OSPAR COMMISSION

Mean Maximum Length of Fish

Pilot Assessment

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Pilot Assessment of Mean Maximum Length of Fish

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Contents

Key Message

Change in species composition within fish communities is assessed through change in the mean maximum length indicator. There is no consistent pattern across the assessed Regions, but long-term decreases to minimum values were found for the North Sea. Mixed patterns of increases and decreases were found within all other Regions.

Background (brief)

Fishing is size-selective, preferentially removing larger fish. This implies that large-bodied species (i.e., that can grow to larger sizes and thus mature at a relatively large size) are more vulnerable to size-selective fishing. Over time this is likely to result in a lower proportion of such large-bodied species and therefore affects fish community species composition. As the larger-bodied species usually fall in the higher trophic levels (above a certain species-specific size they are mostly piscivorous) this is also likely to affect the foodweb functioning (e.g., Bell et al., 2018; Shackell et al., 2009; Thompson et al., 2020). For the Quality Status Report 2023, multiple assessments relating to fish communities have been developed to assess impacts of fishing on the foodweb, with different components showing different responses in the ecosystem.

Background (extended)

Maximum length (**Figure a**) is one of the life-history characteristics that determine species vulnerability to additional mortality. This life-history characteristic is chosen because the assumption is that large-bodied species known to grow to a large maximum length, also reproduce late and so are exposed for longer to pressures affecting the fish community (certainly if these are size-selective like fishing) compared to other fish species. Because they are exposed for longer, such species are expected to be the first to decline if this pressure is high. This life-history parameter was selected to represent species-specific vulnerability, as it is based on data that are widely available.

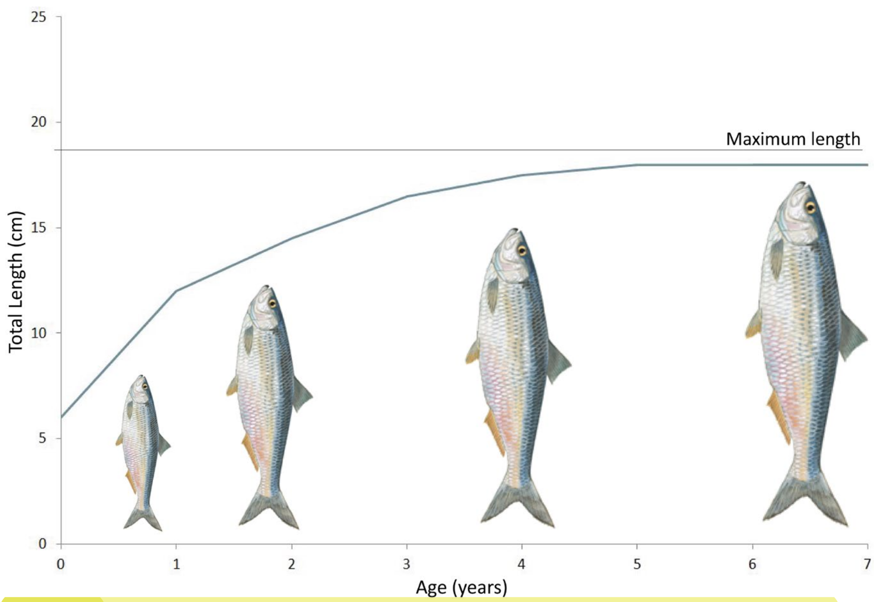

Figure a: Maximum length based on the von Bertalanffy growth curve

A decline in mean maximum length indicates that the abundance of the most vulnerable large-bodied fish and elasmobranch species is decreasing and foodweb functioning is compromised through the loss of mostly piscivorous species. Depending on the magnitude and duration of the pressure this may result in local or regional extinction of large-bodied species and thus a decrease in biodiversity.

The indicator is calculated using catch data from scientific surveys. These are standardised monitoring programmes that occur each year in the same period taking representative samples according to specific guidelines. Different components of the fish community are distinguished based on their feeding behaviour using habitat-based trophic guilds, here we focus on demersal fish (species living near the seafloor).

Assessment Method

Mean maximum length (shown as MML in the equation below) can be calculated for the entire assemblage caught by a particular gear or a subset based on morphology, behaviour, or habitat preferences (e.g., bottom-dwelling species only). Mean maximum length is calculated (ICES, 2012) as:

$$MML = \sum_j (L_{\max j} B_j) \Big/ B$$

where L_{maxj} is the maximum length obtained by species j, B_j is the biomass of all individuals of species j and B is the total biomass of all individuals. Note, other analyses standardise the indicator in relation to abundance (e.g., Mindel et al., 2008) rather than biomass, which results in an indicator that is more sensitive to recruitment events and large interannual fluctuations.

Data for this indicator come from scientific fisheries surveys, which ideally sample the entire fish community but in practice do not. Every survey can be expected to sample a survey-specific subset of the community often referred to as an assemblage. The indicator requires that each survey is conducted at regular intervals (e.g., annually) in the same area with a standard gear. Sufficiency of sample sizes can be judged using re-sampling techniques (Shephard et al., 2012). The number of individuals per species is not always recorded directly by surveys, but may be based on samples with certain detection error (including false negatives specifically for rare species). The detection error is further complicated by differing catchabilities over length classes and species, such that the observed relative abundance between species (and size-classes) is survey-specific. Where available, catchability estimates can be used to correct for this component of the systematic measurement error (e.g., Fraser et al., 2007; Walker et al., 2017). However, such estimates are sparse in the scientific literature and are prone to great uncertainty. Alternatively, model-based estimates of absolute species abundance can be used to rescale observed abundances, but here model uncertainty is also great (ICES, 2014). For simplicity the mean maximum length indicator is therefore calculated as a survey-specific indicator without any correction for detection error (i.e., catchability). This implies that every survey-specific indicator may provide a slightly different perspective to the reality they are supposed to represent. This indicator is calculated by survey and, where possible, also for subdivisional strata that are assumed to represent different habitats and communities. Whereas each survey may provide a slightly different perspective to the reality, the surveys themselves are standardised so that they can be assumed to provide a consistent representation of that perspective over time.

The data are collected under national programmes and the data collection framework. Currently, the most important data source for mean maximum length are those groundfish surveys that are coordinated by the International Council for the Exploration of the Sea (ICES). The International Bottom Trawl Survey (IBTS) programme in the Greater North Sea, the Celtic Seas, Bay of Biscay and Iberian Coast, and Wider Atlantic is particularly important since the trawl is a general-purpose design aimed at catching demersal and pelagic species. However, beam trawl surveys are more efficient at catching benthivorous species (e.g., flatfish species such as sole, or plaice). The two gears can therefore be assumed to provide complementary perspectives of the fish community.

Data Used and Quality Assurance

This assessment draws on raw data from the ICES database of trawl surveys (DATRAS, www.ices.dk/marine-data/data-portals/Pages/DATRAS.aspx). These data have been quality controlled within OSPAR to generate a data product for assessment purposes. Time series of mean maximum length for fish and elasmobranchs are derived from each available groundfish and beam trawl survey.

Time series of mean maximum length by guild were determined for many groundfish surveys carried out across four separate Regions: the Greater North Sea, Celtic Seas, Bay of Biscay and Iberian Coast, and the Wider Atlantic (**Table a**). Ecological subdivisions were determined for the Greater North Sea using a simplification of those strata proposed by the European Union financed project Towards a Joint Monitoring Programme for the North Sea and Celtic Sea (JMP NS/CS) that took place in 2013, and building upon work in the European Union VECTORS project (Vectors of Change in European Marine Ecosystems and their Environmental and Socio-Economic Impacts) that examined the significant changes taking place in European seas, their causes, and the impacts they will have on society. In other OSPAR Regions, the strata from the survey design were considered appropriate to represent the ecological subdivisions (**Figure b**).

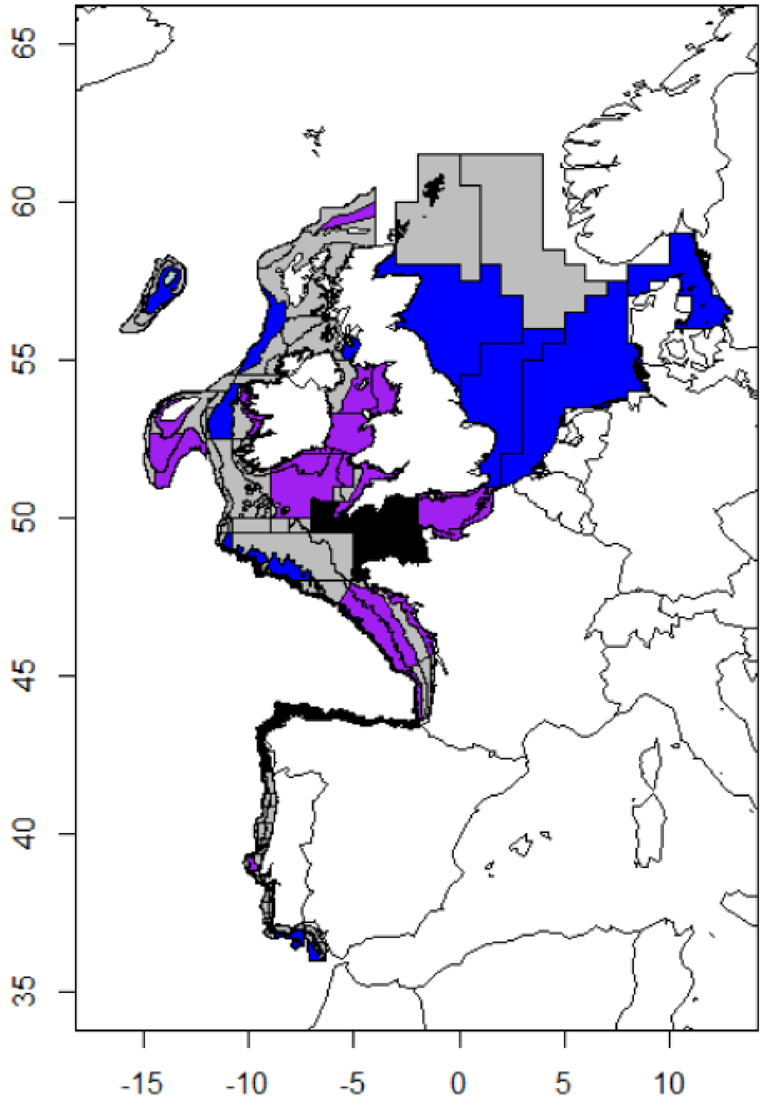

Figure b: Spatial pattern in outcome of mean maximum length indicator by subdivision for preferred surveys by Region. Purple colouring means long-term increase evident; dark blue shows decrease to minimum level; light blue shows decrease to low but not minimum level. Grey areas show areas with no long-term change evident and black areas show surveys that are too short to detect long-term change.

Table a: Groundfish and beam trawl surveys, the Region in which they operate, and the period over which they have been undertaken		
Subregion	**Survey Acronym[1]**	**Survey Period**
Bay of Biscay and Iberian Coast	BBIC(n)SpaOT4	2011 – 2018
	BBIC(s)SpaOT1	2000 – 2020
	BBIC(s)SpaOT4	2002 – 2020

	BBICPorOT4	2002 – 2018
	BBICFraBT4	2011 – 2020
	BBICFraOT4[2]	1997 – 2020
Celtic Seas	CSFraOT4[2]	1997 – 2020
	CSEngBT3	1993 – 2019
	CSEngBT3 Bristol Channel	1993 – 2020
	CSIreOT4	2003 – 2020
	CSNIrOT1	2008 – 2020
	CSNIrOT4	2009 – 2020
	CSScoOT1	1985 – 2020
	CSScoOT4	1997 – 2020
Greater North Sea	GNSEngBT3	1990 – 2020
	GNSFraOT4	1988 – 2020
	GNSGerBT3	1997– 2020
	GNSBelBT4	2004 – 2020
	GNSIntOT1	1983 – 2020
	GNSIntOT1 Eastern Eng. Channel	2007 – 2020
	GNSIntOT3	1998 – 2020
	GNSNetBT3	1999 – 2020
Wider Atlantic	WAScoOT3	1999 – 2020
	WASpaOT3	2006 – 2018

[1.] *Survey acronym convention: First 2 to 4 capitalised letters indicate the OSPAR Region (BBIC: Bay of Biscay and Iberian Coast; CS: Celtic Seas; GNS: Greater North Sea; WA – Wider Atlantic). Next capitalised and lowercase letters signify the country involved (Spa: Spain; Bel: Belgium; Por: Portugal; Fra: France; Eng: England; Ire: Republic of Ireland; Nir: Northern Ireland; Sco: Scotland; Ger: Germany; Int: International; Net: The Netherlands. International refers to the two international bottom trawl surveys carried out in the Greater North Sea under the International Council for the Exploration of the Sea (ICES). In the Bay of Biscay and Iberian Coast Region, Spanish surveys are further delimited by (n) for surveys operating in the northern Iberian Coast area and (s) for surveys operating in the southern Iberian Coast area. Next two capitalised letters indicate the type of survey (OT: otter trawl; BT: beam trawl). Final number indicates the season in which the survey is primarily undertaken (1: January to March; 3: July to September; 4: October to December).*

[2]. *This is a single survey that operates across both the Celtic Seas and the Bay of Biscay and Iberian Coast Regions, from the southern coast of the Republic of Ireland and down the western Atlantic coast of France. For indicator assessment purposes, this single survey was split into its two regional components.*

Standard data collected on these surveys comprise numbers of each species of fish sampled in each trawl haul, measured to defined length categories (i.e., 1 cm below, so a fish with a recorded length of 14 cm would be between 14,00 and 14,99 cm in length). By dividing species- and size-specific catch numbers-at-length by the area swept by the trawl on each sampling occasion, the catch data are converted to standardised estimates of fish density-at-length (referred to below as catch-per-unit-area, CPUA), by species, at each sampling location (i.e., trawl haul). Size-specific catch numbers-at-length is thereafter converted into size-specific catch kilograms-at-length by using the length-weight relationship of fish. W = a 8 L^b.

Summing these species density-at-length estimates per trawl haul across all trawl hauls collected within each sampling stratum in each year (i.e., survey-specific strata following the survey design, which is the ICES ‘statistical rectangles’ in the Greater North Sea and generally depth-based strata elsewhere) provides a survey-specific regional assessment.

Data Treatment

Surveys with Rectangular Sampling Grids (GNSIntOT1, GNSIntOT3, GNSNetBT3, GNSGerBT3, GNSBelBT3, GNSEngBT3, GNSFraOT4)

Catch-per-unit-area (CPUA) data (kg/km^2) from multiple hauls are averaged by species for each rectangular grid cell. In the Greater North Sea these are ICES statistical rectangles, in the eastern Channel a mini-grid 0,25° × 0,25° is used by GNSFraOT4.

The resulting rectangle-based CPUA estimates are multiplied by area (km^2) of their rectangles (using a Lambert equal area projection) to give biomass-at-length (now measured in kg per rectangle). Subdivisional level (not GNSFraOT4) estimates of biomass-at-length are given by the sum of the rectangle-based biomass-at-length estimates and corrected by a scaling factor = 1/(proportion of the area of subdivision monitored in the survey year) (units are now tonnes per subdivision). The scaling factor correction ensures that the weighting of the strata relative to each other in each year is not altered by the sampling levels. Subdivisional estimates of mean maximum length are calculated at this point for investigating the local responses of each community.

Regional estimates of biomass-at-length are estimated from the sum of subdivisions. The regional assessment of mean maximum length is thus based on these summed subdivisional estimates.

Surveys with Irregular Depth Banded Strata (i.e., all surveys other than those with Rectangular Sampling Grids)

Catch-per-unit-area (CPUA) data (kg/km^2) from multiple hauls are averaged by species for each survey strata. Subdivisional estimates of biomass-at-length are subsequently given by CPUA multiplied by area of the survey strata (km^2, using a Lambert equal area projection). Subdivisional estimates of mean maximum length represent the local status of the fish community.

Regional estimates of biomass-at-length are estimated from the sum of subdivisions. The regional assessment of mean maximum length is thus based on these summed subdivisional estimates.

Overall assessment basis

Where multiple surveys were available for assessment, key surveys were prioritised (preferred) for assessment given the length of time series available and spatial coverage. If these measures were equal between surveys, then whichever surveyed the greatest biomass by guild was selected for indicator assessment. The following surveys were considered key:

Greater North Sea

GNSIntOT1 was the preferred survey for the Greater North Sea, given it is the longest survey with the best spatial coverage. For the eastern Channel, GNSEngBT3 was preferred given more consistent sampling here than GNSIntOT1 and GNSFraOT4.

Celtic Seas

CSScoOT1 was preferred over CSScoOT4 and CSIreOT4 due to length of time series. CSIreOT4 was preferred for subdivisions to the west of Ireland and in the northern Celtic Sea, but not in the north where there was overlap with CSScoOT1. CSFraOT4 was preferred in subdivision of the Celtic Sea, except where overlap with CSIreOT4.

CSEngBT3 for the demersal guild was preferred for the Irish Sea over CSNIrOT1 and CSNIrOT4 given its greater length of the survey.

Bay of Biscay and Iberian Coast

BBIC(s)SpaOT1 was preferred over BBIC(s)SpaOT4 given length of survey. BBICPorOT4 and BBIC(n)SpaOT4 did not overlap with any other surveys. BBICFraOT4 was preferred over BBICFraBT4 due to length of survey.

Time series assessment

The long-term trend in each time series (subdivision and survey level) was modelled through the application of a LOESS smoother (i.e., locally weighted scatterplot smoothing) with a simple 'fixed span' of one decade. Breakpoint analyses use data to define stable underlying periods (Probst and Stelzenmuller, 2015). The method makes it possible to say whether there is a significant change in the indicator over time, that is, whether a specific period is significantly different from the historically observed period. The method avoids the arbitrary choice of reference periods for assessment (i.e., how many years to choose to calculate an average), which can lead to subjective assessments. The shorter the period chosen the more likely it is to be comparing noise in the data or natural fluctuations in the system against each other. However, a too long period and the actual changes in the indicator might be averaged out. The minimum detectable period is defined in this analysis as six years and is assumed to be appropriate to capture the response of the fish community as opposed to noise (note that in the IA2017 assessment the minimum period was set as three years). The analysis uses two statistical approaches: (1) applying the 'supremum F test' to identify if a non-stationary time series or if a constant period for the entire time series is more suitable; (2) if considered non-stationary, then breakpoint analysis finds periods of at least six years duration.

Results (brief)

Greater North Sea

In the eastern English Channel, long-term increases were evident in both GNSEngBT3 (since 1990) and GNSFraOT4 (since 1998) (**Figure 1**). The pattern in the more recent GNSIntOT1 is variable from 2007.

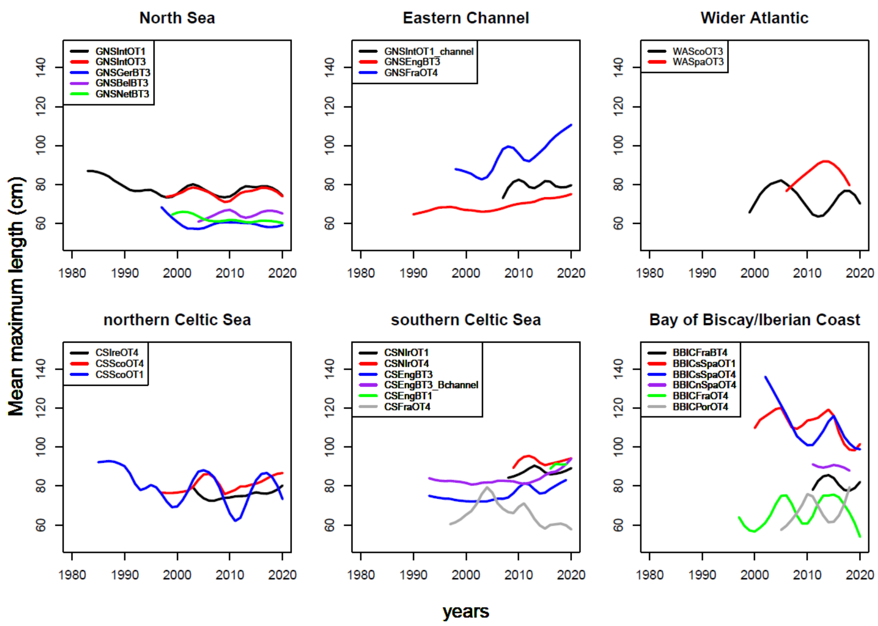

Figure 1: Time series of mean maximum length by survey, showing LOESS smoothed patterns, where overlapping surveys within Regions are grouped.

In the North Sea (including Kattegat), the longest running survey, i.e., GNSIntOT1, shows a long-term decrease prior to the start of the GNSIntOT3 survey in 1998 and beam trawl surveys in 1997. From this period onward both GNSIntOT1 and the shorter time series derived by GNSIntOT3 (from 1998) have been variable but with no clear trend for the North Sea overall. This reveals two overall patterns in the indicator: a decrease was driven by change prior to 1990 in the central and southern North Sea subdivisions (south-east SE, south-west SW, central-west CW and Kattegat-Skagerrak, KS) and a variable pattern with no clear trend in the northern subdivisions (**Figure b** and **Figure 2**).

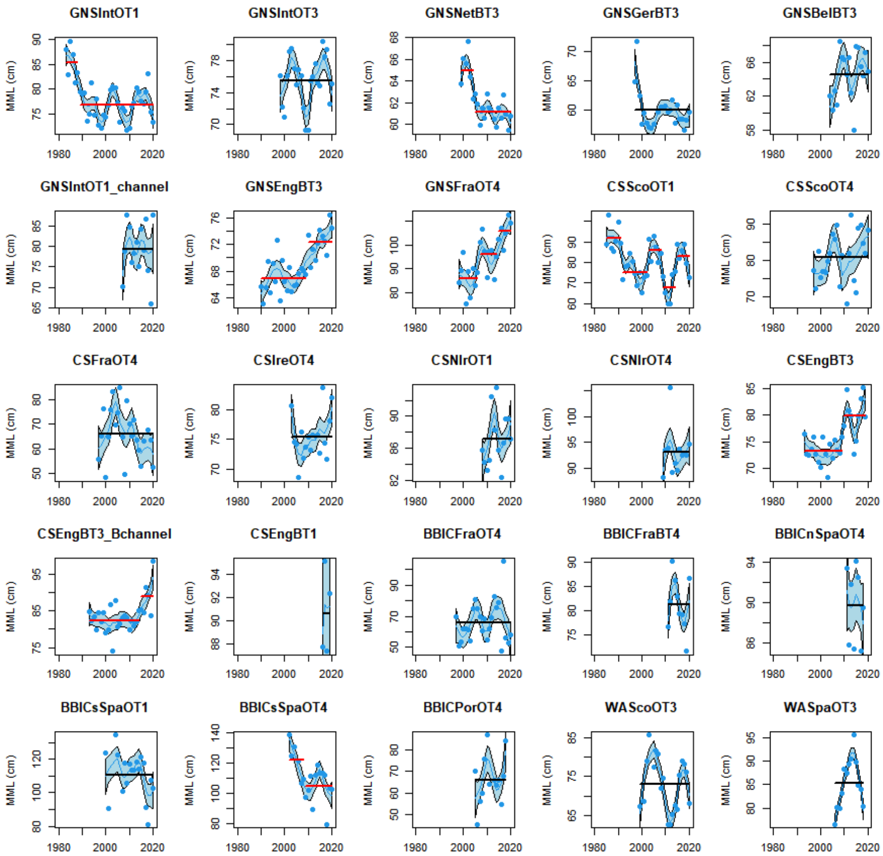

Figure 2: Time series of mean maximum length by survey showing data points, LOESS smoothed patterns and stable periods (black if constant over period assessed and red if a breakpoint is detected).

In the more recent beam trawl data for the central and southern North Sea, a decrease overall in 2005 was found in GNSNetBT3. Following this decrease and in common with the recent time series from GNSGerBT3 and GNSBelBT3 the indicator was found to have stabilised at low values.

Celtic Seas

A mix of outcomes (increases, decreases and no change) were evident in the Region (**Figure b** and **Figure 2**). Overall increases were found in the Irish Sea (CSEngBT3) and Bristol Channel (CSEngBT3_Bchannel) (Figure 1). However, an overall decrease over the longer term followed by a partial recovery in recent years was found in deep waters to the west of Scotland and Ireland (CSScoOT1 and CSIreOT4).

To the south of Ireland increases were also found throughout much of the Celtic Sea with the exception of the deep waters at the edge of the shelf (CSIreOT4) (**Figure b** and **Figure 2**).

Bay of Biscay and Iberian Coast

In the Bay of Biscay and Iberian Coast, seven surveys showed no change overall (**Figure 2**). However, there is evidence of a decrease in the southern areas of the Iberian Coast and an increase in the Bay of Biscay, with the exception of deeper waters sampled by BBICFraOT4 (**Figure b**).

Wider Atlantic

No change overall was evident.

Results (extended)

Greater North Sea

A further decrease was detected in the early 2000s in the south-eastern North Sea in the four surveys that sample this area GNSIntOT1, GNSIntOT3, GNSNetBT3 and GNSGerBT3 (**Figure c**).
One of three surveys that sample the central-western North Sea (GNSNetBT3 but not GNSIntOT1 or GNSIntOT3) found a secondary decline in the subdivision.

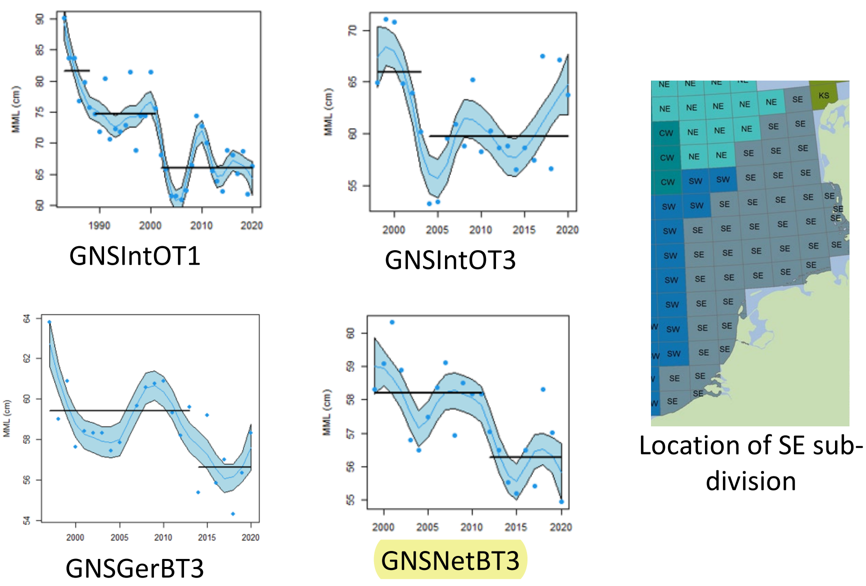

Figure c: Decline in the south-eastern North Sea in the four surveys that sample this subdivision

Celtic Seas

To the west of Ireland, an increase in coastal waters again is opposed by a decrease at the shelf edge. This decrease at the shelf edge continues to the west of Scotland (CSScoOT1). To the north of Scotland an increase was evident in a small subdivision, but an opposing decrease was found in the Clyde subdivision to the south.

Bay of Biscay and Iberian Coast

Overall, a decrease was found in BBICsSpaOT4 only (recent data since 2002), but both BBICsSpaOT1 and BBICsSpaOT4 found decreases in the deepest stratum sampled to the south of Spain (BBICsSpaOT4 also detected a decrease in the second-most deep stratum). These decreases in the south were further supported by decreases in the southerly subdivisions of the Portuguese survey (BBICPorOT4). An area of increasing indicator values was found in the central subdivisions of the Portuguese survey.

Wider Atlantic

Although decreases were found in the shallower central areas of the Rockall Bank (WAScoOT3), the data exhibit oscillations over time that are greater than the detected decline. Similarly, increases were found in more southerly subdivisions of the Porcupine Bank (WASpaOT3) but the last two data points suggest a potential reduction toward the mean level.

Conclusion (brief)

Increases were found in the Irish Sea, Bristol Channel, part of Porcupine Bank, a small subdivision to the north of Scotland, the northern Bay of Biscay and the eastern English Channel.
Decreases were found in the central and southern North Sea and along much of the western edge of the shelf and in shallow areas of Rockall Bank, the Clyde area and to the south of the Iberian Coast.

Knowledge Gaps (brief)

The main causes for the observed spatial and temporal patterns in the mean maximum length indicator are not yet known.

Reference levels representing a pristine or sustainably exploited state and that would allow a formal assessment, are not yet available.

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Assessment Metadata

Field	**Data Type**	
Assessment type	List	Pilot Assessment
SDG Indicator	List	14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans
Thematic Activity	List	Biodiversity and Ecosystems
Date of publication	Date	2022-06-30
Conditions applying to access and use	URL	https://oap.ospar.org/en/data-policy/

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Our vision is a clean, healthy and biologically diverse North-East Atlantic Ocean, which is productive, used sustainably and resilient to climate change and ocean acidification.

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