blue whiting in the sustainability index may therefore provide a distorted perception of the trend in landings made by the bulk of the fishermen operating around the UK, who have experienced many cuts in quotas since the 1990s. The landings figures shown are those used by ICES Working Groups, and are largely based on fishermen's log-book data.

The stocks which were considered sustainable in each year with data are shown in Figure 4, in which a green cell indicates that a stock had full reproductive capacity and was being harvested sustainably in a given year. The species with the most consistent improvements are haddock and plaice, although there is considerable variability by species and area. All three cod stocks in the indicator continue to have reduced reproductive capacity and are being harvested unsustainably, although North Sea cod has experienced recent improvements in spawning stock biomass and fishing mortality in contrast to the Irish Sea and west of Scotland cod stocks which remain seriously depleted.

Table 3. Percentage of fin-fish stocks in UK waters with full reproductive capacity and harvested sustainably since 1990. The total international landings of the stocks considered sustainable is shown.

year	No. stocks	No. sustainable	% sustainable	landings
1990	17	2	12	2523
1991	18	2	11	2326
1992	18	2	11	2604
1993	18	2	11	2666
1994	18	2	11	2552
1995	18	2	11	2577
1996	18	2	11	2138
1997	18	1	6	2114
1998	18	3	17	2808
1999	18	1	6	2828
2000	18	4	22	3005
2001	18	4	22	3321
2002	18	6	33	3206
2003	18	5	28	3985
2004	18	5	28	4073
2005	18	7	39	3671
2006	18	6	33	3360
2007	18	7	39	2998
2008	18	9	50	2543

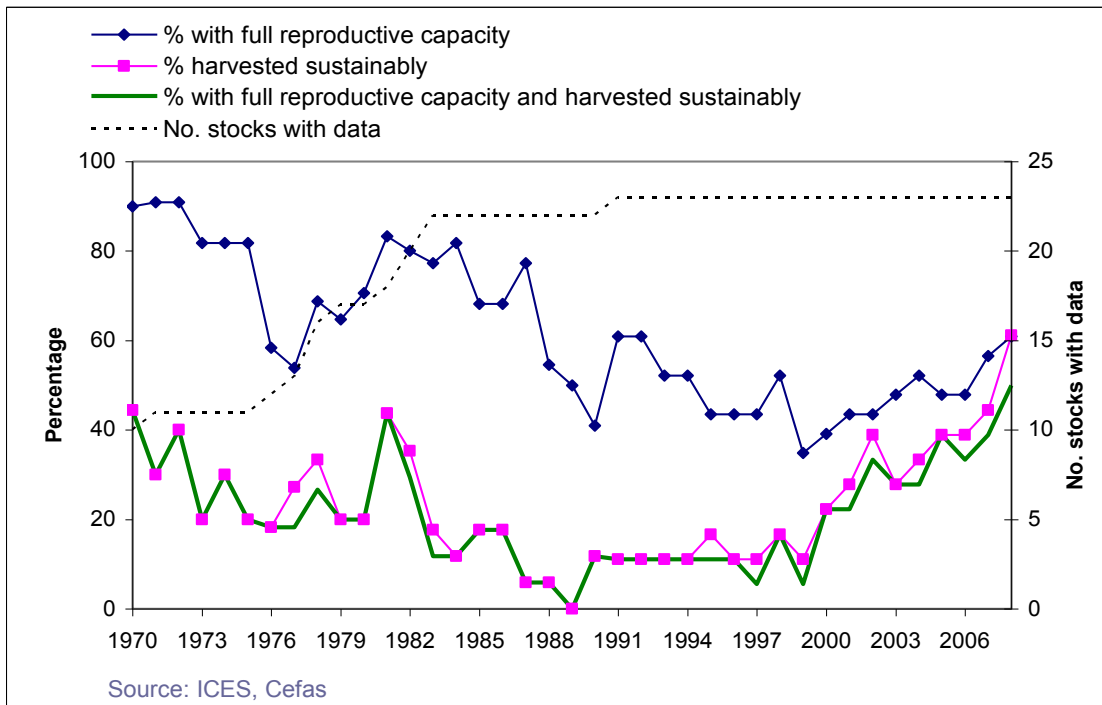


Figure 2. Indicators of sustainability for 1970 – 2008. The % with full reproductive capacity covers all stocks with B_{pa} reference points (23 stocks). The other two indices are only for fin-fish stocks with B_{pa} and F_{pa} reference points (18 out of 23 stocks since 1991). The dotted line shows the number of the stocks with data for each year.

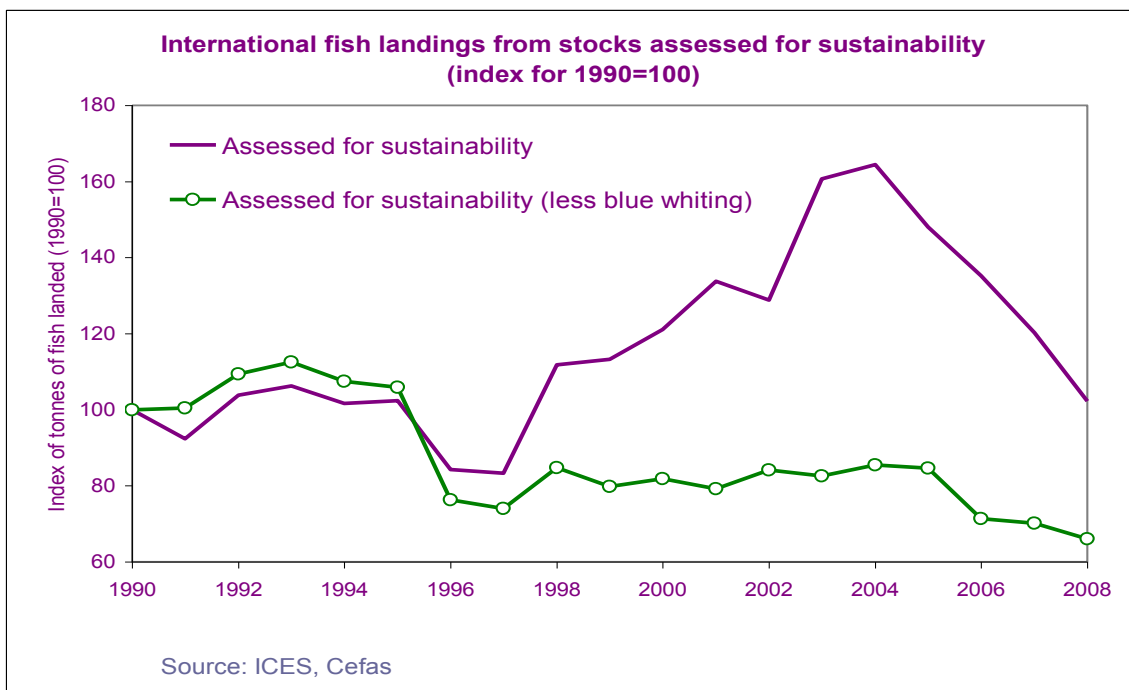


Figure 3. Index of landings from stocks assessed for sustainability. Lines show data for 18 stocks with B_{pa} and F_{pa} , and for 17 stocks excluding blue whiting.

Robustness of the indicator trends.

It is in the nature of the indicator that individual stocks may be included or excluded depending on the current ICES evaluation of the quality of the scientific assessments. The number of stocks in the indicator has declined from 22 in 2006 to 18 in the current update. Each annual update of the scientific assessments will also change the trends for each stock due to addition of new data or a change in assessment procedures following a benchmark assessment. Despite these changes, the overall trend of increasing proportion of stocks being harvested sustainably and with full reproductive capacity from very low values in the 1990s appears robust (Fig. 5).

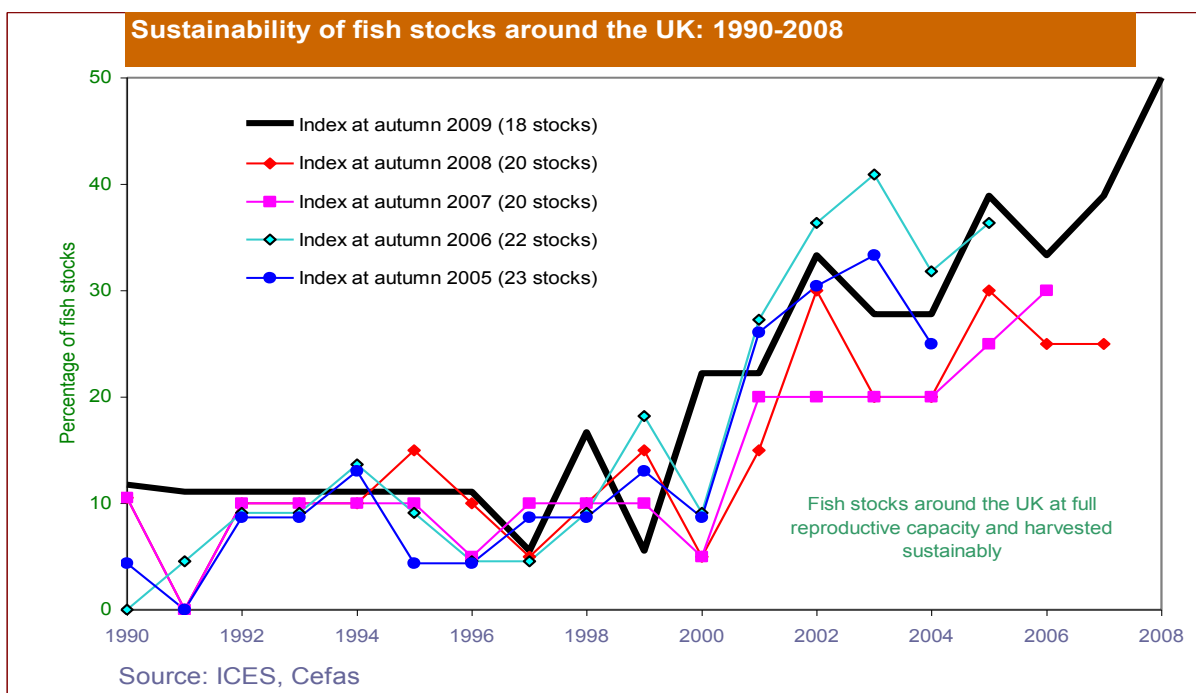


Figure 5. Indices of sustainability including stocks reviewed by ACOM in 2009, compared with the indices from ACOM advice in 2005-2008. The series in 2007 & 2008 are from the same set of 20 stocks.

The ICES assessment of Vlle sole was benchmarked in 2009 and both the assessment and the biological reference points were considered no longer valid for providing management advice. The Vlle-k cod assessment was also considered by ACOM to have unknown bias due to recent high-grading and other problems, although the biological reference points remain unchanged. The most recent assessment of Vlle sole provided by ACOM (in 2008) indicated that the stock was being harvested non-sustainably and was below full reproductive capacity since 2005. The most recent assessment of Vlle-k cod (2008) indicated that the stock was being harvested sustainably since 2006 and was below full reproductive capacity since 2002. Figure 6 shows the effect of including the 2008 assessments in the sustainability indicator and assuming continuation of the same spawning stock

biomass and fishing mortality as in the terminal year of the 2008 assessment. The result is a reduction in the indicator by 3 – 5 percentage points in the 2000s. However the trajectory of the indicator in the 2000s is almost identical whether or not the two stocks are included.

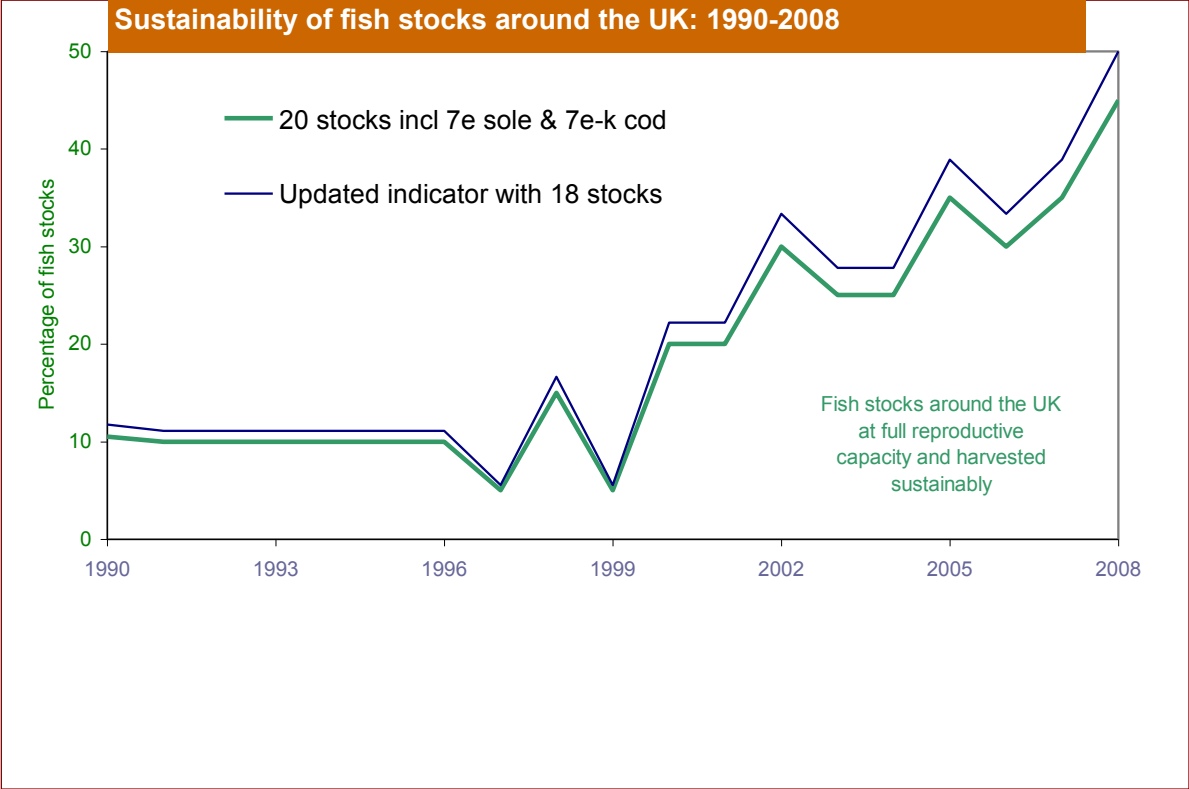


Figure 6. Sensitivity of the sustainability indicator to re-inclusion of VIIe sole and VIIe-k cod, using the 2008 ICES assessments of the stocks and assuming no change in spawning stock biomass and fishing mortality (i.e. both stocks continue in 2008 to be not classified at full reproductive capacity and harvested sustainably).