Centre for Environment Fisheries & Aquaculture Science

Cefas

Methodology review to assess sustainable quota setting

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1. Executive Summary

A methodology review to determine whether quotas, or Total Allowable Catches (TACs), were set at biological sustainable levels was commissioned by the Department for the Environment, Food and Rural Affairs (Defra) to support the fisheries objectives of the UK Fisheries Act 2020.

The methodology review involved an expert panel and considered the setting of TACs at a sustainable level in terms of either being consistent with achieving maximum sustainable yield (MSY) or being consistent with the MSY principle and the ICES' scientific advice for MSY and sustainability of stocks.

The agreed approach to assess MSY consistency is based on whether catch limits do not exceed the best available ICES' scientific advice for stocks (biological areas or units) that are relevant to the management areas (or TAC units).

The application of this approach presented some challenges, specifically in cases where the TAC to assess has a management area that is different from the stock assessment area and ICES' scientific advice. While the methodology review initially focused on the application of the ICES' advice for MSY, the proposed method is applicable when the ICES' advice is base merely on the Precautionary Approach. The application of other types of ICES' advice needs further consideration, in addition to other aspects related to the management areas (TACs).

This report summarises the outcome from the methodology review and provides details on the approach and principles agreed with the expert panel during their last meeting in October 2020, and considerations to develop further the method.

This review was commissioned before the UK exited the European Union (EU) and as such this report makes reference to EU TACs.

2. Introduction

The UK Fisheries Act 2020 refer to fisheries objectives, one of which is the precautionary objective: *'that exploitation of marine stocks restores and maintains populations of harvested species above biomass levels capable of producing maximum sustainable yield.'*

In 2020 the Department for the Environment, Food and Rural Affairs (Defra) commissioned an expert panel to review a methodology to assess the sustainability of quotas (Total Allowable Catches - TACs). The terms of reference for the expert panel were summarised as *'To provide an agreed methodology which enables fisheries managers to determine whether a quota (TAC) was set at a sustainable level and communicate this information effectively'*.

The members of the Expert Panel for the methodology review were:

Neil Hornby: Chair of the panel, former Marine Director at Defra, current Cefas CEO.

Carl O'Brien: Defra Chief Fisheries Science Advisor

Coby Needle: Chief Fisheries Advisor for Scotland

Matt Sayer: Chief Fisheries Scientist Wales

Pieter-Jan Schön: Chief Fisheries Scientist Northern Ireland

Robin Cook: University of Strathclyde

Jon Pitchford: University of York

A set of hierarchical questions in the context of setting TACs at a sustainable level consistent with achieving maximum sustainable yield (MSY), methodology aspects, challenges, and options, were presented by Cefas to the expert panel for discussion in a series of three meetings/workshops.

The main challenge to applying the principle of MSY when setting quotas (TACs) at sustainable levels is that the ICES' scientific advice for MSY or sustainability is provided for stocks (biological units) rather than for management units (TAC areas), and in many cases there is a mismatch between biological and management units. In addition, it is important to consider that there are different types of scientific advice for stocks, and in some cases the assessment of stocks (biological units) might present important limitations and uncertainties, which result in further complications when assessing TACs.

This report summarises the outcome from the methodology review with the expert panel and provides details on the approach and principles agreed.

3. Methodology approach and principles

The general approach and principles to assess MSY consistency when setting or agreeing TACs were discussed with the expert panel and agreed in October 2020.

3.1. Method approach

The approach to assess if TACs or quotas are set at sustainable levels is based on whether catch limits do not exceed the best available ICES' scientific advice for stocks (biological units) that are relevant to the management areas (or TAC units).

The approach considers that there are different categories of ICES' scientific advice and metrics for stocks; and different matching categories between stock assessment areas and the TACs management areas.

A summary of ICES' advice categories and metrics used in this report is provided in **Table 1**.

Table 1. ICES' advice categories and metrics

ICES' advice category	Description
Management Plan (Long-term management plans)	Fishing opportunity advice as harvest control rule (HCR). Only applicable where the management plan is agreed by all parties and has been evaluated by ICES to be precautionary.
MSY pure	Fishing mortality (F_{MSY}) and biomass (MSY $B_{trigger}$) reference points from quantitative stock assessment (data rich assessments which include forecasts).
MSY proxy	F_{MSY} proxy or MSY $B_{trigger}$ proxy from analytical assessments and forecasts that are indicative of trends in fishing mortality, recruitment, and biomass (Qualitative stock assessments).
Precautionary approach (PA)	Fishing opportunity advice derived from stock and/or fishery trends. Data-limited stock assessments: stock status and/or exploitation status measured against proxy MSY reference points where available.

An important element of the approach is the consideration of the spatial extent of the ICES' stock assessment area and the associated advice in relation to the management area where a TAC is applied. Since the advice is provided for stock assessment areas, there is a need for this advice to be matched with any TACs (management unit) that draw on the advice, when assessing consistency with MSY or sustainability.

The ICES' stock assessment areas are shown in the map (**Figure 1**) with the ICES' statistical areas in red, and the ICES' ecoregions overlayed in different colours and shapes.

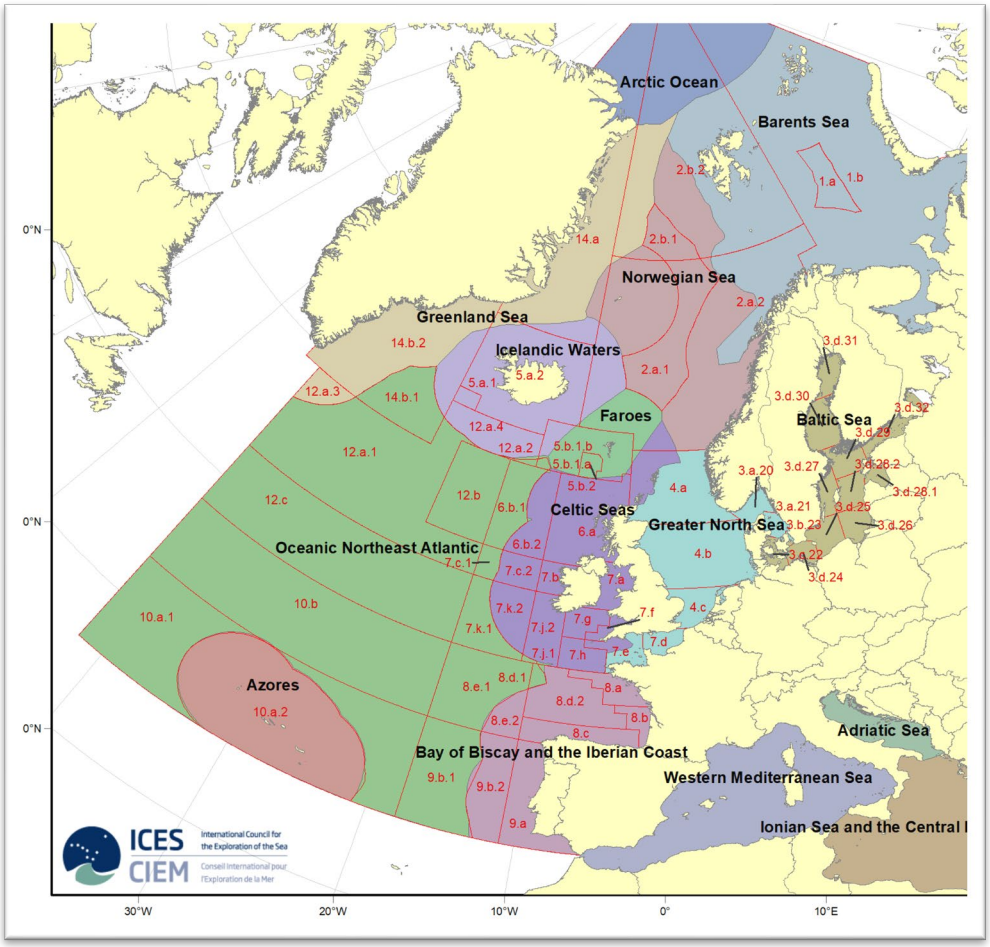


Figure 1. Map of the ICES' stock assessment areas and ecoregions.

In numerous cases, the ICES' stock assessments areas do not match the TAC areas or fisheries management areas/units.

We examined the possible matching scenarios between stock assessment areas and management areas.

We identified six categories of TACs when considering the spatial match between biological areas (ICES recognised stock units) and management areas and they are graphically represented in **Figure 2**.

The simplest category is the ‘direct’ match where the management area is the same as the stock assessment area. If the management area is larger than the stock assessment area it is categorised as ‘wide’. If the management area is part of a stock assessment area it is categorised as ‘subset’. If the management area comprised multiple assessment areas, it is categorised as ‘pooled’.

Other categories apply when the mismatch is more complex. In the case of the ‘subset pooled’ category, the management unit comprises multiple ICES’ stock assessments where one or more contributing stocks straddles more than one management area. The most complex category is ‘fragmented’, where the management area does not match the stock assessment area.

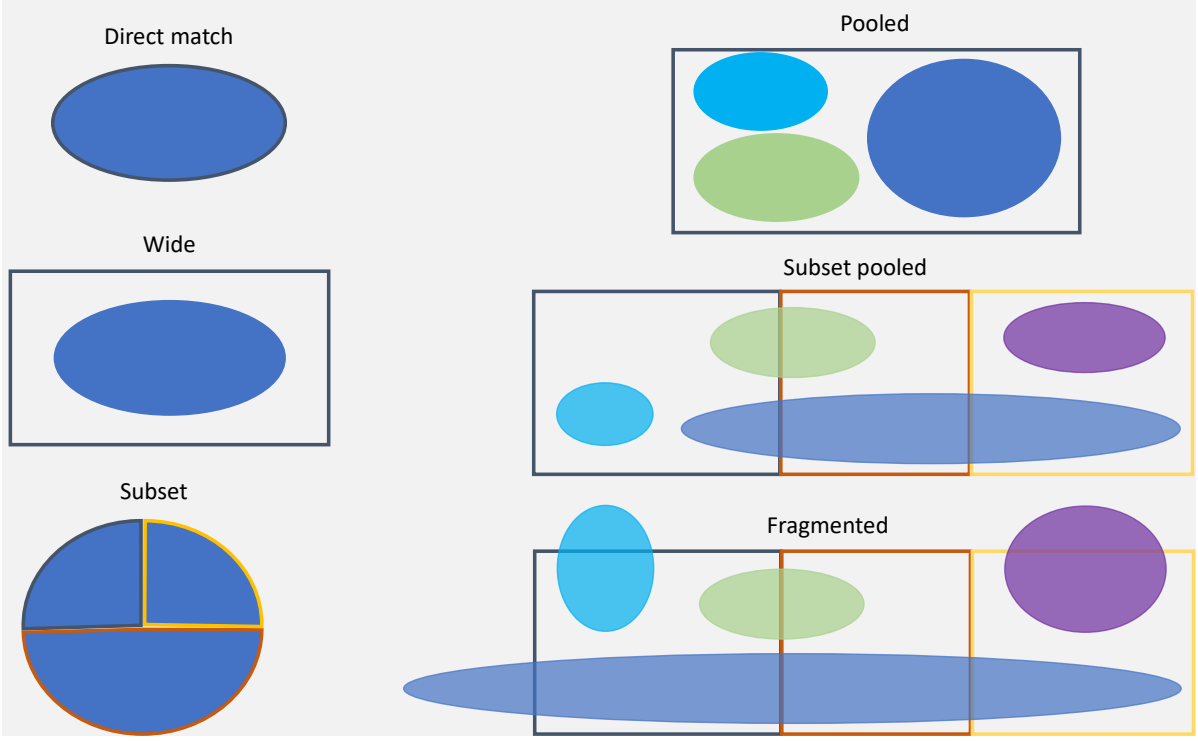


Figure 2. Illustration of TAC categories when considering the match between stock assessment areas and management areas. Coloured circles represent the biological units or stock assessment areas as assessed by ICES and the coloured lines (boxes or borders) represent the management areas or TAC units for each category.

A key aspect of the method proposed is how to use the ICES’ scientific advice to set catch limits that are consistent with MSY and sustainable levels across the different types of spatial match between the assessment areas and management areas.

Table 2 provides a summary of how to consider the use of ICES’ scientific advice in relation to their match with the TACs (management areas) across categories.

Table 2. Use of ICES' advice to assess TACs across types of match categories between management areas and stock assessment areas.

TAC Category	Description	Use of ICES advice to assess TAC consistency with MSY
Direct match	Stock assessment area is the same or matches the management area.	ICES MSY advice can be used directly because the ICES' stock area matches the TAC area. TAC should be no more than the ICES' advice.
Wide match	Stock assessment area is within the management area, but the management area is beyond the assessment area (stock area) and includes surrounding waters where the species rarely occurs but are included to prevent misreporting.	ICES MSY advice can be used as a direct match when additional areas covered by the TAC are essentially to close reporting loopholes and provided catches inside the ICES' assessed area were part of an "of which no more than" clause. TAC should be no more than the sum of the ICES' advice and any precautionary estimates of catch in the area outside the advice area, where MSY consistency can only be granted provided the additional tonnage is not utilised simply to increase the catch above the advice level for the ICES' assessed stock area. When the ICES' advice is zero catch, it applies for the whole management area.
Subset match	There is one ICES' stock assessment for multiple management areas.	ICES MSY advice can be used to enable comparison at the individual management areas. The sum of the individual TACs, for a stock, when combined, should be compared against the ICES MSY advice for the stock. The sum of TACs should be no more than the ICES' advice for the stock.
Pooled match	There are multiple ICES assessed stocks in a management area, and all contributing stocks lie exclusively within the management area.	The sum of the ICES MSY advice for the stocks contributing to the TAC can be used provided a series of conditions are satisfied (see details in the section describing pooled).
Subset pooled match	There is ICES advice on multiple assessed stocks, where one or more contributing stocks straddles more than one management area.	The aggregated MSY advice can be compared to the aggregate TACs provided all units that contribute to either the advice or TACs are grouped, plus the same conditions as for the pooled category apply (see details in section describing subset pooled)
Fragmented	The ICES' assessment advice is relevant to multiple management areas, or one or more stock components do not have a management unit. The management area does not match the stock assessment area.	Consideration is required to identify spatial gaps and comparability of ICES' advice before it is possible to assess MSY consistency. A dedicated analysis would be required to identify the criteria to distribute and/or split the ICES' advice to match the management area (see details in section describing fragmented).

3.2. Principles and considerations of the method review

Following the general approach described in section 2.1, a set of principles and considerations to guide the application of the method were discussed and agreed with the expert panel in October 2020. We distinguish between the general aspects related to stock assessments advice and the aspects related to management, such as the fisheries sharing agreements between nations and the performance of management measures.

The agreed principles are summarised as follows:

***General principles**:*

- The method to assess MSY consistency needs to consider how the scientific advice from assessment areas (stocks units) matches the management areas or the Total Allowable Catch (TAC) units, including the type of ICES' advice, existence of multi-annual plans and sharing agreements.

- Catch limits should not exceed the best currently available scientific advice provided by ICES, both for stocks with advice based on the ICES Maximum Sustainable Yield (MSY) approach and for stocks with advice based on the ICES data-limited Precautionary Approach (PA).

- Catch limits should not exceed the limits specified by the ICES' headline advice, such as the ICES advice F_{MSY} point estimate value with its associated Harvest Control Rule, or the limits from the ICES data-limited Precautionary Approach advice with the associated Harvest Control Rule.
- If the ICES' advice is zero catch for any element of the TAC, any catch above zero is not consistent with MSY, unless sufficient safeguards are put in place for the management unit with zero TAC advice.
- Where stocks are assessed with data-limited approaches and ICES' advice provides stock status with *proxy* reference points, TACs are considered to be set consistent with MSY provided that the Precautionary Approach is adhered to.

- For stocks where ICES' advice is given for catches, it is the catch TAC before any landing obligation exemption deductions are made that should be assessed for MSY consistency. If the only published record of a TAC is where deductions have already been made for any landing obligation exemptions, then the implied full catch must be back calculated to assess the TAC for MSY consistency.
- Where a TAC comprises a mix of MSY-assessed and PA-assessed stocks*, the MSY consistency needs to be evaluated on a case-by-case basis.

  *(there are instances of a single TAC comprising different stocks of the same species, different stocks of sympatric species and different stocks of different genera)

Principles considering management related aspects:

- For TACs in the pooled, subset pooled and fragmented classifications, where management approaches and/or TAC setting rationales have not changed substantially between recent years, then historic stock assessments (exploitation rate) may be used to infer whether the management proposal is likely to deliver MSY for each stock component. Where timescales are too short for quantitative analysis, then expert judgement will be used to determine whether the new regime is sufficiently different from the old regime to deliver F_{MSY}.

- Where a sharing agreement has been established and the TAC is set at or below ICES MSY advice, then the TAC is classified as MSY consistent (for pooled and subset pooled cases, additional criteria must be met, see section 3.4, and 3.5).

- Where there is no sharing agreement for an internationally shared stock, the assessment of MSY consistency for a TAC will consider the sum of the unilaterally declared quotas compared to the sum of ICES' advice for the contributing stocks. Conditional tests may apply to ensure all recognised components of the stock(s) involved are appropriately protected.

- Where a sharing agreement has not been established, recent historic TACs have exceeded MSY advice, and subsequently the stock is assessed to be fished above MSY (F_{MSY}) (retrospective view of management in the most recent years), then the TAC is not considered to be MSY consistent. However, if the stock assessment shows the stock to be fished consistently below F_{MSY}, the TACs on these stocks could be classified as consistent with MSY approach as quotas are set in good faith that the system will continue to deliver MSY (F_{MSY}). Potentially, this is contentious but is not unreasonable.

4. Application of the MSY review assessment methodology

This section provides examples on the application of the method and illustrates specific aspects to consider for each of the six TAC categories provided in **Table 2**, each with a worked example. In all cases, the ICES' stock codes are in lower case (e.g., sol.27.7a) and the management code (following the codes designated by the EU in its TAC and Quota Regulations (TQR) is given in capital letters (e.g., SOL/07A).

4.1. Direct Match Category

The assessment area is the same or matches the management area.

4.1.1. Proposed methodology

ICES MSY or precautionary advice can be used directly when making an assessment, as the ICES' stock assessment area matches the TAC area.

4.1.2. Example: Common sole in the Irish Sea in 2020

The 2020 ICES advice for Sole in the Irish Sea (sol.27.7a) states that when the MSY approach is applied, catches in 2020 should be no more than 561 tonnes.

The TAC (SOL/07A) area matches the ICES' advice area exactly (Figure 3); therefore, the TAC must be set at or less than 561 tonnes to be consistent with MSY. The 2020 TAC was agreed at 457 tonnes.

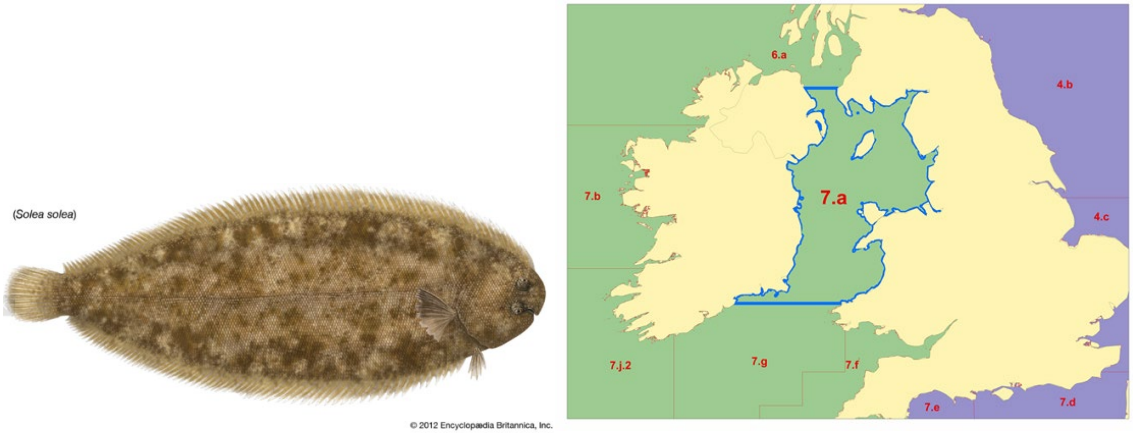


Figure 3. Example of Direct match, TAC (SOL/07A) and common sole stock assessment area in the Irish Sea. Common sole image credits, Britannica encyclopaedia

4.2. Wide Category

The management area is larger than the ICES' stock assessment area and includes surrounding waters where the species rarely occurs but are included to prevent misreporting. The ICES' stock assessment area is always within the TAC area.

4.2.1. Proposed methodology

ICES MSY advice can be used as a direct match because additional areas covered by the TAC exist to close reporting loopholes, provided catches inside the ICES' assessed area were part of an 'of which no more than' clause.

TACs should be no more than the sum of the ICES' advice and any precautionary estimates of catch beyond the advice area. MSY consistency can only be granted provided the additional tonnage is not utilised simply to increase the catch above the advice level for the ICES' assessed stock area. When the ICES' advice is zero catch, it applies for the whole management area, so the TAC can only be MSY consistent if the TAC is set at zero (precautionary estimates for the non-ICES assessed areas should not be used).

4.2.2. Example: Celtic Sea cod in 2020

The 2020 ICES' advice for Celtic Sea cod (*Gadus morhua*) covers the Western English Channel and Southern Celtic Sea Divisions 7.e-k (cod.27.7.e–k). The 2019 ICES' advice stated that when the MSY approach is applied, there should be zero catch in 2020.

The TAC (COD/7XAD34) area is significantly bigger and covers a large part of the Northeast Atlantic (see **Figure 4**). However, because ICES advised zero catch, the catch limit must be set at zero to be consistent with MSY.

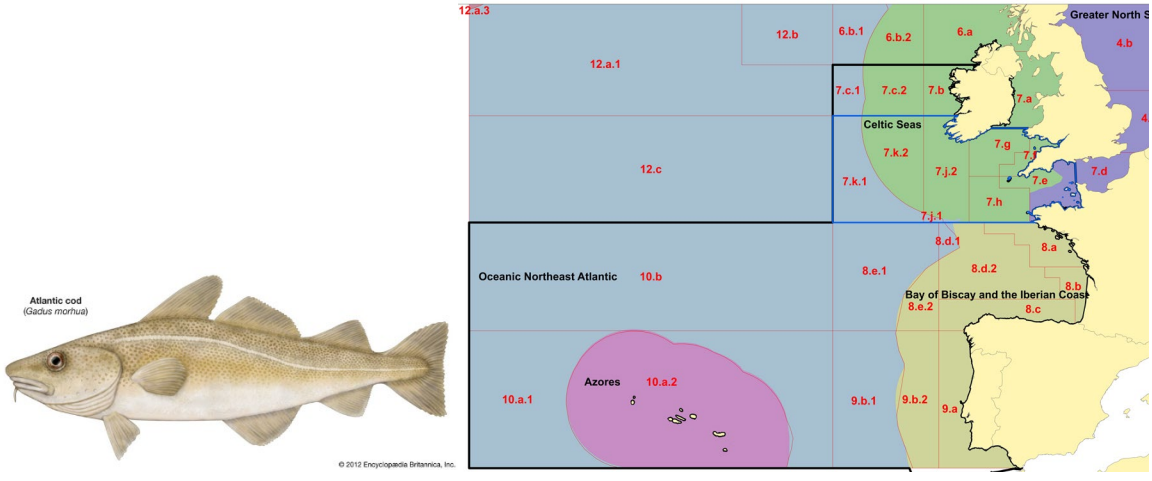


Figure 4. Example of Wide match, Celtic Sea cod, TAC (COD/7XAD34) showing the assessment area (blue border line) within the wider management area (black border line).
Cod image credits, Britannica encyclopaedia

4.3. Subset Category

Several management areas or units comprise one ICES' stock, therefore, there are multiple TACs for one ICES' assessment (stock).

4.3.1. Proposed methodology

The sum of the individual TACs when combined should be compared against the ICES MSY advice. If the sum of TACs is set at or below the ICES MSY advice, then the stock is consistent with MSY.

4.3.2. Worked example of Northern hake in 2020

The ICES' advice for Northern hake covers the Greater North Sea, Celtic Seas and the northern Bay of Biscay (hke.27.3a46-8abd) and the advice provided in 2019 stated that when the MSY approach is applied, catches should be no more than 104 763 tonnes in 2020.

There are four TACs (management areas), HKE/03A, HKE/2AC4-C, HKE/571214 and HKE/8ABDE, which when summed match the boundary of the ICES' advice (assessment area). In this case the sum of the quotas (catch limits) set for these four TAC areas is greater than the ICES MSY advice for the stock (see **Figure 5** and **6**). Therefore, these four TACs are not MSY consistent.

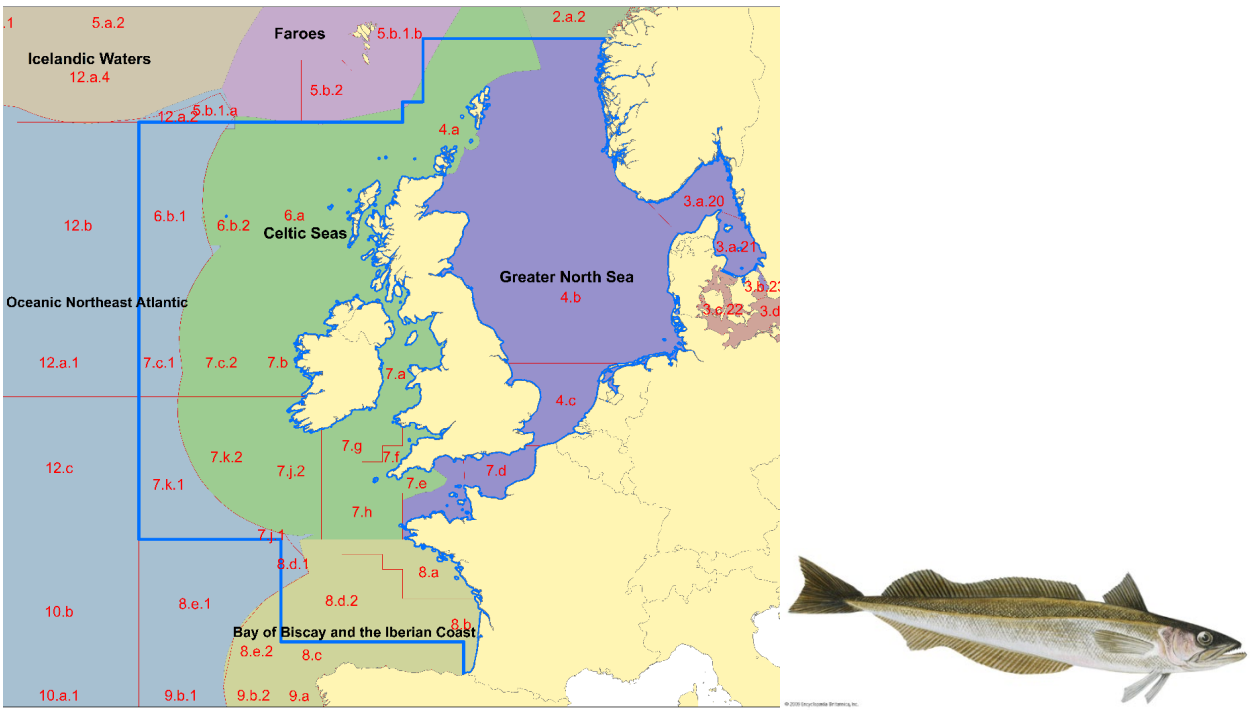


Figure 5. Example of Subset match TAC (Northern Hake) showing the overall stock assessment area (blue border line) in the Greater North Sea, Celtic Seas, and the northern Bay of Biscay.
Hake image credits Britannica encyclopaedia

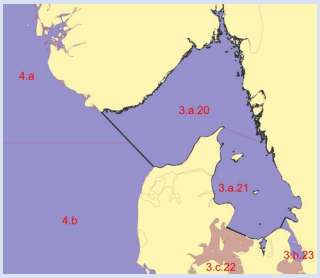
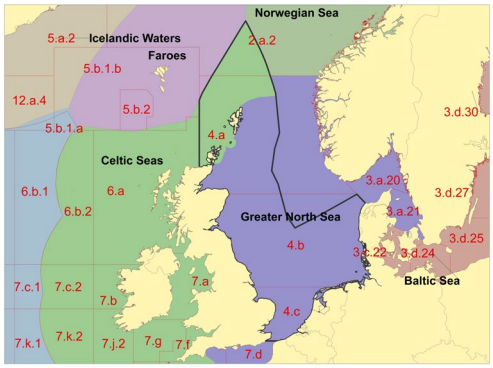
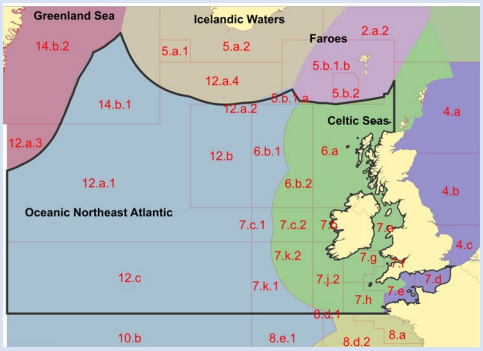
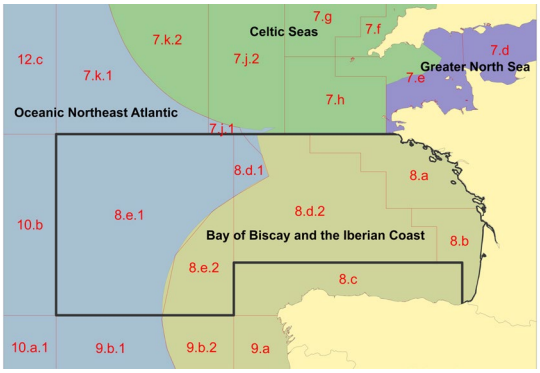
Management area TAC Code	Management area with relevant part of the assessment area	Quota, catch limits (tonnes)
HKE/03A		3 403
HKE/2AC4-C		3 940
HKE/571214		63 325
HKE/8ABDE		42 235
Total		**112 903 tonnes**

Figure 6. Example of Subset match TAC (Northern hake) showing the four management areas with corresponding parts of the stock assessment area, and catch limits set for each TAC.

This example illustrates the situation where the advice (104 763 t) is exceeded by the sum of individual catch limits from the four TACs.

There are some additional matters for consideration concerning areas within the TAC where there is no ICES' advice. For example, in the case of the TAC HKE/2AC4-C (Union waters of 2.a and 4), the part of Division 2.a referred to as Union waters is not included in the ICES' assessment of the stock and advice. Likewise, in the case of the TAC HKE/8ABDE, Division 8.e is not included in the ICES' assessment of the stock and advice. In addition, regarding the TAC HKE/2AC4-C (Union waters of 2.a and 4) the catches by third countries within their section of Subarea 4 are not considered in the setting of the TAC.

4.4. Pooled Category

The management unit comprises multiple ICES' assessed stocks and all contributing ICES' assessed stocks lie exclusively within the management area.

4.4.1. Proposed Methodology:

There are two steps that are necessary to assess MSY consistency in this category.

The basic approach is to compare the TAC for the management area to the sum of the ICES MSY advice from the constituent stock units (step 1), and further assess whether specific criteria are met (step 2). Where there is a concern that a criterion may be violated, further analysis and/or expert judgement will be required to determine if the pooled TAC is consistent with MSY.

The first step is to compare the TAC to the sum of the individual ICES MSY advice values for each contributing stock (advised tonnage; step 1). If the TAC is set at or below the sum of individual ICES MSY advice the first step is passed successfully. Then, the TAC can be assessed further against additional criteria to be met (step 2) for MSY consistency.

4.4.1.1. Advice Tonnage (Step 1):

The sum of the contributing tonnage from each stock should relate to one of the following in order of priority:

a) F_{MSY} point estimates (or F_{MSY} proxy where no direct measure of F_{MSY} is possible), or

b) Management plan (provided the management plan has been evaluated by ICES (and agreed by all relevant parties) to be both precautionary and *consistent with the MSY* principle), or

c) Precautionary Approach, but only where MSY values (or proxies) are not available.

4.4.1.2. Critical Criteria (Step 2):

d) If advice for any one of the contributing ICES' assessed stocks is for zero catch, evaluation of any relevant complementary technical measures should be considered when assessing whether the overall management package is MSY consistent on a stock-by-stock basis. In the absence of an analytical evaluation, expert opinion may be drawn on, and MSY consistency will only be confirmed provided there is a reasonable expectation that, based on the weight of evidence, technical measures may be expected to deliver the required reduction in fishing mortality on a specific stock. Where necessary, this may include ensuring a specific stock has zero catch.

e) If it is anticipated that any one of the contributing ICES' assessed stocks may be over-exploited, an evaluation of complementary technical measures (such as an area restriction to fishing) should be considered when assessing whether the overall

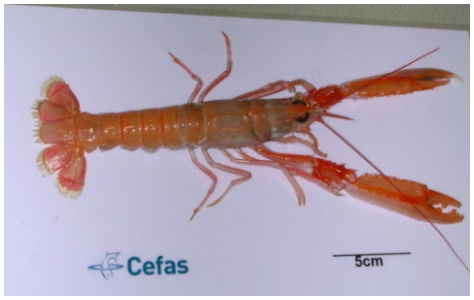
management package is MSY consistent on a stock-by-stock basis. In the absence of an analytical evaluation, expert opinion may be drawn on, and MSY consistency will only be confirmed provided there is a reasonable expectation that, based on the weight of evidence, the technical measures may be expected to deliver the required reduction in fishing mortality.

f) If there is no sharing agreement, for an internationally exploited stock, assessment of MSY consistency for the TAC will consider the sum of the unilaterally declared *quotas* compared to the sum of ICES' advice for the contributing stocks. The same conditional tests will apply (e.g., does one stock unit have an expectation or recent history of being exploited above MSY such as above the point estimate F_{MSY}).

4.4.2. Example of Pooled category: *Nephrops* in Area 6, Union and international waters 5.b in 2020

For the purposes of assessment, ICES considers that the *Nephrops norvegicus* (*Norway lobster*) population comprises a number of spatially distinct functional units (FU) rather than stocks. Each of the FUs are spatially distinct populations due to *Nephrops* constructing and residing in burrows where the location is dependent on the sediment type and its structure. Therefore, in ecological terms each could be considered as a 'stock'.

The management area of the TAC (NEP/5B6C) (**Figure 7**) relates to four assessment areas (FU) (**Figure 8**) with separate advice; from three assessed functional units, together with landings outside the assessed functional units.



The ICES' advice states that to ensure than *Nephrops* stocks are exploited sustainably, *'management should be implemented at the functional unit level'*.

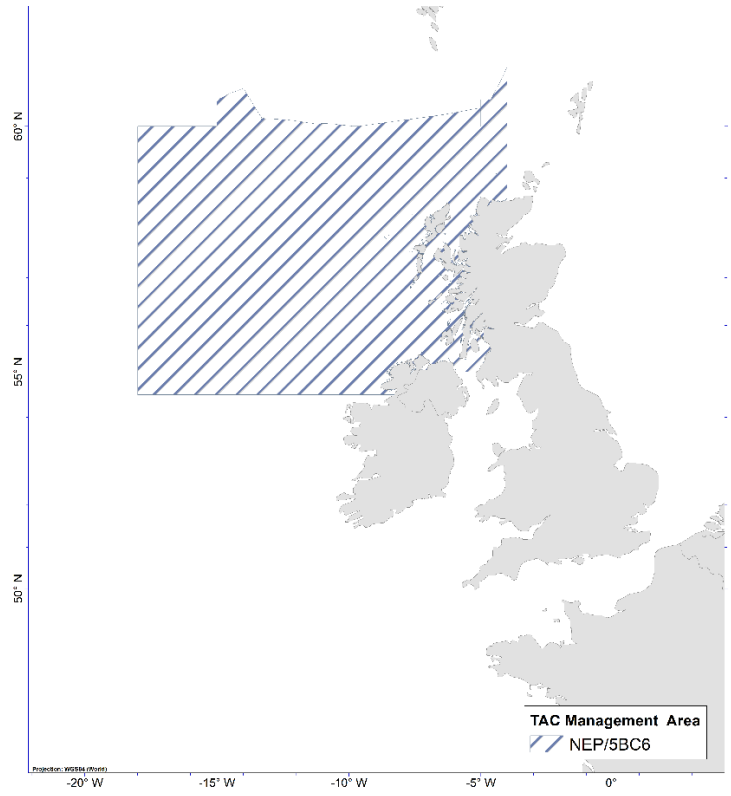


Figure 7. Management area for *Nephrops* in Area 6, Union and international waters of 5.b.

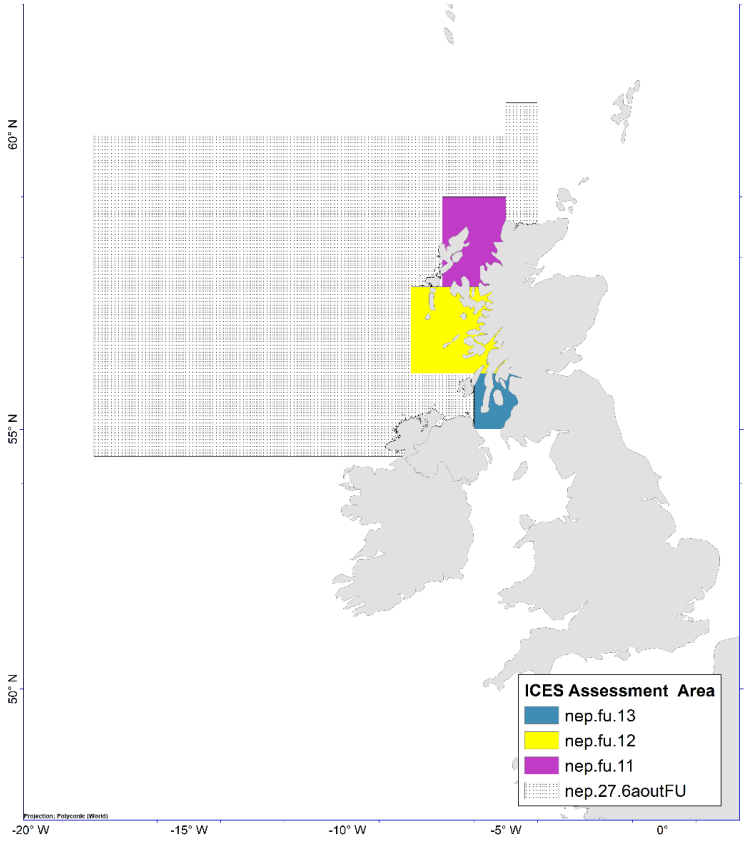


Figure 8. ICES' assessment areas for Nephrops in Area 6, Union and international waters of 5.b.(key: fu and FU denote functional unit).

The worked example to assess this TAC (pooled category) involves four pieces of advice from the following functional units and landings outside the functional units and two steps.

1. ICES stock advice FU11 (MSY approach – EU Multi-Annual plan)
2. ICES stock advice FU12 (MSY approach – EU Multi-Annual plan)
3. ICES stock advice FU13 (MSY approach – EU Multi-Annual plan)
4. ICES stock advice 27.6a.outFU (PA)

Step 1: Sum the point estimate advice for each of the Functional Units within this management area.

Step 2: Consider the historical records for each of the Functional Units (see criteria below, and **Figure 9)**.

- Recent TACs for the management area have been set at the pooled ICES' advice.
- There are no known FU-specific technical measures in place.
- Harvest rates for FUs 11, 12 and 13 fluctuate around their respective F_{MSY}, however FU13 has a consistent history of being fished above F_{MSY} more often than not (F> F_{MSY} in 3 of the last 5 years, see **Table 4**).
- A TAC set at the pooled ICES' advice would therefore only be considered to be MSY consistent if additional measures were put in place which are expected to reduce the exploitation rate in FU13 below the MSY advice for that unit, and that these measures would not be expected to increase effort in the other FUs to the point where F_{MSY} for these units would be exceeded.

Table 4. ICES' advice for catches in 2020 and historical records for each functional unit of *Nephrops* in Area 6. HR/MSY = Harvest rate relative to MSY.

Assessment Area	ICES' advice for catch in 2020	Type of advice	HR/MSY 2017	HR/MSY 2018	HR/MSY 2019
nep FU11	3 347 t	MSY	Pass	Pass	Pass
nep FU12	7 134 t	MSY	Pass	Pass	Pass
nep FU13	5 861 t	MSY	F> Fmsy (Fail)	F> Fmsy (Fail)	Pass
Nep 27.6a outFU	261 t	PA	unknown	unknown	unknown

The sum of the advice is 16 603 t. However, one of the stocks was exploited above F_{MSY} in the previous 3 years and the fourth is unknown.

4.5. Subset Pooled Category

The management area (TAC unit) comprises multiple ICES' assessed stocks where one or more of these straddles more than one management area. All portions of the stock should have a TAC. If there are portions of a stock which fall outside TAC jurisdiction these stocks are classified as *fragmented* (see Section 3.6).

4.5.1. Assessment approach

This category encompasses some of the more complex relationships between stock and management areas. The stocks contributing to the management area in question may straddle multiple management areas and may even be of different species with different classifications of assessment (MSY or PA). A degree of tailoring of the MSY consistency evaluation may be required. The same conditional tests applied to the pooled category should apply in these cases, too.

The basic premise is to compile the MSY advice from all the stock units that contribute to the TAC areas of interest and to compare this value with the sum of the TACs (A, B and C) that impact all the contributing stocks (see **Figure 9**).

For example, TAC A includes the stock 'W' and part of the stock 'X'. For the purposes of assessing whether the TAC in management area A is MSY consistent, the summed TAC for all contributing stocks ('W' and 'X', including the parts of these stocks that are in other TACs B and C) must be less than the combined advice for the two contributing stocks ('W' and 'X').

The TAC in management area B consists of part of the stock 'X' and part of the stock 'Y'. For management area B to be MSY consistent, the summed TACs of contributing stocks ('X' and 'Y', including the parts of these stocks that are in other TACs A and C) must be equal to or less than the combined advice for the two contributing stocks ('X' and 'Y').

The TAC in management area C consists of part of the stock 'X', part of the stock 'Y' and all of stock 'Z'. For management area C to be MSY consistent, the summed TACs of contributing stocks ('X', 'Y' and 'Z' including the parts of these stocks that are in the other TACs A and B) must be equal to or less than the combined advice for the three contributing stocks ('X', 'Y' and 'Z').

As with the Pooled category, assessment of MSY consistency can be a two-step process, and the same critical criteria will need to be met to achieve MSY consistency of the TAC with reference to each of the contributing stocks.

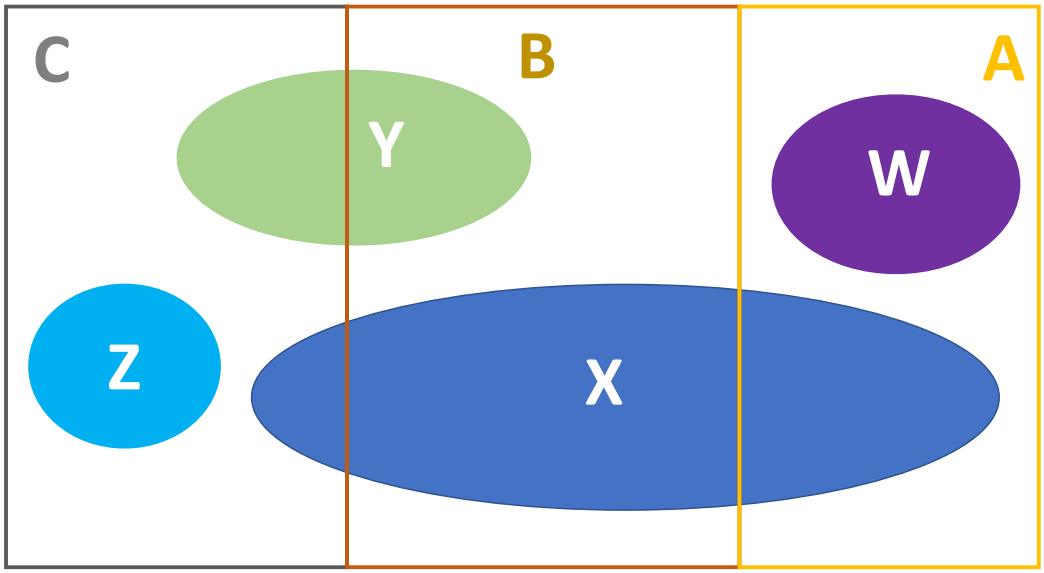


Figure 9. Illustration of the potential linkages between stocks (advice) and management area TAC in the subset pooled category.

4.5.2. Proposed Methodology

The TAC would be considered MSY consistent if the sum of all TACs that affect the contributing stocks is at or below the sum of the contributing ICES MSY advice values. Assessment of MSY consistency is a two-step process (as in the pooled category).

4.5.2.1. Advised tonnage (Step 1)

The contributing tonnage from each stock should relate to one of the following in order of priority:

a) F_{MSY} point estimates (or F_{MSY} proxy where no direct estimate of F_{MSY} is possible), or

b) Management plan (provided the management plan has been evaluated by ICES (and agreed by all relevant parties) to be both precautionary and *consistent with the MSY* principle), or

c) Precautionary Approach, but only where MSY values (or proxies) are not available.

4.5.2.2. Critical Criteria (Step 2):

d) If advice for one of the contributing ICES' assessed stocks is for zero catch, evaluation of any relevant complementary technical measures should be considered when assessing whether the overall management package is MSY consistent on a stock-by-stock basis. In the absence of an analytical evaluation, expert opinion may be drawn on, and MSY consistency will only be confirmed provided there is a reasonable expectation that, based on the weight of evidence, technical measures may be expected to deliver the required action. In some instances, this may be a zero catch on one stock or component.

e) If it is anticipated that one of the contributing ICES' assessed stocks may be over-exploited, an evaluation of complementary technical measures (such as area restrictions) should be considered when assessing whether the overall management package is MSY compliant on a stock-by-stock basis. In the absence of an analytical evaluation, expert opinion may be drawn on and MSY consistency will only be confirmed provided there is a reasonable expectation that, based on the weight of evidence, the technical measures may be expected to deliver the required reduction in fishing mortality.

f) If there is no sharing agreement, assessment of MSY consistency for the TAC of shared stocks will consider the sum of the unilaterally declared quotas against the relevant portions of ICES' advice for the contributing stocks.

As the TACs in this category can be complex, the assessment of MSY consistency requires the application of specific methodologies in each case, i.e., case specific.

4.5.3. Example of Subset Pooled: Anglerfish in Subarea 7 in 2020

The TAC for Anglerfish in Subarea 7 (ANF/07) includes two biological stocks (in this case two separate fish species) and ICES' assessment advice, Black bellied Anglerfish (*Lophius budegassa*) (ank.27.78abd) and White bellied Anglerfish (*Lophius picatorius*) (mon.27.78abd), where both of the contributing stocks straddle more than one management area (in this case, the additional management area is TAC ANF/8ABDE) (see **Figures 10a, 10b**).

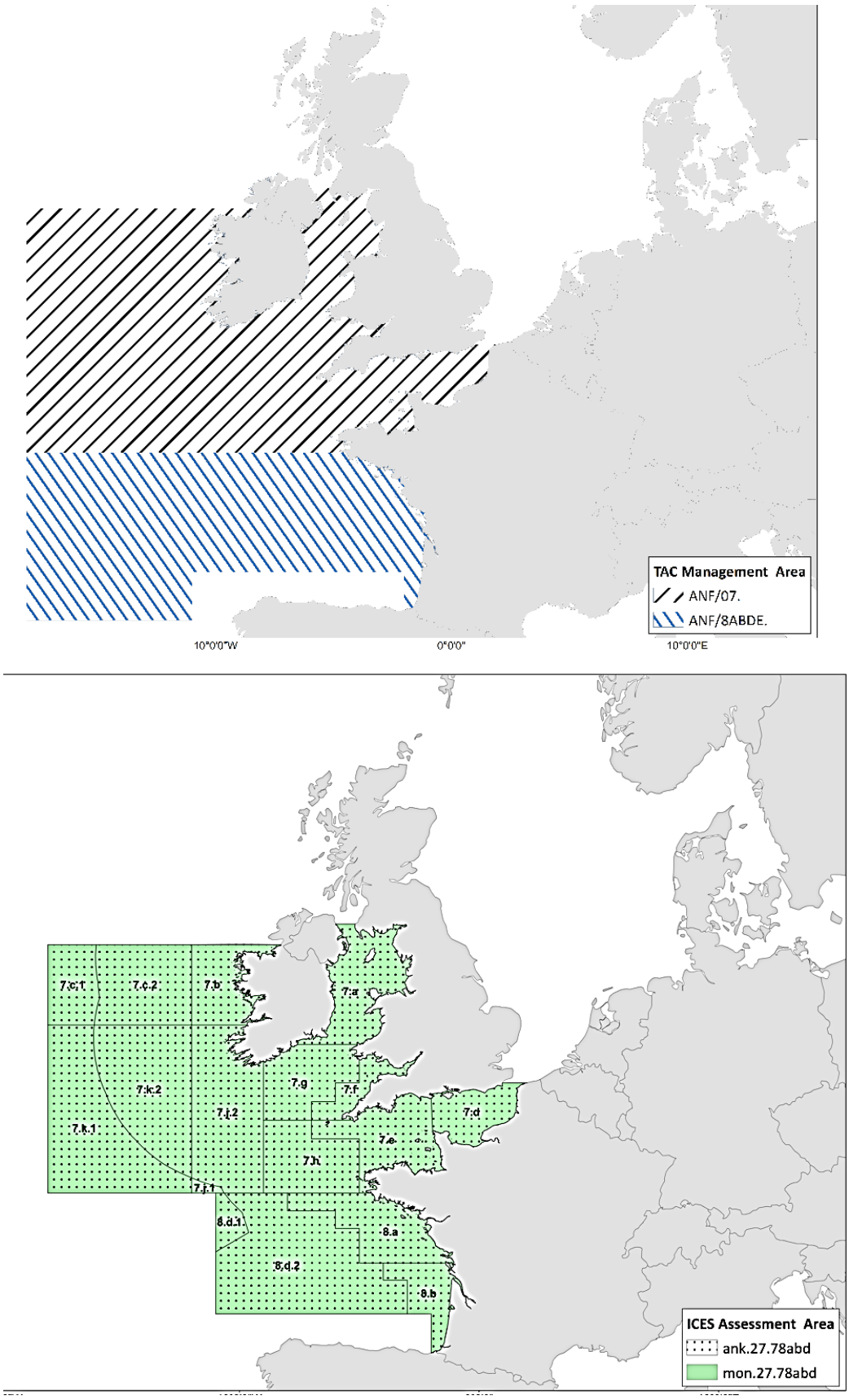


Figure 10a. Management area of Anglerfish in Subarea 7 TAC (ANF/07) and adjacent TAC (ANF/8ABDE) (top panel) and the two stock assessment areas (White bellied and Black-bellied Anglerfish) (bottom panel).

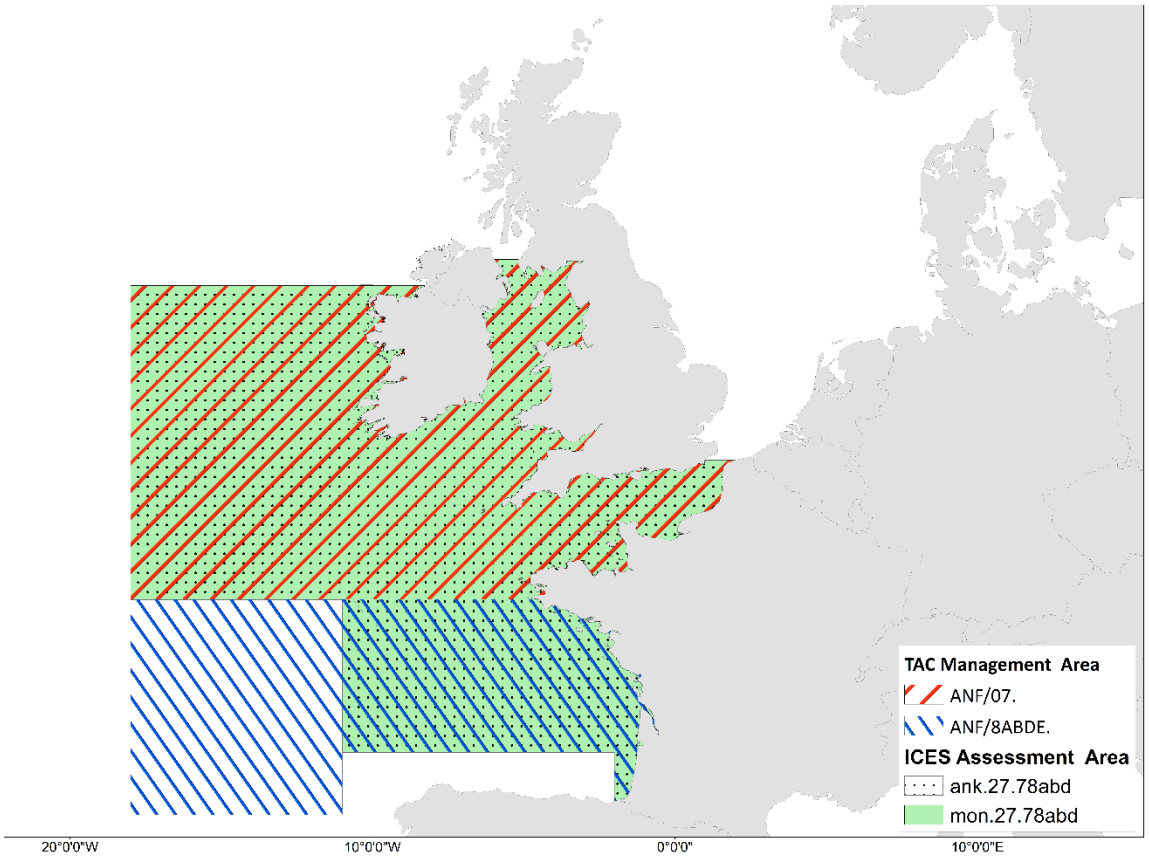


Figure 10b. Overlap between management area of Anglerfish in Subarea 7 TAC (ANF/07) and adjacent TAC (ANF/8ABDE) and the two stock assessment areas (White bellied and Black-bellied Anglerfish).

4.5.3.1. Advised tonnage (Step 1 for Anglerfish in Subarea 7)

Step 1: Confirm that the sum of this TAC plus the TAC for anglerfish in Divisions 8.abd, is the same or less than the sum of the ICES advice for White and Black-bellied anglerfish in Subarea 7 and 8.abd. Advice on Black bellied anglerfish (ank.27.78abd, category 3, PA advice) and White bellied anglerfish (mon.27.78abd, category 1, MSY advice under the EU Multi-Annual plan).

Advised tonnage for catch in 2020: Compare the pooled advice 44 757 t, as the total sum of advice from Black bellied anglerfish (12 959 t), and White bellied anglerfish (31 798 t) against the total quota for Anglerfish in Subarea 7 TAC ANF/07) 44 307 t, from the (35 299 t) from TAC in Subarea 7 (ANF/07), and 9 008 t from TAC in Divisions 8.abd (ANF/8ABDE).

The Total quota (44 307 t) is below the sum of the advice (44 757 t), so it passes step 1.

Note that in the case of the management area covering Divisions in Subarea 8, Division 8.e is not included in the assessed stock area.

4.5.3.2. Critical Criteria (Step 2 for Anglerfish in Subarea 7):

Step 2: Assess whether the advised TAC is likely to result in exploitation rates above F_{MSY} for either of the stocks, and if so whether suitable safeguards are being put in place.

Meeting critical criteria:

- Whilst the TAC in Divisions 8.abd (ANF/8ABDE) also includes the unassessed Division 8.e, the summed TACs for both species covering both management areas is less than the advice which is applicable to a significant portion of the two management areas.
- There are no known specific technical measures in place.
- Although there is a history of $F>F_{MSY}$ for both stocks, fishing mortalities are on a downward trajectory for both species and have been below the F_{MSY} or F_{MSY} proxy for the past 2 years.
- Biomass for each of the two species is well above MSY $B_{trigger}$ and has been increasing for the last 5 or more years.
- Expectation is therefore that the TACs will result in $F<F_{MSY}$ for next year.
- TAC for Anglerfish Subarea 7 (ANF/07) in 2020 was considered consistent with MSY.

4.6. Fragmented category

The management area (TAC) does not match with the ICES' stock assessment area. The ICES' assessment advice is relevant to multiple management areas, or one or more stock components do not have a management unit.

4.6.1. Assessment approach

This category comprises the greatest complexity, where multiple ICES' assessed stocks may contribute to multiple TAC areas as well as having some portions of catch coming from unregulated areas. These stocks either require a bespoke analysis or, in the worst cases, may simply be unclassifiable unless the management regime can become more aligned with the ICES' stock areas.

Where TACs do not match ICES' assessed stock units and there are missing TACs for one or more components, or the stock unit advice is relevant for multiple TACs (fragmented mismatch), a dedicated assessment would be required along with an allocation key to distribute and/or split the ICES' advice to match the management area as required.

Approaches may include comparing the agreed TACs plus 3-year average landings from areas not covered by TACs against the ICES' advice.

Some fragmented TAC cases are so complex that no approach has been established to disentangle ICES' assessment areas from fishery management (or no management) areas. There is a need to develop a meaningful MSY consistency-testing assessment to undertake the most complex cases unless a management regime more closely matching stock units is conceived.

Within the currently considered stocks applicable to the UK, only Tusk (*Brosme brosme*), Greenland Halibut (*Reinhardtius hippoglossoides*), Lemon Sole (*Microstomus kitt*) and Witch (*Glyptocephalus cynolossus*), and Turbot (*Scophthalmus maximus/Psetta maxima*) and Brill (*Scophthalmus rhombus*) fall into this fragmented category. Other stocks may fall into the category in any future expansion of the stock list. Specific methodology for these TAC cases is considered in the following section.

4.6.2. Specific fragmented methodology examples:

TACs in this category can be most complex, so the assessment of MSY consistency requires the application of specific methodologies in each case.

4.6.2.1. Example of Lemon Sole and Witch, Union Waters of 2.a and 4 (L/W/2AC4-C) in 2020

This is one example of two species included in a single TAC where the management area does not match with the assessment area (**Figure 12** and **13**).

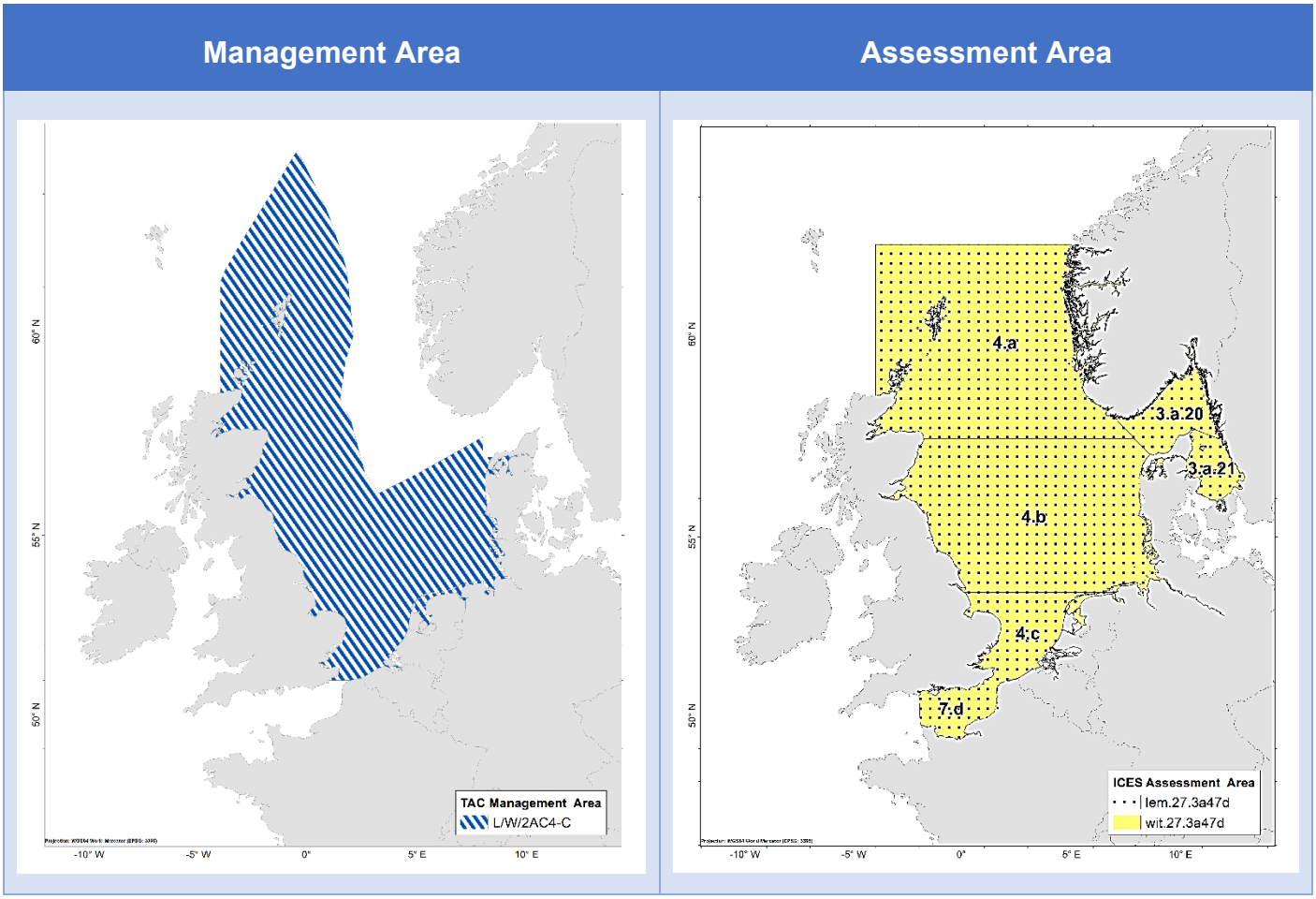


Figure 12. One Management area and 2 stock assessment areas for *Lemon Sole* and *Witch* TAC in Union Waters of 2.a and 4.

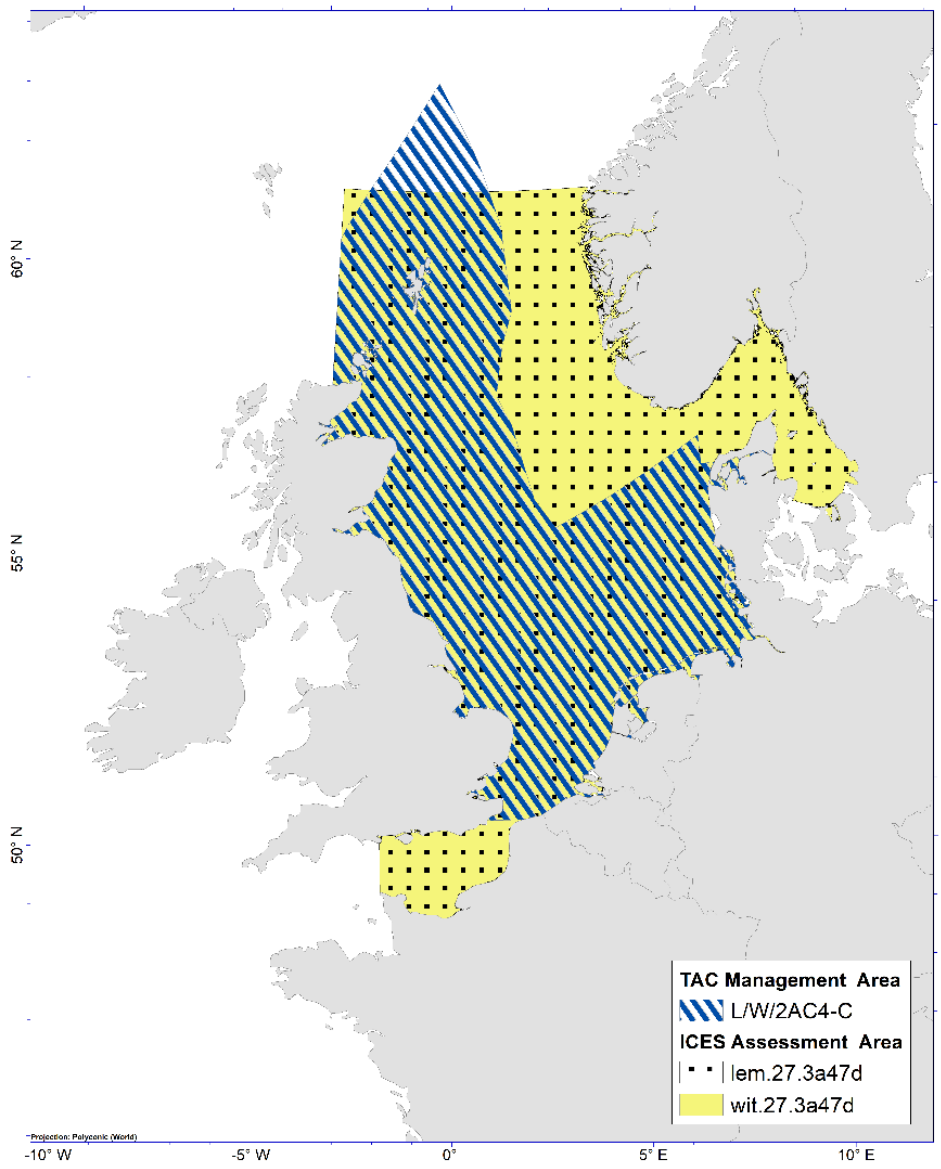


Figure 13. Overlap between Management area and Assessment area for *Lemon Sole* and *Witch* TAC in Union Waters of 2.a and 4 TAC (L/W/2AC4-C).

Step 1: Estimate the advice relevant to the TAC area for each stock.

- Split the advice into 3.a, 4 and 7.d components using landing distribution or scientifically robust stock distribution.

- Deduct Norwegian landing component from Subarea 4 landings (assumes landings by Norway all occur in Norwegian sector). These are not managed by a sharing agreement between EU and Norway and as such the TAC does not encompass Norwegian waters.

Add the combined advice for Subarea 4 and compare with agreed TAC.

Step 2: If step 1 passed, assess whether this TAC is likely to result in over-exploitation of either component.

The use of this approach would have seen MSY consistency rejected at step 1 in 2020: Implied catch advice for Subarea 4 was 4317 t (=793 + 3 524) TAC set at 6 785 t, (see **Table 5**).

Table 5. ICES' advice for catch in 2020 for *Witch* and *Lemon Sole* in Subarea 4 with proportion of stock landings and implied TAC.

	ICES Advice for catch in 2020	Proportion of stock landings in subarea 4	Implied subarea 4 advice	Norway landings % in subarea 4 (assume in Norwegian zone and deduct)	Implied TAC for EU & UK vessels in subarea 4
Witch (wit.27.3a47d)	1 651 t	52%	859	7.58%	793 t
Lemon Sole (lem.27.3a47d)	4 279 t	83%	3552	0.78%	3 524 t

Note that as in the case above, Division 2.a is not part of the assessment area for either stock, or this additional area (if fish occur there) is not taken into account when considering the fishable stock when setting the TAC.

4.6.2.2. Example of Turbot and Brill in Union Waters of 2.a and 4 (T/B/2AC4-C) in 2020

This is another example of two species (Turbot and Brill) being included in a single TAC (see **Figure 14** and **15**).

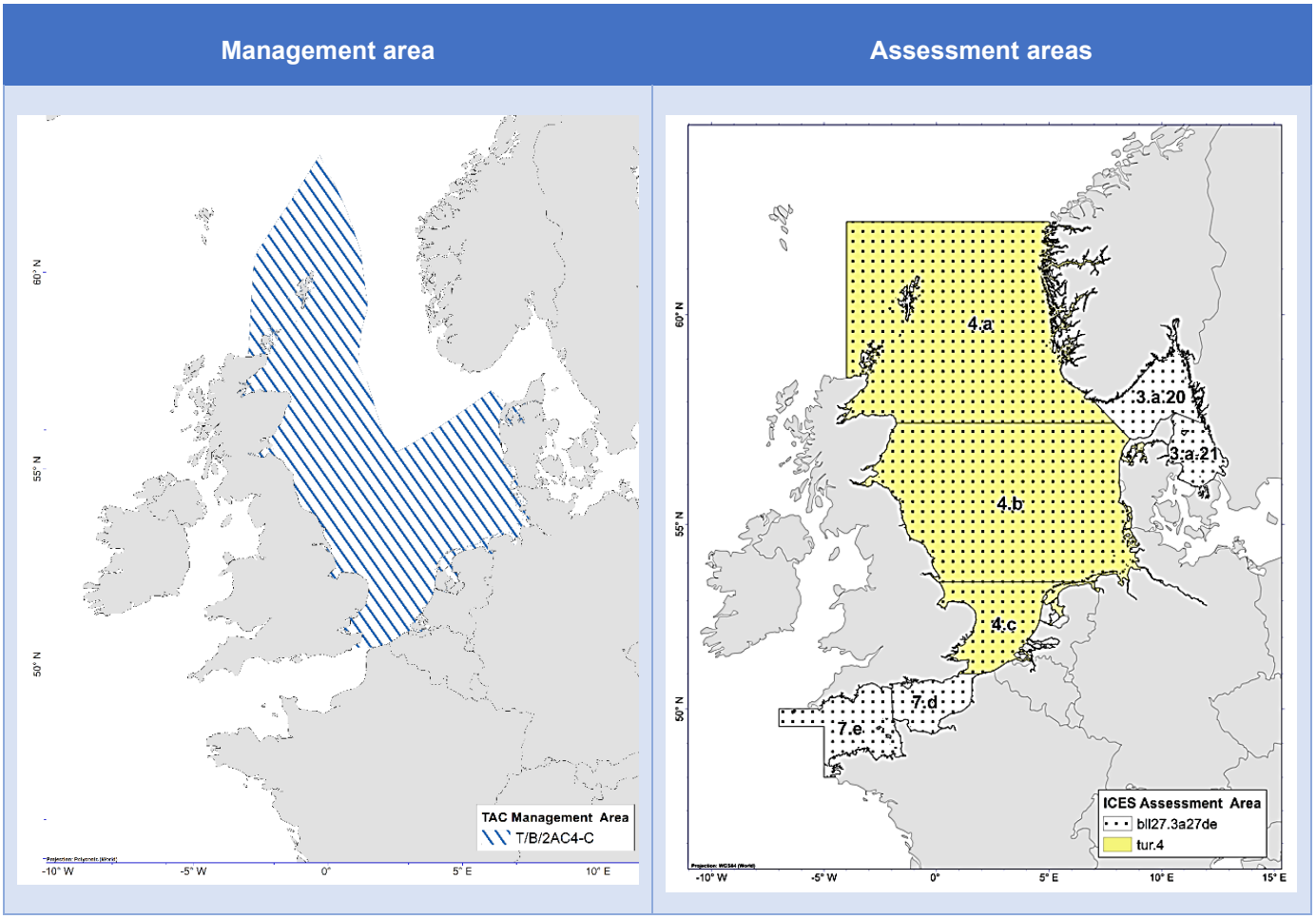


Figure 14. Overlap between management area and the two assessment areas for the *Turbot and Brill in Union Waters of 2.a and 4* TAC (T/B2AC4-C).

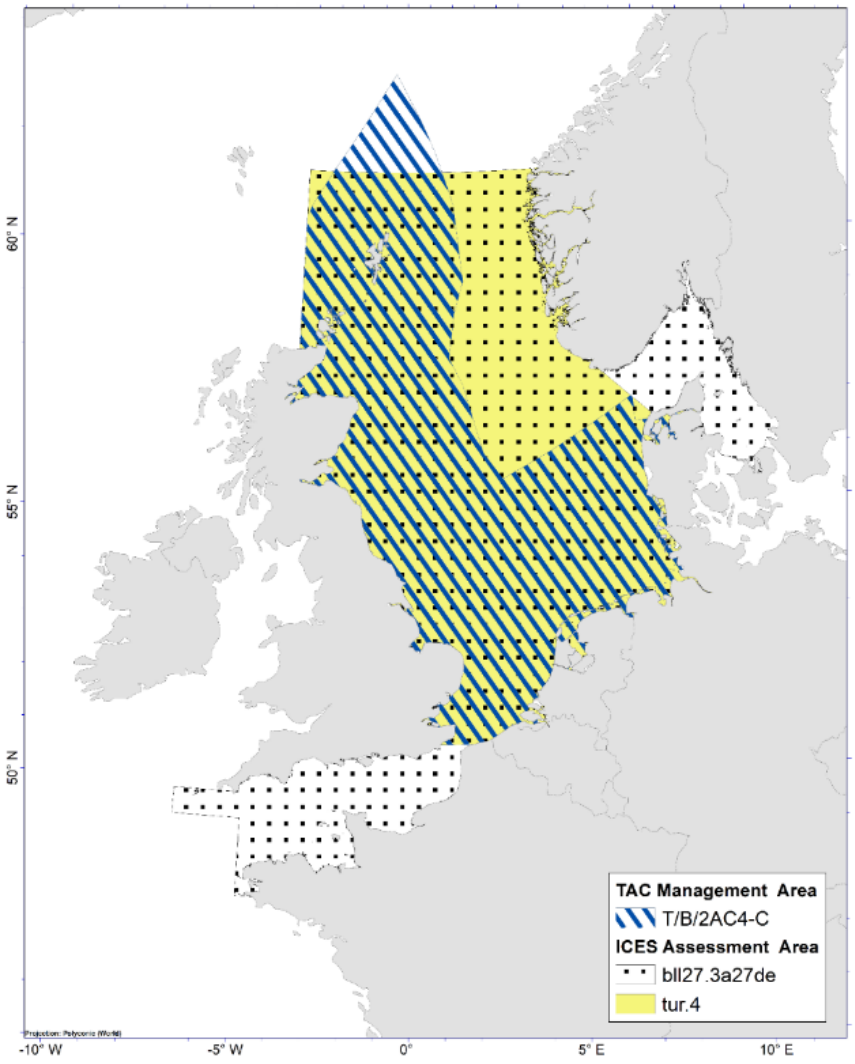


Figure 15. Overlap between management area and assessment area for the TAC T/B2AC4-C.

Step 1: Estimate the advice relevant to the TAC area for each stock.

- Split the Brill advice into 3.a, 4 and 7.d,e components using landing distribution or scientifically robust stock distribution Turbot advice is Subarea 4 only.
- Deduct Norwegian landing component from Subarea 4 landings (assumes landings by Norway all occur in Norwegian sector). Again, these are not managed by a shared agreement between EU and Norway and as such the TAC does not encompass Norwegian waters.
- Add the combined advice for Subarea 4 and compare with agreed TAC prior to landing obligation exemption deductions.

Step 2: If step 1 passed, assess whether this TAC is likely to result in over-exploitation of either component.

Step 1 failed in 2020: If we consider the implied advice for Subarea 4 was 6 117 t, and the TAC was set at 6 498 t *including* landing obligation exemption deductions for turbot (estimated 5.34%), see **Table 6**.

Table 6. ICES' advice for catch in 2020 for Turbot and Brill in subarea 4 with proportion of stock landings and implied TAC.

	ICES Advice for catch in 2020	Proportion of stock landings in subarea 4	Implied subarea 4 advice	Norway landings % in area 4 (10yr av, assume in Norwegian zone and deduct)	Implied catch (no landing obligation exemption deductions) for EU & UK vessels in subarea 4
Turbot (tur.27.4)	4 538 t	100%	4 538	0.69%	4 507 t
Brill (bll.27.3a47de)	2 559 t	63%	1 617	0.42%	1 610 t
					Total 6 117 t

Note than as in the case above, Division 2.a is not part of the assessment area for either stock, or this additional area (if fish occur there) is not taken into account when considering the fishable stock when setting the TAC.

4.6.2.3. Example of Tusk (USK/03A, USK/04-C, USK/567EI, USK/04-N, USK/1214EI) in 2020

The following case for tusk is given as an unquantified example to illustrate a complex relationship between ICES' assessed areas and the TACs (see **Figure 16a, 16b**). The TACs only refer to EU and international waters, therefore do not allow for other national waters within the advice areas. This poses multiple difficulties to make a robust assessment for these TACs.

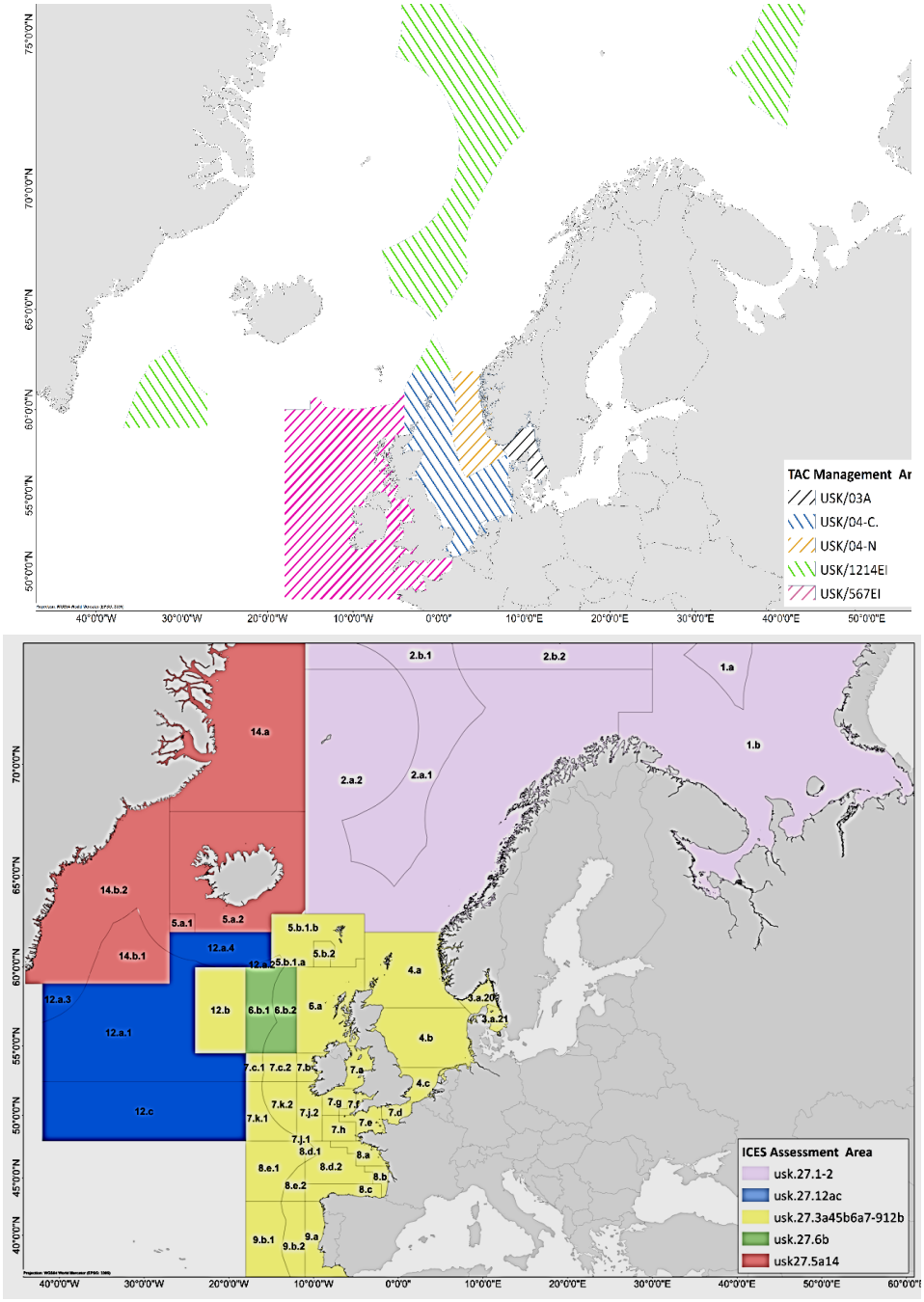


Figure 16a. Management areas (top map) and stock assessment areas (bottom map) for Tusk in the greater North Sea, Division 7b-k.

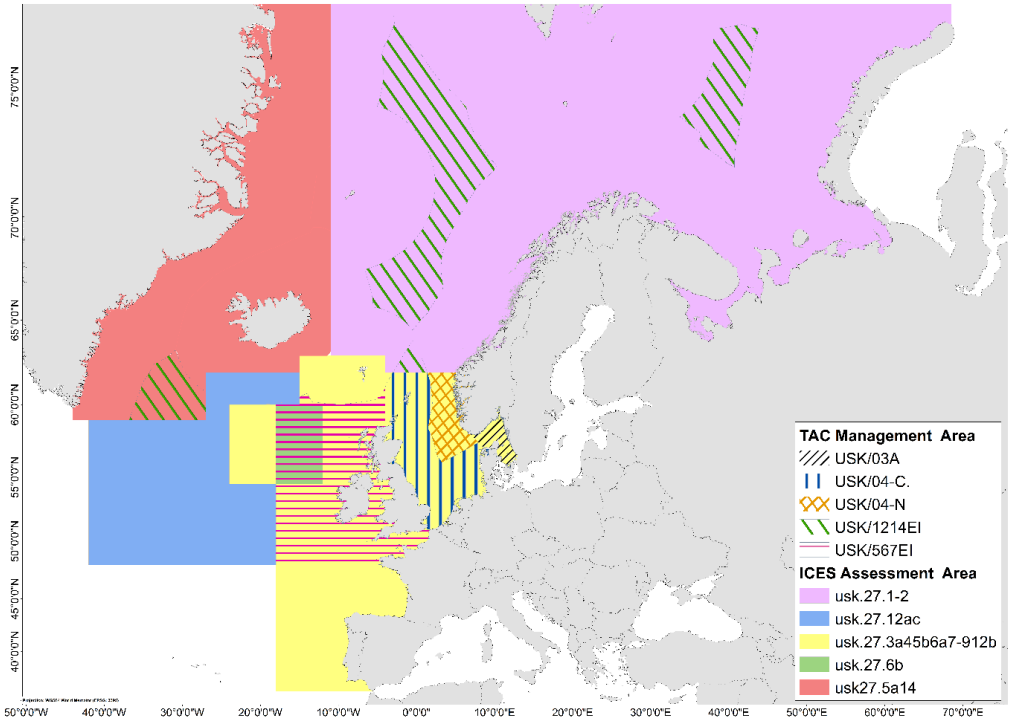


Figure 16b. Overlap between management areas and stock assessment areas for Tusk in the greater North Sea, Division 7b-k

The ICES' assessment area for Tusk in the Northeast Atlantic includes five separate ICES' units of stock advice. Of these, four are relevant to five management units of interest to the EU (see **Figure 17**). One unit of ICES' advice (12, excluding 12b) is within Icelandic waters and the NEAFC regulatory area (international waters) and as such has no EU TAC code. In the case of tusk, the assessment of MSY consistency is considered not feasible for all components.

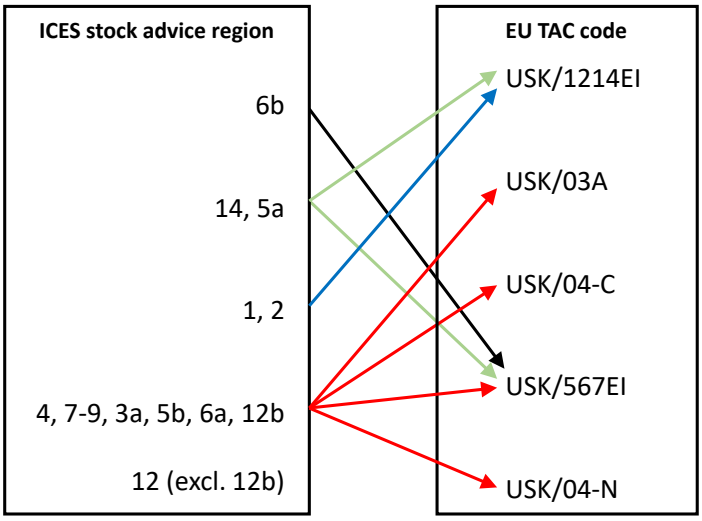


Figure 17. The case of Tusk with five different ICES' assessment stock advice and their relationship to five separate management units (TACs).

4.7. No Sharing agreement cases

International fisheries agreements are an important part of fisheries management. The occurrence and status of sharing agreements can influence the method to assess consistency with MSY or sustainable levels for any of the TAC' categories.

4.7.1. Methodology proposed

If there is no sharing agreement for an internationally shared stock, the assessment of MSY consistency for a TAC will consider the sum of the unilaterally declared quotas compared to the sum of ICES' advice for the contributing stocks.

The specific method proposed for complex cases of pooled subsets with no sharing agreement is specifically explained with the example of the TACs for Beaked Redfish (REB/1N2AB) and Redfish spp. (REG/12INT) (see **Figure 18)**.

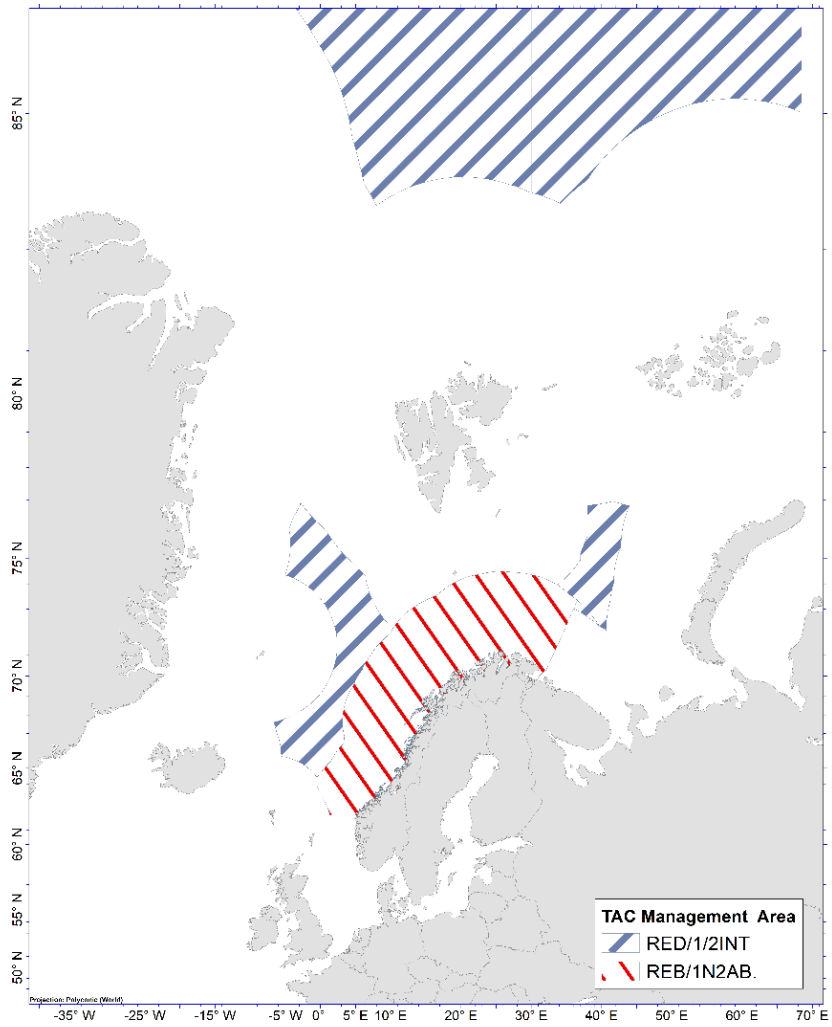


Figure 18. Management areas for Beaked Redfish (REB/1N2AB) and Redfish spp. (RED/12INT).

The ICES' stock assessment areas for Beaked redfish (*Sebastes mentella*) and Golden redfish (*Sebastes norvegicus*) are shown in **Figure 19**. In some instances, these species are caught together and are often landed as generic 'redfish' with no designation of species.

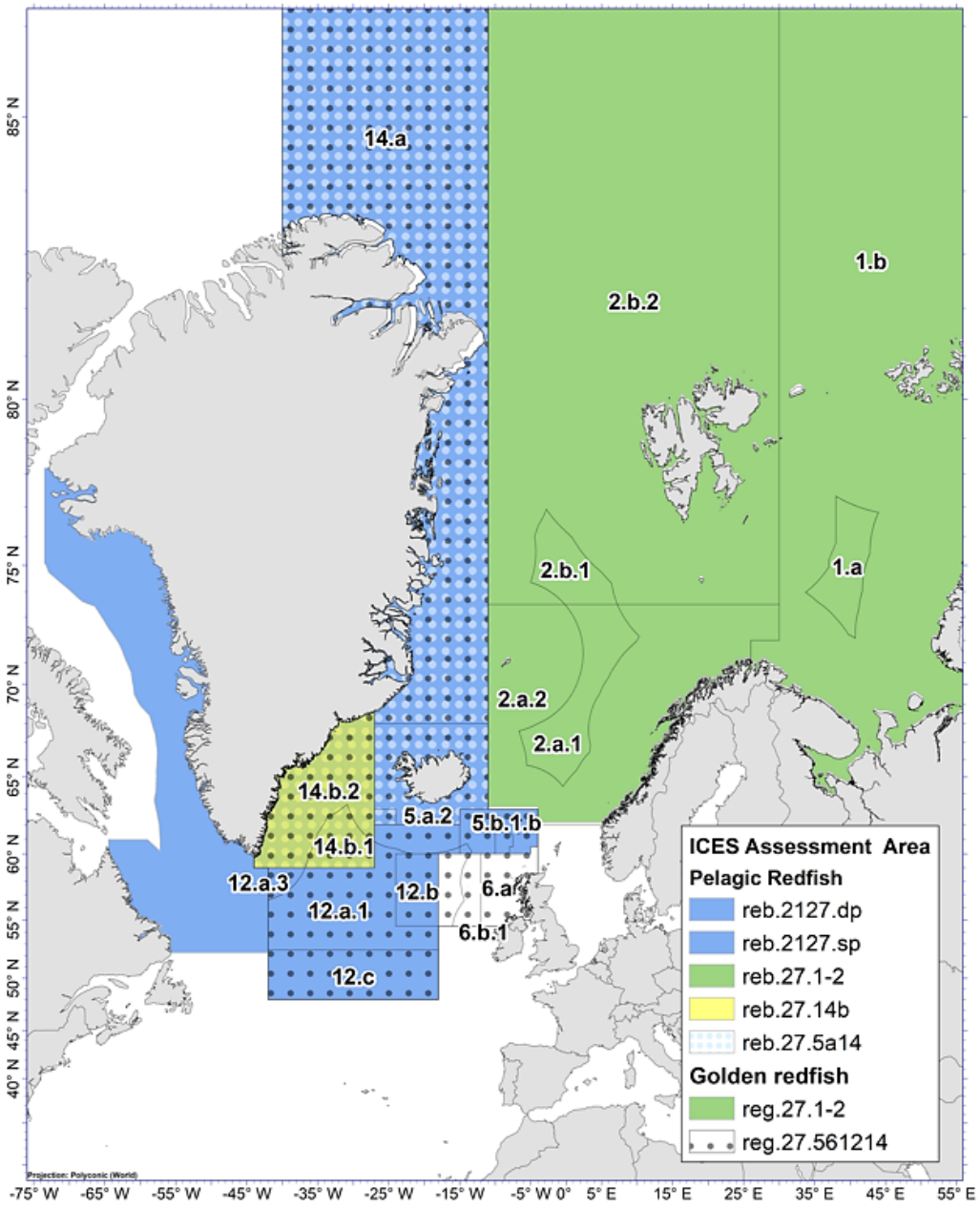


Figure 19. ICES' assessment areas for beaked (REB) and golden (REG) redfish.

4.7.1.1. No sharing agreement example: Beaked Redfish (Norwegian waters of subareas 1 and 2, REB/1N2AB)

Step 1: Estimate the advice relevant to the TAC area for this stock.

- Split the Beaked Redfish advice into Norwegian and international waters components using either catch distribution or scientifically robust stock distribution.

Step 2: If step 1 passed, assess whether this TAC is likely to result in significant catches of the co-occurring Golden Redfish in this management area.

- Are there sufficient technical measures or management regulations in place to minimise catches of Golden Redfish?

In this example, there are sufficient technical measures imposed by the Norwegian fisheries management to minimise any catches of Golden Redfish. However, in international waters of 1 and 2 (RED/12INT) there is not distinction between Beaked and Golden Redfish stocks. Therefore, there are no species-specific regulations enforced.

Due to the situation in international waters of 1 and 2 where there is not distinction between species, then the TAC REB/1N2AB would fail to pass step 2.

5. Areas for further work

The methodological review focused on the application of the ICES' advice metric MSY point estimate and headline advice as its starting point. This method can also be applied when the ICES' advice is the Precautionary Approach. However, there is a need to consider further the application of other types of ICES' advice, specifically to the ranges of F_{MSY} or F ranges, and other aspects of the Multi-Annual Plans, as well as Mixed Fisheries considerations.

There are additional management aspects that require consideration when applying this method to assess the sustainability of negotiated catch limits. These are:

- The assessment of catch limits from a management perspective would require an accounting exercise that includes all the catch and landing data that occur in a management area to assess that the overall catch/landing is not above the ICES' advice.
- There might be catches or landings generated from a 3rd country (not the UK and/or the EU), that might not be entirely accounted for when considering the assessment of a TAC. We referred to these as 3rd country catches, which are directly influenced by the existence, changes, or lack of sharing agreements of the fisheries management areas between countries/governments/Coastal States.
- There is a need for further work on the spatial analysis to determine how the different ICES' assessment areas relate to the various management areas (TACs). The proposed categorisation of TACs would need to be reviewed and updated to ensure that any additional aspects are adequately addressed in the assessment. For instance, the fragmented category and no sharing agreement cases would need further development of the method.

6. References

ICES Ecoregions and advisory areas: https://www.ices.dk/advice/ICES ecoregions and advisory areas/Pages/ICES-ecosystems-and-advisory-areas.aspx

ICES. 2020. Guide to ICES advisory framework and principles. In Report of the ICES Advisory Committee, 2020. ICES Advice 2020, section 1.1. https://doi.org/10.17895/ices.advice.7648

ICES. 2021. Advice on fishing opportunities. In Report of the ICES Advisory Committee, 2021. ICES Advice 2021, section 1.1.1. https://doi.org/10.17895/ices.advice.7720

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7. Acknowledgements

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